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Education in Emergency
Self - Instructional Materials

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Key Stage 5 Cl - XI - XII
Vol. V

Self-Instructional Materials

Key-stage V

(Classes XI and XII)

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INFORMATION FOR STUDENTS

i. The lessons on English, Dzongkha, and Mathematics subjects are meant for all the students of classes XI and XII, regardless of their stream.
ii. The lessons for *Science, Arts, and Commerce* streams are provided in separate sections for students to choose depending on their areas of study.
iii. The answers to questions that students need to solve in each activity are provided in the last section on 'Answers'.
iv. Each lesson is designed for fifty-five minutes.

ENGLISH

1. Transformation of Sentences: Types of Sentences

- Differentiate types of sentences based on the meaning they convey.
- Apply rules to change one type of sentence to another as per the instruction.

Introduction

The four types of sentences are imperative, interrogative, declarative and exclamatory sentences. These sentences can be transformed into different form without changing the meaning of the sentence. This process is known as transformation of sentences.

Before we discuss the transformation of sentences, read the poem to get the gist of the **four types of sentences** based on the meaning they convey.

I am but a **declarative**
I end with a period
and I make statements.

I am but an **imperative**
I make **command** or **request**
Please read it, stand up.

I am but **interrogative**
I **interrogate**, I **question**
Are you reading?

I am but **exclamatory**
I depict a **strong emotion**
Alas! Ouch! That’s scary!

That me, a sentence
Will you use me?
In your essay, story
and any writing you do!

ACTIVITY 1

Instructions: Let us look at **four types of sentences** given below with examples.

Declarative/Assertive sentence

Sentences that state a fact, opinion or an idea. Most sentences are declarative.

Example: 1. I do not eat meat.

2. He told me lies.

Imperative/Command sentence

Sentences that express command, suggestion or request.
Example:
1. Go to your room right now.
2. Don't tell me what to do.

Question /Interrogative sentence

Interrogative sentence asks a question and is followed by a question mark
Example:
1. Isn't it very hot today?
2. Would you like to have a cup of tea?

Exclamatory sentence

An exclamatory sentence expresses strong feelings and always ends with an exclamation mark.
Example:
1. That sounds terrible!
2. I can't believe you lied to me!

Transformation of Sentences (based on the meaning they convey-Types of Sentences)

The transformation of a sentence is about changing its form without changing its meaning. We can transform an exclamatory sentence into a declarative sentence or declarative to exclamatory sentence without altering its meaning. Similarly, other sentences can be changed keeping its meaning same.

Let us look at how each type of sentence can be transformed to another without altering its meaning.

Rules of Transformation of Sentence

The **basic rules** to follow while transforming one type of sentence to another:

- Identify the type of sentence.
- Follow the instruction given.
- Apply the rules learnt while changing the sentence.
- Ensure the **meaning** and the **tense** remain same.

1. Transforming Declarative to Exclamatory Sentence:
   a. Use:
      What + a/an + adjective/ adverb + subject + verb+!
      How + adjective/ adverb + subject + verb+!

Examples:

Declarative Sentence: It is a great dress.
Exclamatory Sentence: What a great dress it is!
Declarative Sentence: He is very knowledgeable.
Exclamatory Sentence: How knowledgeable he is!

Note: In declarative sentence, 'What +a/an' and 'How' is replaced by a very and these are used after verb and before adjective/ adverb.

   b. If +subject+ verb+noun/noun phrase+!
      If + subject+had+ noun/noun phrase+!

Example:

Declarative Sentence: I wish I were a captain.
Exclamatory Sentence: If I were a captain!
Declarative Sentence: I wish I had wings of a bird.
Exclamatory Sentence: If I had wings of a bird!

2. Transforming Exclamatory Sentence to Declarative Sentence
   a. Use: Subject + verb + a + very + adjective/ adverb.

Example:

Exclamatory Sentence: What a splendid performance it was!
Declarative Sentence: It was a very splendid performance.

3. Transforming Imperative Sentence to Declarative Sentence:

a. If the sentence starts with a verb, use: Subject+ auxiliary verb+verb (pp)+ to +verb phrase

Example:

Imperative Sentence: Come here.
Declarative Sentence: You are ordered to go there.

b. Starting with 'let', use: Subject+auxiliary verb+verb(like commanded/ ordered)+ to + let + noun phrase

Example:

Imperative Sentence: Let him go.
Declarative Sentence: You are commanded to let him go.

4. Transforming Interrogative Sentence into Declarative Sentence:
   a. In a sentence beginning with auxiliary verb:

Example:

Interrogative: Isn't reading a good habit?
Declarative Sentence: Reading is a good habit.

   b. Declarative sentence without auxiliaries are changed into interrogative with 'Wh' question word + do/did/does based on the tense used.

Example:

Declarative Sentence: Everyone loves music.
Interrogative Sentence: Who doesn't love music?

5. Transforming Imperative Sentence into Interrogative Sentence
   a. Starting with a verb:

Example:

Imperative Sentence: Please, get me a bottle of water.
Interrogative Sentence: Will you, please, get me a bottle of water?

ACTIVITY 2

Instruction: Follow the instruction given in parenthesis to change the following sentences.

1. Please leave your footwear outside. [Change it into interrogative sentence]
2. Will you wait here? [Change it into declarative sentence]
3. If you eat a lot of candies, you will spoil your dental health. [Change it into Imperative sentence]
4. What a beautiful scene! [Change it into declarative sentence]
5. Aren't dogs faithful animals? [Change it into declarative sentence]
6. We are not going to surrender like this. [Change it into interrogative sentence]
7. Cell phones are a nuisance. [Change it into exclamatory sentence]
8. What a pleasant surprise! [Change it into declarative sentence]
9. Never speak to me like that again. [Change it into declarative sentence]
10. Close the door. [Change it into interrogative sentence]

Summary

Sentences can be categorized based on their meaning and structure. Based on their meaning, there are four types of sentences.

- Declarative sentence declares or state fact, opinion or an idea.
- Imperative sentence expresses command, suggestion or request.
- Interrogative sentence asks questions.
- Exclamatory sentence expresses strong emotions.
- Rules for transforming one type of sentence to another:
  1. Identify the sentence.
  2. Follow the instruction given.
  3. Apply the rules learnt while changing the sentence.
  4. Ensure the meaning and the tense remain the same.

Self-check for Learning

Instruction: Identify the four types of sentences given below. Change them as per the instruction given in the brackets.

1. What a lonely place it is! (Change it into declarative sentence)
2. It is kind of you to invite us for dinner. (Change it into interrogative sentence)
3. Wasn't it careless of him to leave the door unlocked?(Change it into an exclamatory sentence)
4. There is no greater feeling than love. (Change it into an interrogative sentence)
5. Is this the way to talk to your elders? (Change it into declarative sentence)
6. It is a very beautiful day. (Change it into exclamatory sentence)
7. What a delicious lunch we had yesterday! (Change into an declarative Sentence)
8. The child is very pretty. (Change it into an exclamatory Sentence
9. You are requested to slow down your pace. (Change it into imperative sentence)
10. This is indeed a great pleasure. (Change it into exclamatory sentence)

2. Figures of Speech

- List different types of figures of speech with examples.
- Identify figures of speech from the suggested titles of the prescribed text books.

Introduction

Figures of speech is not a new topic for us. We are aware of its significance in a language. Figures of speech are means of expressing our thoughts more vividly and with more clarity. As we use figure of speech, we learn to appreciate the richness of English language besides being able to embellish our own writing. This is especially useful when we carry out creative reading and writing activities. For instance, it helps us to make our writing memorable by calling attention of a reader on the point we feel is important for them to notice. It also helps to make the reading interesting and effective by adding power or force to the expression. The example given below uses personification to put emphasis on the danger of Covid-19 and also help to gain the attention of the readers.

Without a visa or legal documents, the Novel Corona Virus (Covid-19) has succeeded in crossing the borders from East Asia to West Europe, affecting about 387,306 individuals (31 January 2020- 24 March 2020) from various corners of the world, failing to discriminate people based on their status, wealth, age or citizenship leading to a global lockdown.

(Source: Voices of Youth)

ACTIVITY 1

Instructions: Different types of figures of speech are explained in Table 1. Read and identify their characteristics.

Table 1

Figure of Speech	Examples
1. Simile is a figure of speech that compares two unlike things. It does not state that something is another thing, instead they compare using the words ‘like’ or ‘as’.	• My friend is as good as gold. • Her eyes smile like stars.
2. Metaphor compares two unlike things by saying that one thing is the other.	• She was a gem among women. • This is the icing on the cake.

3. Oxymoron is a phrase made up of seemingly contradictory terms.	Silent cry, loving hatred, living dead, tears of joy
4. Proverb (aka saying and aphorism) is a short traditional saying that is thought to express wisdom.	• A stitch in time saves nine. • Birds of same feathers flock together.
5. Apostrophe is a direct address made to a person, thing or abstraction.	• Pardon me, thou bleeding piece of earth. • Oh, holy night!
6. Euphemism is an expression used by the speaker to be less offensive, disturbing or troubling to the listener compared to the word or phrase it replaces.	• restroom for toilet • pass away for die • Between jobs instead of unemployed
7. Exclamation is a sudden outcry expressing violent emotion, such as fright, grief or hatred.	• Out! • Damned spot!
8. Hyperbole is a deliberate exaggeration.	• I am so hungry, I could eat a horse. • I died of embarrassment.
9. Litotes is an understatement, a positive statement expressed by negating its opposite expression.	Not bad, not useless, not unhappy, not bad looking, not unwelcome, etc.
10. Irony – There is discrepancy in what is said and what is really meant.	• Nice weather! When it is raining.
11. Onomatopoeia is a word imitating a sound. It is used because it is often difficult to describe sounds.	The humming bee, cackling hen, whizzing arrow, roaring lions, sizzling pan, hissing snake, etc.
12. Personification is when animals, inanimate objects or abstractions are represented as having human characteristics.	• Dew drops sing to the garden stones. • Lightning danced across the sky. • The wind howled in the night.
13. Rhetorical questions are questions without a direct answer.	• Did you help me when I needed help? • What is the meaning of life?
14. Transferred epithet is used to transfer the quality of one thing to another.	Sad world, peaceful house, (In both the case we know it is not the world that is sad nor the house that is peaceful.)
15. Alliteration is the repetition of the same sounds at the beginning of words.	• For the greater good of … • She sells sea shells.

16. Consonance is the repetition of consonant sounds in a short sequence of words.	• The ‘t’ sound in “Is it blunt and flat? • Toss the glass, boss.
17. Assonance is the repetition of the vowel sound within a short passage of poetry or phrase.	• Try to light a fire. • A stitch in time saves nine.
18. Metonymy is a figure of speech that replaces the name of thing with the name of something closely associated with it.	• the bottle for alcohol • the press for journalism • the White House for the US government
19. Pun is an expression that achieves emphasis on humour by suggesting that there can be two distinct meanings by the same word.	• The word ‘grave’ for serious and tomb. • You were right, so I left.
20. Synecdoche is a figure of speech by which something is referred to indirectly either by naming only some part of it.	• hands for manual labourers • the law for police officers • the word ‘head’ to refer to number of people

ACTIVITY 2

Instruction: Now you have gained some understandings on figures of speech, let us now do an exercise to understand figures of speech better. Identify the figure of Speech.

i. Sonam was a lion in the fight. --------------
ii. Tshering looks as fresh as the morning dew. ----------------
iii. I can wait for thousand years to get to my dream place. -----
iv. Wash the washer with some water. ----------
v. Death lay its icy hands even on emperors and young princess. --------------
vi. Your handwriting is not bad. -------------------------
vii. Thank you for lending me your ears. ------------------
viii. The clown is seriously funny. -------------
ix. Andrew Marvell once wrote, ‘A grave is a fine and a private place’. ------------------
x. Time and tide waits for no man. ----------------------

ACTIVITY 3

Instruction: Refer Table 1 and write one example for each figure of speech.

Summary

Using Figure of speech is crucial in English Language. Besides adding intensity to our expressions, it helps in creating vivid rhetorical effect.

- Simile is a figure of speech that compares two unlike things using ‘as’ or ‘like’.
- Metaphor compares two unlike things without using ‘as’ or ‘like’.
- Oxymoron is a phrase made up of seemingly contradictory terms.
- Proverb is a thought that expresses wisdom.
- Apostrophe is a direct address made to an object, abstract thing or a person who doesn’t exist.
- Euphemism is an expression used by the speaker to be less offensive, disturbing or troubling to the listener compared to the word or phrase it replaces.
- Exclamation is a sudden outcry expressing violent emotion.
- Hyperbole is a deliberate exaggeration.
- Litotes is an understatement, a positive statement expressed by negating its opposite expression.
- Irony – There is discrepancy in what is said and what is really meant.
- Onomatopoeia is a word imitating a sound. It is used because it is often difficult to describe sounds.
- Personification is when animals, inanimate objects or abstract things are represented as having human characteristics.
- Rhetorical questions are questions askedfor emphasis without expecting a direct answer.
- Transferred epithet is used to transfer the quality of one thing to another.
- Alliteration is the repetition of the same sounds at the beginning of words.
- Consonance is the repetition of consonant sounds in a short sequence of words.
- Assonance is the repetition of the vowel sound mostly used in poetry.
- Metonymy replaces the name of thing with the name of something closely associated with it.
- Pun makes use of words that have more than one meaning, or words that sound similar but have different meanings, to humorous effect.
- Synecdoche is in which a part is made to represent the whole or vice versa.

Self-check for Learning

Instruction: Now that you are familiar with figures of speech and you have given your own examples, to get further practice, please read a poem [Digging by Seamus Heaney for grade XII and 'Gaylong Sumdhar Tashi by Dasho Sonam Kinga for grade XI] from your Reading & Literature book. List as many examples of figures of speech as you can.

Class 11

3. A Change of Fate - *Excerpt from Gaylong Sumdar Tashi: Song of Sorrows Translated into English by Sonam Kinga*

When my mother arranged my marriage
With Ngedup Bumo, daughter of Aum Gayling Zam,
I was neither strong nor seasoned;
And yet a son, Dendup Tashi, was born to us.

Before my peasant's life finished its story,
The monk-tax compelled me to start another.
I would have to go the next day
To start my next life, a peasant monk!

That last night, the night of all nights,
My wife, Ngedup Bumo, slept on my right,
And I, Sumdar Tashi, slept on her left.
Our son, Dendup Tashi, was between us.

Even as we spoke our thoughts and emotions,
The sleeping Night awoke as a rising Dawn,
And when the Dawn drowned the Night
I had to take a cleansing bath.

And when I went for the cleansing bath,
The dirt of my outer body
Was washed away by a ladleful of water;
But the deep sorrow of my heart
Could not be removed, even when my beloved faced me;
My anguished grief haunted my dreams
And pained the sole of my foot when I walked.

I, Gaylong Sumdar Tashi, join the order,
Not for fun, not for pleasure.
Oh, my evil fate! I had to bear the monk-tax.
Losing my happiness, sorrow overwhelmed me.

Departure

After descending the hills of the deity and the devil[13],
I looked back from the hamlet of Phang Yul Gaang[14]
And saw my dear mother looking out
Through the eyes of a window facing east.
My beloved Ngedup, a mere shadow,
Held our son, Dendup Tashi, close to her heart.
Alas, I could no longer hear her
But there she was, sadly waving a tattered scarf.

The way she waved the white scarf was a desperate call
That beckoned me to return to her and our son.
The thought of returning haunted me time and again,
But how could I! There was the royal command.
And yet how couldn't I! There was my beloved Ngedup.

As the bright day gave way to dusty dusk,
I arrived at the hamlet of Bajo Thang.[15]
The sun in the azure sky
Kissed the summit of the western hills,
The brook of Bajo[16] wailed its songs,
The swans[17] lamented their flight towards Tibet,
The wind shook leaves loose from giant Pemai Gesar.[18]
When such sorrows combined their forces,
It only bred greater storms of sorrow.

After spending the night in a shaded glade,
I arrived at the glorious *dzong* of Punakha.
Early on the morning of the next day,
I made my offerings to Gyelse Mewang Depa.

---

13 This hill could not be identified.
14 A village in Shar, Wangdi Phodrang.
15 A village beside Puna Tsangchhu (River Sankosh) in Wangdue Phodrang.
16. Refer 26
17. The birds are identified as Ruddy Shell Duck. They migrate to the warmer valleys of Wangdue Phodrang in winter and leave for Tibet as spring arrives.
18. Bombax cieibi (red cotton tree).

Class 12

1. Digging - *Seamus Heaney*

Between my finger and my thumb
The squat pen rests; snug as a gun.

Under my window, a clean rasping sound
When the spade sinks into gravelly ground.
My father, digging. I look down

Till his straining rump among the flowerbeds
Bends low, comes up twenty years away
Stooping in rhythm through potato drills
Where he was digging.

The coarse boot nestled on the lug, the shaft
Against the inside knee was levered firmly.
He rooted out tall tops, buried the bright edge deep
To scatter new potatoes that we need picked
Loving their cool hardness in our hands.

By God, the old man could handle a spade,
Just like his old man.

My grandfather cut more turf in a day
Than any other man on Toner's bog.
Once I carried him milk in a bottle
Corked sloppily with paper. He straightened up
To drink it, then fell to right away

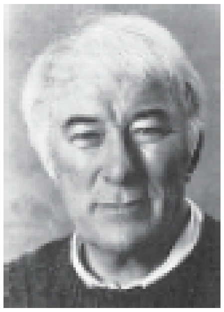
Nicking and slicing neatly, heaving sods
Over his shoulder, going down and down
For the good turf. Digging.
The cold smell of potato mould, the squelch and slap
Of soggy peat, the curt cuts of an edge
Through living roots awaken in my head.
But I've no spade to follow men like them

Between my finger and my thumb
The squat pen rests.
I'll dig with it.

About the Poet

Seamus Heaney *was born in April 1939. He grew up as a country boy and attended the local primary school. When he was twelve years of age, Seamus Heaney won a scholarship to St. Columb's College, a Catholic boarding school situated in the city of Derry, forty miles away from the home farm, and this first departure from Mossbawn was the decisive one. It was followed by a transfer to Belfast and by another move to the Irish Republic where Heaney has made his home. All of these subsequent shifts and developments were dependent, however, upon that original journey from Mossbawn which the poet has described as a removal from "the earth of farm labour to the heaven of education." It is not surprising, then, that this move has turned out to be a recurrent theme in his work, from "Digging", the first poem in his first book, through the much more orchestrated treatment of it in "Alphabets"(The Haw Lantern, 1987), to its most recent appearance in "A Sofa in the Forties" which was published this year in The Spirit Level.*

The first verses he wrote when he was a young teacher in Belfast in the early 1960s and many of the best known poems in North, his important volume published in 1975, are linguistically tuned to the Anglo-Saxon note in English. Heaney's poems first came to public attention in the mid-1960s when he was active as one of a group of poets who were subsequently recognized as constituting something of a "Northern School" within Irish writing. Heaney married Marie who was to be the mother of his three children. She has been central to the poet's life, both professionally and imaginatively, appearing directly and indirectly in individual poems from all periods of his oeuvre right down to the most recent, and making it possible for him to travel annually to Harvard.



In 1984, Heaney was named Boylston Professor of Rhetoric and Oratory, one of the university's most prestigious offices. In 1989, he was elected for a five-year period to be Professor of Poetry at Oxford University, a post which requires the incumbent to deliver three public lectures every year but which does not require him to reside in Oxford. In recent years, he has been the recipient of several honorary degrees; he is a member of Aosdana, the Irish academy of artists and writers, and a Foreign Member of The American Academy of Arts and Letters. In 1996, subsequent to his winning the Nobel Prize in Literature in 1995, he was made a Commandeur de L'Ordre des Arts et Lettres by the French Ministry of Culture.
- From Les Prix Nobel 1995.

3. Drama

Learning Objectives

- Define drama.
- Discuss the importance of reading William Shakespeare's work.
- Identify or plot the main elements of the play.

Introduction

For about ten seconds, think about what a drama is. Write down the meaning of drama / play in your own word.

Let us now look at the definition of drama. Drama is a mode of fictional representation through dialogue and performance, which is an imitation of some action. It is written for theater, television, film or radio. Drama is a performance or acting on the stage in front of audience with speech, with primary proposes to entertain, but it also reflects our life, our character and our everyday activity. It is like seeing our reflection in the mirror.

There are many types of drama but in this lesson, we are going to learn about William Shakespeare's Play, "The Merchant of Venice".

ACTIVITY 1

Read the information given below.

The significance of reading William Shakespeare's play:

i. William Shakespeare is considered the greatest playwright. He possesses the ability to write great plots. His themes are universal and timeless; every generation can relate to and find meaning in his themes. His themes include revenge, love, marriage, power, ambition, murder, obsession, dreams, loyalty, death, sin, guilt, mercy and judgement.

ii. In *The Merchant of Venice* themes like friendship, love, and obedience are obvious. These are the themes we will be able to recognise and relate to our life.

iii. The play also offers an opportunity for us to reflect on abstract ideas like religious tolerance, racial discrimination, justice, cruelty, colour prejudice, class distinction and traditional gender roles.

iv. Shakespeare weaves his plot around the follies of his characters, which in turn leave them at the mercy of Chance.

v. Through the situations of Antonio and Shylock, we can explore how subplots can be intertwined to heighten characterisation.

vi. As one of the greatest manipulators of words, Shakespeare kindles strong emotions in his audience. Even the most prejudiced audience cannot help but sympathise with a marginalised character like Shylock.

Something to Recall:

- Have you ever said that something is the "be-all and the end-all"
- That you wanted to "break the ice"?
- Have you asked, "Knock, knock! Who's there?"
- That 'love is blind'
- Have you ever said, 'It's Greek to me'.

Yes, we all did. If we have done that, we are quoting Shakespeare. We should study Shakespeare simply to appreciate how much of our daily discourse we owe to his wordsmithery. His turns of phrase were unconventional and ingenious.

It is worth to study the plays written by William Shakespeare. His writing has tremendous influence even to the present day. He wrote about 37 plays. Among them, we will explore more about 'The Merchant of Venice' in our next activity.

ACTIVITY 2

Instruction: Before we delve into **The Merchant of Venice** play, carry out the attitude survey below. Read each theme and write **Agree** if you agree with the theme or **Disagree** if you do not agree with the theme.

Theme	Agree/Disagree
i. Money can affect my level of happiness.	
ii. Appearances can be deceiving.	
iii. A true friend would do anything for their friends.	
iv. People should forgive those who have wronged them.	
v. People should keep their promise, no matter what	

ACTIVITY 3

Instruction: Copy the themes given in Activity 1 in your notebook. Write a paragraph for each theme justifying your stand.

Brief background information on The Merchant of Venice.

In the 16th Century, William Shakespeare wrote a play called "The Merchant of Venice." This period was known as the Elizabethan era, the time when the people, in general, carried anti-Semitic feelings and because of their Anti-Semitism the subject matter of the play alone would have grabbed the audiences' attention. Anti-Semitism means the hostility toward or discrimination against a different religious, ethnic, or racial group

The Merchant of Venice

Now we are going to look at the main elements of the play:

- **Main Characters**

The main characters in the play are:

- Antonio is the rich merchant of Venice, very generous and kind. He is a very good friend of Bassanio.
- Bassanio is young, fashionable, romantic and good friend of Antonio. He doesn't earn but loves to spend lavishly.
- Portia is a rich lady of Belmont. She is wise and learned. She is obedient and loving.
- Shylock is a Jew and a money lender by profession. He does not get along with Antonio.

- **Settings**

Venice:

- Antonio, Bassanio and Shylock site in Venice.
- The action of the play takes place in Venice.
- The city is located on the sea coast in the north of Italy.
- Venice was very popular place for trade/ commerce and law during 16th century.

Belmont:

- Belmont is an imaginary place, a small island.
- It is the place where Portia lives
- Belmont is associated with music and love
- People are characterized for kindness and generosity.

- **Important event in the plot**

Plot I

- Bassanio wants to marry a rich and beautiful woman called Portia, who lives in Belmont
- Bassanio needs money to go to Belmont to woo Portia but has no money. He indirectly asks help from Antonio, his closest friend to whom he already owes a lot.
- Antonio's ships are all on the sea and he has no money at hand to help Bassanio. However, Antonio risk borrowing money from Shylock, a Jewish moneylender and also a hardcore enemy of Antonio. They borrow 3000 ducats for 3 months.
- They sign a bond to pay back the money in 3 months and failure to pay back the exact sum on the exact time will lead to Antonio losing a pound of flesh from his heart. Antonio signs the bond without hesitation.

Plot II

- Portia is bounded by the 'will' of her dead father.
- The 'will' dissuade Portia from marrying the person of her choice. He grumbles over the lack of will to choose her own husband.

- Portia's late father designed three caskets made of gold, silver and lead with enchanting inscriptions. One of the caskets contain Portia's portrait. Suitors wanting to marry Portia should undergo the test by choosing the right casket that contains Portia's beautiful portrait.
- Suitors from far and wide comes to try their luck. Prince of Morocco and Prince of Arragon are among them. Prince of Morocco picks the golden casket as his choice while Prince of Arragon picks the silver casket.
- Bassanio tries his luck and chooses the right casket (i.e lead) and marries Portia.

➢ **The Climax**

- Antonio is dragged to the Court of Venice by Shylock for Antonia fails to pay his debt.
- Shylock appeals for justice and wants nothing but a pound of flesh of Antonio.
- Portia in disguise of a young lawyer rescues Antonio with her wisdom by pointing out the technical loopholes in the bond. She points to the fact that the bond only authorizes Shylock to exact just a pound of flesh, and not even shed a tiny drop of blood.
- Shylock gives up the idea of extracting a pound of flesh, knowing the impossibility of cutting an exact pound of flesh without shedding a drop of blood.

➢ **The Resolution**

- The court of Venice frees Antonio
- Shylock is punished and half of his wealth and property is confiscated by state and half given to Antonio.
- Antonio, as a gentleman refuses his share of property. Instead, he makes Shylock to give it to his own daughter
- Reduced to a pitiable figure, Shylock is asked to change his faith by converting into Christianity. Helplessly, Shylock does as he is asked.
- Antonio's ships return safely from venture.

➢ **Themes**

Some of the themes are friendship, Love, Anti-Semitism- racism, Mercy or forgiveness

ACTIVITY 4

1. Antonio risks his own life to borrow money from his enemy to help Bassanio. Would you do the same to help a friend? Why?
2. Portia's choice of husband depends on the lottery designed by her dead father. Is it a wise decision for her dead father to curb the will of a living daughter?
3. Do you think it is a wise idea to reintroduce Merchant of Venice in English Curriculum? Justify your stand.
4. Write down at least FIVE quotations you know of William Shakespeare.

Summary

- Drama is a mode to present a story that is acted on stage with speech.
- William Shakespeare is popular playwrights in the world of English literature.
- His works are poetic, thematic, social and unique. Plot and themes are timeless and universal.
- The Merchant of Venice is popular play with romantic elements and its main purpose is to portray the social issue of anti-semitism.

Self-check for Learning

Instruction: You got the glimpse of the main events in the play. Now read the play from your textbook. For grade 11, read Act 1 scene and grade 12, read Act 3 scene 1. After reading, answer the following question.

Grade 11	Grade 12
1. How is the theme 'Friendship' explored in Act 1 Scene 1?	1. Explain how Shylock justifies that Jews and Christian are alike.
2. Antonio was sad for no reason in the beginning of the play. What are the reasons cited by Solanio and Salerio for his unexplained sadness?	2. Tubal, is another Jew in the play. He appears in act 3 scene 1 with both good and bad news for Shylock. Discuss the bad and the good news brought by him.
3. How did Gratiano add humour to the play in the scene?	3. William Shakespeare painted the darkest picture of Shylock as a bad father/human being in this scene. Bring out the lines from this scene that depicts Shylock's character at its worst.

The Merchant of Venice Act 1, Scene 1

Enter ANTONIO, SALERIO, and SOLANIO

Original Text	Modern Text(Translation)
Antonio In sooth, I know not why I am so sad. It wearies me; you say it wearies you. But how I caught it, found it, or came by it, What stuff 'tis made of, whereof it is born, I am to learn. And such a want-wit sadness makes of me, That I have much ado to know myself.	ANTONIO: To tell the truth, I don't know why I am so sad. I'm tired of being sad, and you say you're tired of it, too. But I don't know how I caught, found, or came by this sadness; what it's about; or where it came from. And since I don't know anything about this sadness, I clearly have a ways to go in understanding myself.
SALERIO Your mind is tossing on the ocean, There, where your argosies with portly sail, Like signors and rich burghers on the flood— Or, as it were, the pageants of the sea— Do overpeer the petty traffickers That curtsy to them, do them reverence As they fly by them with their woven wings.	SALERIO: Your mind is focused on the ocean where your merchant ships are sailing like rich, important men parading on the sea. They tower over the little trade boats that they pass by, sailing along, and it's as if the little boats bow before the greatness of your ships.
SOLANIO Believe me, sir, had I such venture forth, The better part of my affections would Be with my hopes abroad. I should be still Plucking the grass to know where sits the wind, Peering in maps for ports and piers and roads. And every object that might make me fear Misfortune to my ventures out of doubt Would make me sad.	SOLANIO: Believe me, sir, if I were involved in a trade venture like yours, most of my mental energy would be with my ships, as well. I'd be pulling up shoots of grass to use them to check the wind, and looking at maps of ports and piers and roads. And any little thing that might make me worry that something bad would happen to my ships would make me sad, without a doubt.

SALERIO	SALERIO
My wind cooling my broth Would blow me to an ague when I thought What harm a wind too great might do at sea I should not see the sandy hourglass run, But I should think of shallows and of flats And see my wealthy Andrew docked in sand, Vailing her high top lower than her ribs To kiss her burial. Should I go to church And see the holy edifice of stone And not bethink me straight of dangerous rocks, Which, touching but my gentle vessel's side, Would scatter all her spices on the stream, Enrobe the roaring waters with my silks, And, in a word, but even now worth this, And now worth nothing? Shall I have the thought To think on this, and shall I lack the thought That such a thing bechanced would make me sad? But tell not me. I know Antonio Is sad to think upon his merchandise.	I'd get upset blowing on my hot soup, because it would make me think of what a strong wind at sea could do to my ships. If I saw the sands run in an hourglass, I would think of flat shallows where my ship, "The Andrew," run aground with all its riches and flipped over, completely done for. If I went to church and saw its stone construction, I couldn't help but think of dangerous rocks that could break the sides of my ships and scatter valuable spices all over the water, causing my silks to fall out and drape on the waves. They are worth so much, and would all of a sudden be lost and worth nothing to me. How could I think of such things and not get sad? But you don't need to tell me. I know that Antonio is sad because he's worrying about his merchandise.
ANTONIO Believe me, no. I thank my fortune for it— My ventures are not in one bottom trusted, Nor to one place, nor is my whole estate Upon the fortune of this present year. Therefore my merchandise makes me not sad.	ANTONIO: Believe me, you're wrong. Thank goodness, not all my merchandise is in one ship or any one place, and I haven't risked all my riches on this year's venture. Therefore, it's not my merchandise that is making me sad.
SOLANIO Why then, you are in love.	SOLANIO Well, then, you must be in love.
ANTONIO Fie, fie!	ANTONIO Oh please!

SOLANIO Not in love neither? Then let us say you are sad Because you are not merry— and ’twere as easy For you to laugh and leap and say you are merry Because you are not sad.Now, by two-headed Janus, Nature hath framed strange fellows in her time. Some that will evermore peep through their eyes And laugh like parrots at a bagpiper, And other of such vinegar aspect That they’ll not show their teeth in way of smile Though Nestor swear the jest be laughable.	SOLANIO: You're not in love either? Then let's just say you are sad because you are not happy. It would be just as easy for you to laugh and jump around and just say you are happy because you are not sad. I swear, by two-headed Janus, nature has made all kinds of different people. Some people are always happy and could even laugh at a funeral, while others are so sour they don't even crack a smile at anything, not even at a joke that Nestor called the funniest.
Enter BASSANIO, LORENZO, and GRATIANO	BASSANIO, LORENZO, and GRATIANO enter.
Here comes Bassanio, your most noble kinsman, Gratiano, and Lorenzo. Fare ye well. We leave you now with better company.	Here comes Bassanio, your most noble relative, along with Gratiano and Lorenzo. Goodbye. We'll leave you to these better friends.
SALERIO I would have stayed till I had made you merry If worthier friends had not prevented me.	SALERIO: If it weren't for these better friends coming along, I would have stayed until I made you smile.
ANTONIO Your worth is very dear in my regard. I take it your own business calls on you And you embrace th' occasion to depart.	ANTONIO: I see you as very worthy. I gather you have business to take care of and are just taking this opportunity to leave.
SALERIO *[to BASSANIO, LORENZO, GRATIANO]* Good morrow, my good lords.	SALERIO *[To BASSANIO, LORENZO, and GRATIANO]* Good day, my good lords.
BASSANIO *[to SALERIO and SOLANIO]* Good signors both,when shall we laugh? Say, when? You grow exceeding strange. Must it be so?	BASSANIO *[To SALERIO and SOLANIO]* Both of you are good men; when are we going to have fun times together? Tell me, when? You're practically strangers now. Does it have to be that way?

SALERIO We'll make our leisures to attend on yours.	SALERIO The next time we get a chance, we'll spend some time together.
Exeunt SALERIO and SOLANIO	SALERIO and SOLANIO exit.
My Lord Bassanio, since you have found Antonio, We two will leave you. But at dinnertime I pray you have in mind where we must meet.	My Lord Bassanio, since you've found Antonio, the two of us will leave you two alone. But please remember where we're meeting for dinner.
BASSANIO: I will not fail you.	BASSANIO: Don't worry.
GRATIANO You look not well, Signor Antonio. You have too much respect upon the world. They lose it that do buy it with much care. Believe me, you are marvelously changed.	GRATIANO: You don't look good, Sir Antonio. You care too much about worldly things. Those who care too much about things end up losing them. Believe me, you really don't look yourself.
ANTONIO I hold the world but as the world, Gratiano— A stage where every man must play a part, And mine a sad one.	ANTONIO: I value the world for what it is, Gratiano: a stage where every man must play a role. And my role is a sad one.
GRATIANO Let me play the fool. With mirth and laughter let old wrinkles come. And let my liver rather heat with wine Than my heart cool with mortifying groans. Why should a man whose blood is warm within Sit like his grandsire cut in alabaster, Sleep when he wakes, and creep into the jaundice By being peevish? I tell thee what, Antonio— I love thee, and 'tis my love that speaks— There are a sort of men whose visages Do cream and mantle like a standing pond, And do a willful stillness entertain With purpose to be dressed in an opinion Of wisdom, gravity, profound conceit, As who should say, "I am Sir Oracle, And when I ope my lips, let no dog bark!"	GRATIANO: Well let me play the fool, then. I don't care if laughter causes wrinkles. I'd rather destroy my liver with wine than waste away with sad groans. Why should a warm-blooded man be as cold and stoic as a statue of his dead grandfather? Why should he be so inactive that he is practically asleep while awake, and start to get jaundice from being cranky so much? I tell you what, Antonio—I love you, and I'm speaking out of love—there are some people whose faces are so unmoving that they grow scum like a still pond, and they try hard to maintain a still expression so that they can seem to be wise, serious, and profound, like someone who could say, "I am Sir Oracle, and when I open my lips to speak, let no dog bark!"

O my Antonio, I do know of these That therefore only are reputed wise For saying nothing, when I am very sure If they should speak,would almost damn those ears Which, hearing them, would call their brothers fools. I'll tell thee more of this another time. But fish not with this melancholy bait For this fool gudgeon, this opinion.— Come, good Lorenzo.— Fare ye well awhile. I'll end my exhortation after dinner.	Oh my Antonio, these kind of men only have the reputation of wisdom because they say nothing, and I'm sure that if they should speak, everyone listening would realize they are fools. I'll tell you more about this another time. But stop trying to get people to think you're serious and wise by acting all melancholy. Come with me now, good Lorenzo. Goodbye for now, Antonio. I'll finish the rest of my encouraging speech after dinner.
LORENZO Well, we will leave you then till dinnertime. I must be one of these same dumb wise men, For Gratiano never lets me speak.	LORENZO: Well, we'll leave you until dinnertime, then. I must be one of these dumb but wise-seeming men he talks about, because Gratiano never lets me speak.
GRATIANO Well, keep me company but two years more, Thou shalt not know the sound of thine own tongue.	GRATIANO: Well, stick around with me for two more years and you'll forget what your voice even sounds like.
ANTONIO Farewell. I'll grow a talker for this gear.	ANTONIO: Goodbye. I'll start to talk more, now.
GRATIANO Thanks, i' faith, for silence is only commendable In a neat's tongue dried and a maid not vendible.	GRATIANO: Thanks, because in fact the only tongues that should keep quiet are beef tongues on the dinner plate, and those of uncooperative maids.
Exeunt GRATIANO and LORENZO	GRATIANO and LORENZO exit.
ANTONIO Is that any thing now?	ANTONIO: What do you think of all that?
BASSANIO Gratiano speaks an infinite deal of nothing, more than any man in all Venice. His reasons are as two grains of wheat hid in two bushels of chaff -you shall seek all day ere you find them, and when you have them they are not worth the search.	BASSANIO:Gratiano speaks an endless stream of nonsense, more than any man in all of Venice. Trying to find the point of what he's talking about is like looking for two grains of wheat hidden in bushels of hay. You could look all day before you find them, and once you do it's not even worth the effort you put into it.

ANTONIO Well, tell me now what lady is the same To whom you swore a secret pilgrimage, That you today promised to tell me of?	ANTONIO: Well, then tell me know who the lady is that you made an agreement with to go on a secret trip? You promised to tell me today.
BASSANIO 'Tis not unknown to you, Antonio, How much I have disabled mine estate, By something showing a more swelling port Than my faint means would grant continuance. Nor do I now make moan to be abridged From such a noble rate. But my chief care Is to come fairly off from the great debts Wherein my time something too prodigal =Hath left me gaged. To you, Antonio, I owe the most in money and in love, And from your love I have a warranty To unburden all my plots and purposes How to get clear of all the debts I owe.	BASSANIO: Antonio, you know how I've been using up my wealth, living a more lavish life than I can afford. Now, I'm not complaining about having to be more frugal, but I do care about fairly paying off the debts that I incurred while I was living beyond my means. I owe the most to you, Antonio, both in money and in love. And because we are good friends, I know I can tell you all my plans and plots for paying back all the debts I owe.
ANTONIO I pray you, good Bassanio, let me know it. And if it stand, as you yourself still do, Within the eye of honor, be assured My purse, my person, my extremest means Lie all unlocked to your occasions.	ANTONIO: Please do tell me, good Bassanio. And if your plan is as honorable as you still are, rest assured that I will help you with my money, myself, and whatever other ways I can.
BASSANIO In my school days, when I had lost one shaft, I shot his fellow of the selfsame flight The selfsame way with more advisèd watch To find the other forth— and by adventuring both, I oft found both. I urge this childhood proof Because what follows is pure innocence. I owe you much, and, like a willful youth, That which I owe is lost. But if you please To shoot another arrow that self way Which you did shoot the first, I do not doubt, As I will watch the aim, or to find both Or bring your latter hazard back again And thankfully rest debtor for the first.	BASSANIO: Back during my school days, I was shooting arrows once and lost one. So, I shot another arrow the same exact way and paid better attention to it so that I could follow its course, and it led me to the first arrow. With this example from my childhood in mind, listen to my plan, which is completely innocent. I owe you a lot, and like a rash young man I have lost the money I owe you. But if you shoot another arrow the same way you shot the first, by lending me money again, I have no doubt that I will bring both arrows back to you, because I'll watch the second one more carefully. Or at least I'll bring back the first, and remain in your debt for the second.

ANTONIO You know me well, and herein spend but time To wind about my love with circumstance. And out of doubt you do me now more wrong In making question of my uttermost Than if you had made waste of all I have. Then do but say to me what I should do That in your knowledge may by me be done, And I am pressed unto it. Therefore speak.	ANTONIO: You know me well, and are wasting your time complicating my affection for you with explanation and reasoning. You do me more wrong in doubting that I love you enough to lend you more money than if you had wasted all of my money. Simply tell me what you would like me to do, and I will do it. Tell me.
BASSANIO In Belmont is a lady richly left, And she is fair and—fairer than that word— Of wondrous virtues. Sometimes from her eyes I did receive fair speechless messages. Her name is Portia, nothing undervalued To Cato's daughter, Brutus' Portia. Nor is the wide world ignorant of her worth, For the four winds blow in from every coast Renownèd suitors, and her sunny locks Hang on her temples like a golden fleece, Which makes her seat of Belmont Colchos' strand, And many Jasons come in quest of her. O my Antonio, had I but the means To hold a rival place with one of them, I have a mind presages me such thrift That I should questionless be fortunate!	BASSANIO: There's a lady in Belmont who has inherited some riches and is both beautiful—more beautiful than can be described—and virtuous. We've occasionally exchanged some knowing glances. Her name is Portia, and she lives up to her namesake, Cato's daughter and the wife of Brutus. Her worthiness as a wife is well-known, and suitors come to her from all four corners of the world. Her blonde hair hangs over her temples like the Golden Fleece, and it makes many a Jason want to come on a quest for her. Antonio, if I only had the means to stand as a rival with these suitors, I know without a doubt that I would be successful in wooing her!
ANTONIO Thou know'st that all my fortunes are at sea. Neither have I money nor commodity To raise a present sum. Therefore go forth, Try what my credit can in Venice do— That shall be racked even to the uttermost To furnish thee to Belmont, to fair Portia. Go presently inquire, and so will I, Where money is, and I no question make To have it of my trust or for my sake.	ANTONIO: You know that all my money has been put into my ships. I have neither money nor any goods to sell in order raise some funds for you. So go forth and see how far my credit will get you in Venice, all of which I will use to get you to Belmont and to beautiful Portia. Go ask around to find somewhere you can borrow some money, and so will I. I am certain that people will lend me the money, either for my own sake or for the sake of my business.
Exeunt ANTONIO and BASSANIO	ANTONIO and BASSANIO exit.

The Merchant of Venice Act III Scene 1

The Original Text	Modern Text (Translation)
Enter SOLANIO and SALERIO	SOLANIO and SALERIO enter.
SOLANIO Now, what news on the Rialto?	SOLANIO: What news is there from the Rialto now?
SALERIO Why, yet it lives there unchecked that Antonio hath a ship of rich lading wracked on the narrow seas. The Goodwins I think they call the place—a very dangerous flat, and fatal, where the carcasses of many a tall ship lie buried, as they say, if my gossip report be an honest woman of her word.	SALERIO Well, there's an unproven rumor around there that Antonio has lost a ship carrying many riches on the English Channel. It supposedly happened on a very dangerous, deadly sandbar I think they call The Goodwins, where the remains of many tall ships lie buried. That is, if this gossip turns out to be true.
SOLANIO I would she were as lying a gossip in that as ever knapped ginger or made her neighbors believe she wept for the death of a third husband. But it is true, without any slips of prolixity or crossing the plain highway of talk, that the good Antonio, the honest Antonio—oh, that I had a title good enough to keep his name company!—	SOLANIO: I hope this rumor is as false as a woman who tells her neighbors she has wept over the death of her third husband. But it is true, at the risk of talking your ear off, that the good Antonio, the honest Antonio—oh, I wish I had something to call him that was good enough to be next to his name!
SALERIO Come, full stop!	SALERIO Come on, get to the point.
SOLANIO Ha, what sayest thou? Why, the end is he hath lost a ship.	SOLANIO: Hm, what are you saying? Oh, the point is that he has lost a ship.
SALERIO I would it might prove the end of his losses.	SALERIO: I hope this is the last of his losses.
SOLANIO Let me say "Amen" betimes, lest the devil cross my20 prayer, for here he comes in the likeness of a Jew.	SOLANIO: Let me say "amen" now, so that the devil doesn't interfere with that prayer, because here comes the devil himself, in the shape of a Jew.

Enter SHYLOCK	SHYLOCK enters.
SOLANIO How now, Shylock? What news among the merchants?	SOLANIO: How are you, Shylock? What's the news among the merchants?
SHYLOCK You knew—none so well, none so well as you—of my daughter's flight.	SHYLOCK: You knew about my daughter's plan to run away, and no one knew better than you.
SALERIO That's certain. I, for my part, knew the tailor that made the wings she flew withal.	SALERIO: That's for sure. For my part, I knew the tailor who made the wings she flew away on.
SOLANIO And Shylock, for his own part, knew the bird was fledged, and then it is the complexion of them all to leave the dam.	SOLANIO: And as for Shylock, he knew his little birdie had wings and he knew she was likely to leave the nest.
SHYLOCK She is damned for it.	SHYLOCK: She is damned for running away.
SOLANIO That's certain—if the devil may be her judge.	SOLANIO: That's certain, if you, the devil, are her judge.
SHYLOCK My own flesh and blood to rebel!	SHYLOCK: I can't believe my own flesh and blood rebelled against me!
SOLANIO Out upon it, old carrion! Rebels it at these years?	SOLANIO: No way, you old thing! You can't control your flesh even at your age?
SHYLOCK I say my daughter is my flesh and blood.	SHYLOCK: I mean my daughter is my own flesh and blood.
SALERIO There is more difference between thy flesh and hers than between jet and ivory, more between your bloods than there is between red wine and rhenish. But tell us,do you hear whether Antonio have had any loss at sea orno?	SALERIO: There's a greater difference between your flesh and hers than between coal and ivory, and a greater difference between your blood and hers than between red and white wine. But tell us, have you heard whether Antonio has suffered any losses at sea or not?

SHYLOCK There I have another bad match!— a bankrupt, a prodigal who dare scarce show his head on the Rialto, a beggar that was used to come so smug upon the mart. Let him look to his bond. He was wont to call me usurer; let him look to his bond. He was wont to lend money for a Christian courtesy; let him look to his bond.	SHYLOCK: With him I have more bad luck! He is a bankrupt, reckless with money, and he doesn't dare show his head in the Rialto. He is a beggar who used to be smug in the market. Let him pay attention to his obligations. He used to always insult me for charging interest; well, let him pay attention to his obligations. He used to lend money as a Christian favor; let him pay attention to his obligations.
SALERIO Why, I am sure, if he forfeit thou wilt not take his flesh.What's that good for?	SALERIO: Well, I'm sure that if he doesn't pay you back you won't actually take his flesh. What would that be good for?
SHYLOCK To bait fish withal. If it will feed nothing else, it will feed my revenge. He hath disgraced me and hindered me half a million, laughed at my losses, mocked at my gains, scorned my nation, thwarted my bargains, cooled my friends, heated mine enemies—and what's his reason? Iam a Jew. Hath not a Jew eyes? Hath not a Jew hands, organs, dimensions, senses, affections, passions? Fed with the same food, hurt with the same weapons, subject to the same diseases, healed by the same means, warmed and cooled by the same winter and summer as a Christian is? If you prick us, do we not bleed? If you tickle us, do we not laugh? If you poison us, do we not die? And if you wrong us, shall we not revenge? If we are like you in the rest, we will resemble you in that. If a Jew wrong a Christian, what is his humility? Revenge. If a Christian wrong a Jew, what should his sufferance be by Christian example? Why, revenge. The villainy you teach me I will execute—and it shall go hard but I will betterthe instruction.	SHYLOCK: I could use it as bait for fish. If it will feed nothing else, it will at least feed my revenge. Half a million times he has disgraced me and hindered me. He has laughed at my losses, mocked my profits, scorned my people, messed with my business deals, turned my friends against me, and encouraged my enemies. And what's his reason for all this? I am a Jew. Does a Jew not have eyes? Does a Jew not have hands, organs, senses, affections, passions? Are we not fed with the same food, hurt by the same weapons, affected by the same diseases, healed by the same medicines, warmed and cooled by the same winter and summer as Christians? If you stab us, do we not bleed? If you tickle us, do we not laugh? If you poison us, do we not die? And if you wrong us, should we not take revenge? If we are like you in all the other ways, we will resemble you in terms of revenge, too. If a Jew wrongs a Christian, what does he do? He takes revenge. If a Christian wrongs a Jew, what should the Jew do, following the Christian example?

Why thou, loss upon loss! The thief gone with so much, and so much to find the thief—and no satisfaction, no revenge. Nor no ill luck stirring but what lights o' my shoulders, nosighs but o' my breathing, no tears but o' my shedding.	There's no news of them? All right, then. And I don't even know how much I'm spending to search for them. Loss on top of loss! The thief took so much, and now it takes even more money to find the thief. And still I have no satisfaction, and can find no revenge. No one f eels bad luck, remorse, or grief as much as I do now.
TUBAL Yes, other men have ill luck too. Antonio, as I heard in Genoa—	TUBAL: Other men have bad luck, too. I heard in Genoa that Antonio—
SHYLOCK What, what, what? Ill luck, ill luck?	SHYLOCK: What, what, what? He's had some bad luck? Bad luck?
TUBAL Hath an argosy cast away coming from Tripolis.	TUBAL: Antonio has lost a ship coming from Tripoli.
SHYLOCK I thank God, I thank God! Is 't true, is 't true?	SHYLOCK: I thank God, I thank God! Is it true? Is it true?
TUBAL I spoke with some of the sailors that escaped the wrack.	TUBAL: I spoke with some of the sailors that escaped the shipwreck.
SHYLOCK I thank thee, good Tubal. Good news, good news! Ha, ha, heard in Genoa.	SHYLOCK: Thank you, good Tubal. Good news, good news! Ha ha, good news heard in Genoa.
TUBAL Your daughter spent in Genoa, as I heard, in one nightfourscore ducats.	TUBAL: As I heard, your daughter spent eighty ducats in one night in Genoa.
SHYLOCK Thou stickest a dagger in me. I shall never see my goldagain. Fourscore ducats at a sitting! Fourscore ducats!	SHYLOCK You stick a knife in my heart. I will never see my gold again. Eighty ducats in one sitting! Eighty ducats!

MATHEMATICS

1. Function, Limit and Continuity

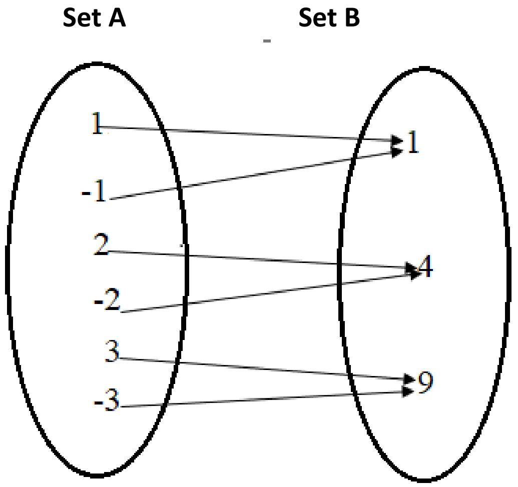
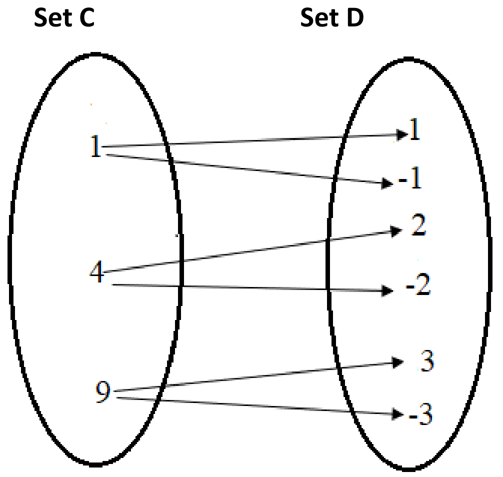
- Express the definition of function.
- State the definition of limits.
- Examine the existence of limits of given functions.
- Evaluate limit value of algebraic and trigonometric functions.
- Apply the concept of limit to test the continuity of function.

Introduction

Calculus originally known as infinitesimal Calculus is a branch of mathematics which focus on limits, continuity, derivatives, integral and infinite series. The theory on modern Calculus was developed by Isaac Newton and Wilhelm Leibnz in 17th century. However, the elements of Calculus appeared earlier in ancient Greece then in China and Middle east, and still later in Medieval Europe and India.

Functions:

Consider the following examples.

Example 1	Example 2
	

In example 1, a number in set A is connected with it's square number in set B. As the result of this relation, we obtain the set of ordered pairs as P={(1, 1),(-1, 1),(2, 4),(-2, 4),(3, 9),(-3, 9)}.
In example 2, a number in set C is connected with it's square root number in set D. As the result of this relation, we obtain the set of ordered pairs as Q={(1, 1),(1, -1),(4, 2),(4, -2),(9, 3),(9, -3)}.
Observing the difference between the diagrams of two examples, we can notice that in example1, only one arrow starts from every element thus resulting a set of ordered pairs in which no two or

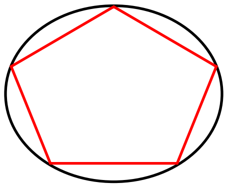
more ordered pairs have same first component whereas in example 2, more than one arrow starts from set C thus, resulting in a set of ordered pairs in which more than one ordered pair have the same first component such as (1, 1), (1, -1). Hence, a set of ordered pair in which no two ordered pair have same first component is called function. Therefore example 1 is a function whereas example 2 is not a function.

Keynote: A special relationship where each input has a single output is known as function and functions are denoted as f(x). Thus, example 1 can be denoted as $f(x)=x^2$.

Limits:

Let us study the example below to understand the meaning of limit

Consider that the regular polygon is inscribed in a circle of given radius as shown in figure below;



We notice following points from geometry;

a) The area of polygon cannot be greater than area of circle however large the number of sides.
b) As the number of sides of polygon increases indefinitely, the area of polygon continually approaches the area of circle.
c) Ultimately the difference between area of circle and the area of polygon can be made as small as possible by sufficiently increasing the number of sides of polygon. This can be expressed as limit of area of polygon inscribed in a circle is the area of circle as sides increases indefinitely (approaches infinity) and is denoted as

$$\lim_{sides \to \infty} area\ of\ polygon = area\ of\ circle$$

Definition of limits

- ✓ Limit is the value of *f(x)* as the function approaches near a certain value of x.
- ✓ The limit of a function as x approaches a real number a from the left is written as: $\lim_{x \to a^-} f(x)$ and is known as left hand limit
- ✓ The limit of a function as x approaches a real number a from the right is written as: $\lim_{x \to a^+} f(x)$ and is known as right hand limit.

Meaning of $x \to a$

Let *x* be the variable and *a* be a constant. Since *x* is a variable, we can change its values as we want. It can be so changed that its value comes nearer and nearer to *a*. Then we say that *x* approaches *a* and express it by notation $\boldsymbol{x \to a}$.

Let us see the example below to understand the meaning of $\boldsymbol{x \to a}$

Consider the function $y = f(x) = \dfrac{x^2 - 1}{x - 1}$.

Let us work it out for x=1, there will be two cases as below;

i. Right hand limit $x \to 1^+$, i.e. when x approaches 1 through values greater than 1

ii. Left hand limit $x \to 1^-$, i.e. when x approaches 1 through values less than 1

When x approaches 1 through values more than 1 ($x \to 1+$)

X	$f(x) = \dfrac{x^2 - 1}{x - 1}$
1.5	2.50000
1.1	2.10000
1.01	2.01000
1.001	2.00100
1.0001	2.00010
1.00001	2.00001
…	….

When x approaches 1 through values less than 1 ($x \to 1^-$)

x	$f(x) = \dfrac{x^2 - 1}{x - 1}$
0.5	1.50000
0.9	1.90000
0.99	1.99000
0.999	1.99900
0.9999	1.99990
0.99999	1.99999
…	….

Thus, as x approaches 1, from the above tables we noticed that $f(x) = \dfrac{x^2 - 1}{x - 1}$ approaches 2.

Therefore, we say that the limit of $\frac{x^2-1}{x-1}$ as x approaches 1 is 2 and it is written as:

$$\lim_{x \to 1} \frac{x^2 - 1}{x - 1} = 2$$

Keynote: *A function will have a limiting value only if its right-hand limit equals its left-hand limit*

Working rule for finding the left- and right-hand limits	Example 1
1. To find the left-hand limit as $x \to a$ i. Put $x = a - h$ in f(x) ii. Take the limit of $f(a - h)$ as $h \to 0$ $\lim_{x \to a^-} f(x) = \lim_{h \to 0} f(a - h)$	If $f(x) = \frac{x^2-9}{x-3}$, find if $\lim_{x \to 3} f(x)$ exists $= \text{L.H.L} = \lim_{x \to 3^-} \left(\frac{x^2-9}{x-3}\right)$ $= \lim_{h \to 0} \left(\frac{(3-h)^2 - 9}{(3-h) - 3}\right)$ $= \lim_{h \to 0} \left(\frac{h^2 - 6h}{-h}\right)$ $= \lim_{h \to 0} \frac{h - 6}{-1} = 6$
2. To find the right-hand limit as $x \to a$ i. Put $x = a + h$ in f(x) ii. Take the limit of $f(a + h)$ as $h \to 0$ $\lim_{x \to a^-} f(x) = \lim_{h \to 0} f(a + h)$	$= \text{R.H.L} = \lim_{x \to 3^+} \left(\frac{x^2-9}{x-3}\right)$ $= \lim_{h \to 0} \left(\frac{(3+h)^2 - 9}{(3+h) - 3}\right)$ $\lim_{h \to 0} \left(\frac{h^2 + 6h}{h}\right)$ $= \lim_{h \to 0} \frac{h + 6}{1} = 6$
If $\lim_{x \to a^-} f(x) = \lim_{x \to a^+} f(x)$, then limit exists.	Since, L.H.L. = R.H.L = 6 The limit exists

Example 2: Does $\lim_{x \to \frac{1}{2}} f(x)$ *exist if* $f(x) = \begin{cases} x, & \text{if } 0 \le x < \frac{1}{2} \\ 0, & \text{if } x = \frac{1}{2} \\ x - 1, & \text{if } \frac{1}{2} < x \le 1 \end{cases}$?

Solution:

$$\text{R.H.L} = \lim_{x \to \frac{1}{2}^+} f(x) = \lim_{x \to \frac{1}{2}^+} (x-1) \qquad \left[\text{since } f(x) \text{ is defined as } x-1 \ for\ x > \frac{1}{2}\right]$$

Substitute $x = \frac{1}{2} + h$, then $h \to 0$ as $x \to \frac{1^+}{2}$

$$= \lim_{h \to 0}\left(\frac{1}{2} + h - 1\right) = \lim_{h \to 0}\left(h - \frac{1}{2}\right) = 0 - \frac{1}{2} = -\frac{1}{2}$$

$$\text{L.H.L} = \lim_{x \to \frac{1}{2}^-} f(x) = \lim_{x \to \frac{1}{2}^-} x \qquad \left[\because f(x) \text{ is defined as } x \ for\ x < \frac{1}{2}\right]$$

Substitute $x = \frac{1}{2} - h$, then $h \to 0$ as $x \to \frac{1^-}{2}$

$$= \lim_{h \to 0}\left(\frac{1}{2} - h\right) = \frac{1}{2} - 0 = \frac{1}{2}$$

since R.H.L $\neq$ L.H.L, $\therefore \lim_{x \to \frac{1}{2}} f(x)$ does not exist.

ACTIVITY 1

1. Show that $\lim_{x \to 1} \dfrac{x^2 - 1}{x - 1}$ exist.

2. Does $\lim_{x \to 0} f(x)$ $exist$ if $f(x) = \begin{cases} x, & if\ x < 0 \\ 0, & if\ x = 0 \\ x-1, & if\ x > 0 \end{cases}$?

Algebraic Limits

Algebraic limits are those functions which are not trigonometric, inverse trigonometric, exponential and logarithmic functions. we generally have five methods to evaluate the values of algebraic limits but we will look into four methods of evaluating the algebraic limits in this package.

Table below consists of different methods of evaluating algebraic limits with a respective example. Study and analyse the table below to get the clear idea on different methods of finding the value of algebraic limits.

Methods	Examples	Solutions
Direct substitution	$\lim_{x\to1}[(x-1)^2+5]$	$\lim_{x\to1}[(x-1)^2+5]$ $=\lim_{x\to1}(1-1)^2+\lim_{x\to1}5$ $=0+5=5$ *Note: Directly substitute the value in the given expression. If we get a finite number, then that number is the limit of the expression. If you get a value in form of $\frac{2}{0},\frac{0}{0}$ or some undefined form, you have to evaluate the limit using following three methods.*
Factorization	$\lim_{x\to1}\frac{x^2-1}{x-1}$	$\lim_{x\to1}\frac{x^2-1}{x-1}$ $=\lim_{x\to1}\frac{(x+1)(x-1)}{x-1}$ $=\lim_{x\to1}(x+1)=1+1=2$ Note: You have to factorize either numerator denominator depending on given functions to simplify.
Form $\frac{x^n-a^n}{x-a}$	$\lim_{x\to2}\frac{x^5-32}{x^2-4}$	Using $\lim_{x\to a}\frac{x^n-a^n}{x-a}=na^{n-1}$ $\lim_{x\to2}\frac{x^5-32}{x^2-4}=\frac{x^5-2^5}{x^2-2^2}$ $=\lim_{x\to2}\frac{1}{x+2}.\frac{x^5-2^5}{x-2}$ $=\lim_{x\to2}\frac{1}{x+2}.\lim_{x\to2}\frac{x^5-2^5}{x-2}$ $=\frac{1}{2+2}\times5\times2^{5-1}=\frac{1}{4}\times5\times16=20$
Rationalisation	$\lim_{x\to0}\frac{\sqrt{(1+x)}-\sqrt{(1+}}{x}$	$\lim_{x\to0}\frac{\sqrt{(1+x)}-\sqrt{(1+x^2)}}{x}$ $\lim_{x\to0}\frac{\sqrt{(1+x)}-\sqrt{(1+x^2)}}{x}X\frac{\sqrt{(1+x)}+\sqrt{(1+x^2)}}{\sqrt{(1+x)}+\sqrt{(1+x^2)}}$ $=\lim_{x\to0}\frac{(1+x)-(1+x^2)}{x\left[\sqrt{(1+x)}+\sqrt{(1+x^2)}\right]}$ $=\lim_{x\to0}\frac{x(1-x)}{x\left[\sqrt{(1+x)}+\sqrt{(1+x^2)}\right]}$ $=\lim_{x\to0}\frac{1-x}{\sqrt{(1+x)}+\sqrt{(1+x^2)}}$ $=\frac{1-0}{\sqrt{(1+0)}+\sqrt{(1+0)}}=\frac{1}{1+1}=\frac{1}{2}$

		Note: we use this method to remove square roots. Remember to multiply and divide by the conjugate of given radical. *Conjugates is formed by changing the sign between the binomials. Example conjugate of x+y is x-y and vice versa.* *For the above example, the radical is* $\sqrt{(1+x)} - \sqrt{(1+x^2)}$, *so we multiplied and divided the given function with the conjugate* $\sqrt{(1+x)} + \sqrt{(1+x^2)}$ *to remove square roots.*

Trigonometric limits

Trigonometric limits are those limits which contains trigonometric functions.

Standard results:

$$\lim_{x\to 0} \sin x = 0 \qquad \lim_{x\to 0} \cos x = 1 \qquad \lim_{x\to 0} \frac{\sin x}{x} = 1 \qquad \lim_{x\to 0} \frac{\tan x}{x} = 1$$

We will use above standard results to evaluate the trigonometric limits. Let us look at few examples to get the concept on evaluating trigonometric limits.

Examples: Evaluate the following limits

1. $\lim_{x\to 0} \frac{\sin 5x}{x}$

Solution:

$\lim_{x\to 0} \frac{\sin(5x)}{x} \times \frac{5}{5}$……………………………make coefficient of x same

$$\lim_{x\to 0} \frac{\sin(5x)}{5x} \times 5$$

Let y = 5x

$\lim_{y\to 0} \frac{\sin y}{y} \times 5 = 1 \times 5 = 5$ …………………using the result $\lim_{x\to 0} \frac{\sin x}{x} = 1$

2. $\lim_{x\to 0} \frac{\tan \frac{1}{2}x}{3x}$

$\lim_{x\to 0} \frac{\tan \frac{1}{2}x}{3x} \times \frac{\frac{1}{6}}{\frac{1}{6}}$..............[*make coefficient of x same*]

Solution:

$\lim_{x\to 0} \frac{\tan \frac{1}{2}x}{\frac{1}{2}x} \times \frac{1}{6} = \frac{1}{6} \times 1 = \frac{1}{6}$..........[using the result $\lim_{x\to 0} \frac{\tan x}{x} = 1$]

ACTIVITY 2

1. Evaluate the following limits.

i. $\lim_{x\to 0} 7x^2 - 5x + 1$

ii. $\lim_{x\to 2} \frac{x^2-4}{x-2}$

iii. $\lim_{x\to 0} \frac{\sqrt{1+x}-\sqrt{1-x}}{2x}$

iv. $\lim_{x\to 3} \frac{x^5-243}{x^2-9}$

v. $\lim_{x\to 0} \frac{\sin 2x}{x}$

Continuity of functions

A function *y=f(x)* is said to be continuous at a point, if the graph of the function is continuous, i.e. unbroken on both side of the point and closed to it including the point itself.

Conditions of continuity

A function f(x) is said to be continuous at x=a, if it satisfies the following conditions:

i. f(a) is defined

ii. $\lim_{x\to a} f(x)$ exists

iii. $\lim_{x\to a} f(x)$=f(a)

Keynote: If any of the above-mentioned condition is not met, then the function is not continuous at $x=a$.

Let us look into examples below to examine the continuity of function

Example 1: A function is defined as $f(x) = x\sin\left(\frac{1}{x}\right), x \neq 0$ *and* $f(0) = 0$, show that it is continuous at $x=0$.

Solution:

Given

a=0,

f(a) = f (0) =0

L.H.L.= $\lim_{x\to 0^-} f(x) = \lim_{x\to 0^-} x\sin\left(\frac{1}{x}\right)$

$$= \lim_{h\to 0}(0-h)\sin\left(\frac{1}{0-h}\right) = \lim_{h\to 0} -h\, sin\frac{1}{-h} = 0$$

R.H.L. $= \lim_{x\to 0^+} f(x) = \lim_{x\to 0^+} x\sin\left(\frac{1}{x}\right)$

$$= \lim_{h\to 0}(0+h)\sin\left(\frac{1}{0+h}\right) = \lim_{h\to 0} h\, sin\frac{1}{h} = 0$$

L.H.L.=R.H.L.=0, limit exist

Therefore $\lim_{x\to 0} f(x) = f(0) = 0$

Hence the function is continuous at *x=0.*

Example 2: If $f(x)=\begin{cases} x-1; & 1\le x<2 \\ 2x-3; & 2\le x<3 \end{cases}$, Find whether *f(x)* is continuous at *x=2.*

Solution;

Given; a=2

$f(a)=f(2)=2\times 2-3=1............[\because\ f(x)\ is\ define\ as\ 2x-3\ at\ x=2]$

$R.H.L=\lim_{x\to 2^+} f(x)=\lim_{x\to 2^+} 2x-3$

$sub\ x=2+h,\ then\ h\to 0\ as\ x\to 2^+$

$\lim_{h\to 0} 2(2+h)-3=\lim_{h\to 0} 4+2h-3=\lim_{h\to 0} 1+2h=1+2\times 0=1$

$L.H.L=\lim_{x\to 2^-} f(x)=\lim_{x\to 2^-} x-1$

$sub\ x=2-h,\ then\ h\to 0\ as\ x\to 2^-$

$\lim_{h\to 0} 2-h-1=\lim_{h\to 0} 1-h=1-0=1$

$R.H.L=L.H.L=1, \lim it\ exist$

$Therefore\ \lim_{x\to 2} f(x)=f(2)=1,\ the\ \ function\ is\ continous\ at\ x=2$

Using the conditions of continuity to prove that the function given below is continuous.

i. The function f(x) is defined as $f(x)=\begin{cases} 5x-4, & when\ 0<x\le 1 \\ 4x^3-3x, & when\ 1<x\le 2 \end{cases}$, prove that it is continuous at *x=1*

Summary

- A special relationship where each input has a single output is known as function
- Limit is the value of *f(x)* as the function approaches near a certain value of *x*
- Limit of function exists only if R.H. L=L.H. L

- Algebraic limits are evaluated using various methods such as Direct Substitution, factorization, rationalisation and in the form $\frac{x^n-a^n}{x-a}$, depending on the given algebraic functions
- A function *y=f(x)* is said to be continuous at a point, if the graph of the function is continuous
- A function is not continuous, if it does not meet any of condition.

Self-check for Learning

1. Which of the given set of ordered pairs are the function? Justify your answer.
   A= {(1, 7), (2, 7), (4, 7), (6, 7)}
   B= {(1, 1), (1, 2), (1, 3), (1, 4)}
   C= {(x, y), (y, z), (z, a), (a, b)}

2. Evaluate the following limits
   a). $\lim_{x\to 1}\frac{x-1}{2x^2-7x+5}$
   b) $\lim_{x\to 0}\frac{\tan 2x}{x}$

3. State the conditions of continuity of a function at a particular value of *x*.

2. Differentiation

- Definition of derivative of a function
- Differentiation from first principle.
- The basic results of different functions and rules.
- Derivatives of composite, implicit and parametric functions.
- Successive differentiation upto 2nd order.

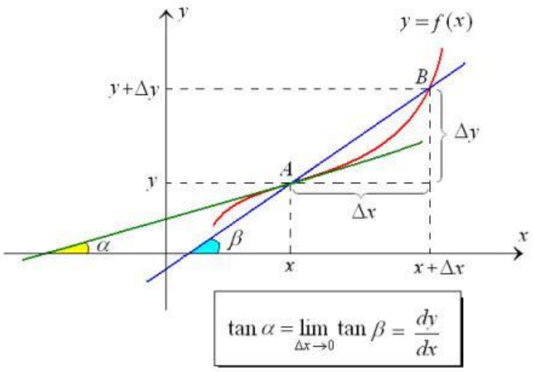
Introduction

The derivative is the exact rate at which one quantity changes with respect to another. The process of finding the derivatives is called as differentiation. Modern differentiation and derivatives are usually credited to "Sir Issac Newton" and "Gottfried Leibniz". They developed the fundamental theorem of calculus in the 17th century. Derivatives have many applications in the real life like to calculate the profit and loss in business using graphs, to check the temperature variation, to determine the speed or distance covered such as miles per hour, kilometre per hour etc. Derivatives are used to derive many equations in Physics and Chemistry.

A small, unspecified, nonzero change in the value of a quantity is called **Increment**. Often it is shown by using the symbol Δ or δ (read as delta). Example: Δx (or δx) means the change in the value of *x*.

Let $y = f(x)$ be a continuous function of *x*, then $\lim_{\delta x \to 0} \frac{\delta y}{\delta x}$ exists ,is called the *differential coefficient* or the *derivative of f(x) with respect to x* and denoted by any one of the following symbols: $\frac{dy}{dx}, \frac{d}{dx}y, Dy, y', f'(x)$ or $\frac{d}{dx}f(x)$.

Let *AB* be the secant line, passing through the points $(x, f(x))$ and $(x+\Delta x, f(x+\Delta x))$. If $B \to A$, that is, Δx approaches zero, then the secant line approaches the tangent line at the point $(x, f(x))$. Accordingly, the slope of the tangent line is the limit of the slope of the secant line when Δx approach zero: Thus, the derivative $f'(x)$ can be interpreted as the slope of the tangent line at the point (x, y) on the graph of the function $y = f(x)$.



The slope of the function at a given point is the slope of the tangent line to the function at that point.

Derivative = $\frac{dy}{dx}$ =Slope of the tangent at P (x, y) = Rate of change

The process of finding the differential coefficient of a function $f(x)$ with respect to x is called ***differentiation.***

Differentiation from ***first principles*** can be defined as $f'(x) = \lim_{\delta x \to 0} \frac{f(x+\delta x)-f(x)}{\delta x}$

Differentiating a function from first principle consists of following steps.

1. Put the function to be differentiated equal to y i.e., $y = f(x)$....... (i)
2. Let δx be an increment in the value of x and δy, the corresponding increment in the value of y so that
   $y + \delta y = f(x + \delta x)$....... (ii)
3. Find δy by subtracting (i) from (ii), we will get $\delta y = f(x + \delta x) - f(x)$... (iii)
4. Find the ratio $\frac{\delta y}{\delta x}$ by dividing both the sides by δx in (iii,) we will get,
   $\frac{\delta y}{\delta x} = \frac{f(x+\delta x)-f(x)}{\delta x}$
5. Take the limits of both sides as $\delta x \to 0$,
   $\lim_{\delta x \to 0} \frac{\delta y}{\delta x} = \lim_{\delta x \to 0} \frac{f(x+\delta x)-f(x)}{\delta x}$,
   $\frac{dy}{dx} = \lim_{\delta x \to 0} \frac{f(x+\delta x)-f(x)}{\delta x}$ this gives the limit definition of derivative of the function.

Example: Differentiate the following functions from first principles:

(i) $y = x^2$ (ii) $f(x) = 2x$

Solution:

(i) $y = f(x) = x^2$

Let δx be an increment in the value of x and δy be the corresponding increment in the value of y

$\therefore y + \delta y = f(x+\delta x) = (x+\delta x)^2$

$\delta y = f(x+\delta x) - y = f(x+\delta x) - f(x) = (x+\delta x)^2 - x^2 = 2x\,\delta x - (\delta x)^2$

Dividing both sides by δx, $\frac{\delta y}{\delta x} = \frac{2x\,\delta x - (\delta x)2}{\delta x} = 2x - \delta x$

Taking limit as $\delta x \to 0$, $\frac{dy}{dx} = \lim_{\delta x \to 0} \frac{\delta y}{\delta x} = 2x - 0 = 2x$.

$\therefore \frac{d(x^2)}{dx} = 2x$

(ii) $f(x)=2x$

$f(x+\delta x)=(2(x+\delta x)$

$f(x+\delta x)-f(x)=(2x+2\delta x)-2x=2\delta x$

Dividing both sides by δx, $\frac{\delta y}{\delta x}=\frac{2\,\delta x}{\delta x}=2$

Taking limit as $\delta x \to 0$, $\frac{dy}{dx}=\lim_{\delta x\to 0}\frac{\delta y}{\delta x}=2$

$\therefore \frac{d(2x)}{dx}=2.$

ACTIVITY 1

1. Differentiate $3x^2$ from first principle:

Rules for differentiating two functions:

Differentiation of two functions can be done by following the rules given below:

Let *u* and *v* be the two functions of *x* whose differential coefficients exist, then

- Rule for differentiating sum or difference of two functions.

$$\frac{d}{dx}(u \pm v)=\frac{du}{dx}\pm\frac{dv}{dx}$$

- Rule for differentiating product of two functions.

$$\frac{d}{dx}(u \times v)=u\frac{dv}{dx}+v\frac{du}{dx}$$

- Rule for differentiating quotient of two functions.

$$\frac{d}{dx}\left(\frac{u}{v}\right)=\frac{v\frac{du}{dx}-u\frac{dv}{dx}}{v^2}$$

- Chain rule: If $y = f(u)$, a function of u and $u = g(x)$, a function of x where f and g are differentiable, then

$$\frac{dy}{dx}=\frac{dy}{du}\times\frac{du}{dx}$$

ACTIVITY 2

1. Differentiation of Algebraic functions.

i. $\frac{d}{dx}x^n = nx^{n-1}$

ii. $\frac{d}{dx}(x) = 1$

iii. $\frac{d}{dx}(ax+b)^n = an(ax+b)^{n-1}$

iv. $\frac{d}{dx}c = 0$

v. $\frac{d}{dx}\sqrt{x} = \frac{1}{2\sqrt{x}}$

Standard Differentiation:

Example 1: Find $\frac{dy}{dx}$ of the following functions

1. $3x^2$

Solution:

Let $y = 3x^2$

Differentiating with respect to x by applying formula

$$\frac{d}{dx}x^n = nx^{n-1}$$

$$\frac{dy}{dx} = 3\frac{d}{dx}x^2 = 3 \times 2x = 6x$$

Example 2:

2. $x^2 - 3x + 5.$

Solution:

Let $y = x^2 - 3x + 5$

$$\frac{dy}{dx} = \frac{d}{dx}x^2 - 3\frac{d}{dx}x + \frac{d}{dx}5$$

$$\frac{dy}{dx} = 2x - 3.$$

Example 3:

3. $(3x-5)^3$

Solution:

Let $y = (3x-5)^3$

$$\frac{d}{dx}(ax+b)^n = an(ax+b)^{n-1}$$

$$\frac{d}{dx}(3x-5)^3 = 3 \times 3(3x-5)^{3-1}$$

$$\frac{dy}{dx} = 9(3x - 5)^2$$

Example 4:

4. $\frac{x}{x+1}$

Solution:

Let $y = \frac{x}{x+1}$

This function can be differentiated applying quotient rule of differentiation.

$$\frac{d}{dx}\left(\frac{u}{v}\right) = \frac{vu' - uv'}{v^2}$$

Let

$u = x$ $\qquad v = x + 1$

$u' = 1$ $\qquad v' = 1$

Applying the *quotient rule of differentiation*

$$\frac{dy}{dx} = \frac{(x+1).1 - x.1}{(x+1)^2}$$

$$\frac{dy}{dx} = \frac{x+1-x}{(x+1)^2}$$

$$\frac{dy}{dx} = \frac{1}{(x+1)^2}$$

ACTIVITY 3

1. Differentiate the following:

(i) $6x^8$ (ii) $x^{\frac{3}{4}}$ (iii) $(3x^2 + 5)^9$ (iv) $\frac{x^3}{3x-2}$

Differentiation of Trigonometric functions:

1. $\frac{d}{dx}\sin x = \cos x$
2. $\frac{d}{dx}\cos x = -\sin x$
3. $\frac{d}{dx}\tan x = \sec^2 x$
4. $\frac{d}{dx}\cot x = -\text{cosec}^2 x$
5. $\frac{d}{dx}\sec x = \sec x \tan x$
6. $\frac{d}{dx}\text{cosec}\, x = -\text{co sec}\, x \cot x$

Example:

Differentiate the following functions with respect to x

$y = \sin\,(x^2 - x + 3)$

Solution:

This function is composite function and it can be differentiated using chain rule.

Let $y = \sin u$ $where\ u = x^2 - x + 3$

$\frac{dy}{du} = \cos u$ and $\frac{du}{dx} = 2x - 1$

$\frac{dy}{dx} = \frac{dy}{du} \times \frac{du}{dx}$

$$\frac{dy}{dx} = \cos u \times (2x - 1)$$

$$\frac{dy}{dx} = (2x - 1)\cos(\,x^2 - x + 3)$$

ACTIVITY 4

1. Differentiate.

   i. Sin (x^2) (ii) cot $(\sin\sqrt{x})$ (iii) $\frac{\cos x - \sin x}{\cos x + \sin x}$

Differentiation of logarithmic and exponential function:

1. $\frac{d}{dx}\log_a x = \frac{1}{x\log_e a}$
2. $\frac{d}{dx}\log x = \frac{1}{x}$
3. $\frac{d}{dx}a^x = a^x \log_e a$, where $a \in R$
4. $\frac{d}{dx}e^x = e^x$

Example:

If $y = e^{x^2}$, find $\frac{dy}{dx}$

Solution:

Let $y = e^u$ and $u = x^2$

$\frac{dy}{du} = e^u$ and $\frac{du}{dx} = 2x$

$$\frac{dy}{dx} = \frac{dy}{du} \times \frac{du}{dx}$$

$$\frac{dy}{dx} = e^u \times 2x$$

$\frac{dy}{dx} = e^u \times 2x$ $\therefore \frac{dy}{dx} = 2xe^{x^2}$

ACTIVITY 5

1. Differentiate w.r.t x.

i. $\log(\cos x)$ (ii) $\log\sqrt{\frac{x-1}{x+1}}$ (iii) $5^{\log(\sin x)}$ (iv) $\frac{e^x-e^{-x}}{e^x+e^{-x}}$

Differentiation of inverse trigonometric function:

1. $y = \sin^{-1} x; \frac{dy}{dx} = \frac{1}{\sqrt{1-x^2}}$
2. $y = \cos^{-1} x; \frac{dy}{dx} = \frac{-1}{\sqrt{1-x^2}}$
3. $y = \tan^{-1} x; \frac{dy}{dx} = \frac{1}{1+x^2}$
4. $y = \cot^{-1} x; \frac{dy}{dx} = \frac{-1}{1+x^2}$
5. $y = \sec^{-1} x; \frac{dy}{dx} = \frac{1}{|x|\sqrt{x^2-1}}$
6. $y = \operatorname{cosec}^{-1} x; \frac{dy}{dx} = \frac{-1}{|x|\sqrt{x^2-1}}$

Example 1:

Find $\frac{dy}{dx}$ if $y = \sin^{-1}\frac{x}{a}$

Solution:

Applying chain rule;

$$\frac{dy}{dx} = \frac{d}{dx}\sin^{-1}\left(\frac{x}{a}\right)\frac{d}{dx}\left(\frac{x}{a}\right)$$

$$\frac{dy}{dx} = \frac{1}{\sqrt{1-\frac{x^2}{a^2}}} \times \frac{1}{a}$$

$$\frac{dy}{dx} = \frac{a}{\sqrt{a^2-x^2}} \times \frac{1}{a}$$

$$\frac{dy}{dx} = \frac{1}{\sqrt{a^2-x^2}}$$

Example 2:

Differentiate: $\tan^{-1}\left(\frac{2x}{1-x^2}\right)$

Solution:

Sometimes a substitution facilitates differentiation.

Let $y = \tan^{-1}\left(\frac{2x}{1-x^2}\right)$. Put $x = \tan\theta$ so that $\theta = \tan^{-1}x$.

$y = \tan^{-1}\left(\frac{2\tan\theta}{1-\tan^2\theta}\right) = \tan^{-1}(\tan 2\theta) = 2\theta = 2\tan^{-1}x.$

$$\therefore \frac{dy}{dx} = 2 \times \frac{1}{1+x^2} = \frac{2}{1+x^2}$$

ACTIVITY 6

1. Differentiate w.r.t x:

(i) $\sin^{-1}(3x)$ (ii) $\sin(\tan^{-1}x)$ (iii) $\tan^{-1}\frac{1-\cos x}{\sin x}$ (iv) $\sin^{-1}\sqrt{\frac{1-\cos 2x}{2}}$

Differentiation of implicit function:

A function or relation in which the dependent variable is not isolated on one side of the equation. For example, the equations $x^3 + xy - y^3 = 1$ and $e^{x-y} = \log\left(\frac{x}{y}\right)$ represent implicit relation.

A function in which the dependent variable can be written explicitly in terms of the independent variable.

For example, the following are explicit functions: $y = x^2 - 3$ and $y = \log(\sin x)$

While differentiating an implicit function, take derivative of all the terms. When you take derivative of y term you must multiply by $\frac{dy}{dx}$.

Example 1:

Find $\frac{dy}{dx}$, if $\sqrt{x} + \sqrt{y} = 5$

Solution:

$$\frac{d}{dx}\sqrt{x} + \frac{d}{dx}\sqrt{y} = \frac{d}{dx}5$$

$$\frac{1}{2\sqrt{x}} + \frac{1}{2\sqrt{y}}\frac{dy}{dx} = 0$$

$$\frac{1}{2\sqrt{y}}\frac{dy}{dx} = -\frac{1}{2\sqrt{x}}$$

$$\frac{dy}{dx} = -\frac{1}{2\sqrt{x}} \times \frac{2\sqrt{y}}{1}$$

$$\frac{dy}{dx} = -\sqrt{\frac{y}{x}}$$

Example 2:

Find $\frac{dy}{dx}$ in $x^3 + 8xy + y^3 = 64$

Solution:

$x^3 + 8xy + y^3 = 64$

Differentiating implicitly with respect to x, we get

$\frac{d}{dx}(x^3) + \frac{d}{dx}(8xy) + \frac{d}{dx}(y^3) = \frac{d}{dx}(64)$.... (i)

$\frac{d}{dx}(x^3) = 3x^2,$

Using product rule: $\frac{d}{dx}(8xy) = 8\left(x\frac{dy}{dx} + y\frac{d}{dx}x\right) = 8\left(x\frac{dy}{dx} + y \times 1\right) = 8x\frac{dy}{dx} + 8y$

$\frac{d}{dx}(y^3) = \frac{d}{dy}(y^3) \times \frac{dy}{dx} = 3y^2\frac{dy}{dx}, \quad \frac{d}{dx}(64) = 0$

Substituting these values in (i)

$3x^2 + 8x\frac{dy}{dx} + 8y + 3y^2\frac{dy}{dx} = 0$

$8x\frac{dy}{dx} + 3y^2\frac{dy}{dx} = -3x^2 - 8y$

$\frac{dy}{dx}(8x + 3y^2) = -(3x^2 + 8y)$

$\frac{dy}{dx} = -\frac{(3x^2 + 8y)}{(8x + 3y^2)}$

ACTIVITY 7

1. Find $\frac{dy}{dx}$ if

(i) $x^2 + y^2 = a^2$ (ii) $2x^2 - xy + y^2 + 3y - 4 = 0$

Differentiation a function with respect to another function:

If $u = f(x)$ and $v = g(x)$ are the given two functions, then to differentiate $f(x)$ with respect to $g(x)$, that is to find $\frac{du}{dv}$, find $\frac{du}{dx}$ and $\frac{dv}{dx}$ and use the result $\frac{du}{dv} = \frac{du}{dx} / \frac{dv}{dx}$

Example:

Differentiate $x^2 - 2x + 5$ with respect to $(3 + x^2)$

Solution:

Let $u = x^2 - 2x + 5$ and $v = (3 + x^2)$

$\frac{du}{dx} = 2x - 2 = 2(x - 1) \quad \frac{dv}{dx} = 2x$

$$\frac{du}{dv} = \frac{\frac{du}{dx}}{\frac{dv}{dx}} = \frac{2(x-1)}{2x} = \frac{(x-1)}{x}$$

ACTIVITY 8

1. Differentiate:

(i) $\sin x^3$ w.r.t x^3 (ii) $x^3 - x^2 - x + 1$ with respect to $3x^2 - x + 2$

Differentiation of a parametric functions:

Two functions are said to be parametric functions if they are related to each other by a third variable called parameter. If x and y are functions of a third variable t (parameter), then

$$\frac{dy}{dx} = \frac{dy}{dt} \Big/ \frac{dx}{dt}$$

Example:

If $x = \frac{1}{t}$ and $y = t^2 - 1$ find $\frac{dy}{dx}$

Solution:

$\frac{dx}{dt} = -\frac{1}{t^2}$ $\quad \frac{dy}{dt} = 2t$

$$\frac{dy}{dx} = \frac{dy}{dt} \Big/ \frac{dx}{dt} = \frac{dy}{dt} \times \frac{dt}{dx}$$

$\frac{dy}{dx} = \frac{2t}{-\frac{1}{t^2}} = 2t \times -t^2$

$$\frac{dy}{dx} = -2t^3$$

ACTIVITY 9

1. Find $\frac{dy}{dx}$:

   i. if $x = at^2$ and $y = 2at$ ii. If $x = a(\theta + \sin\theta), y = a(1 - \cos\theta)$

Second derivative of a function

If $\boldsymbol{y = f(x)}$, $\boldsymbol{\frac{dy}{dx}}$ is the first derivative of the function. The second derivative of the function is obtained by finding the derivative of first derivative of the function i.e.,

$$\frac{d^2y}{dx^2} = \frac{d}{dx}\left(\frac{dy}{dx}\right).$$

Example 1:

If $y = 2x^2 - 5x + 6$, Find $\frac{d^2y}{dx^2}$

Solution:

$y = 2x^2 - 5x + 6.$

Differentiating w.r.t x, $\frac{dy}{dx} = 4x - 5.$

Differentiating once againw.r.t x, $\quad \frac{d^2y}{dx^2} = \frac{d}{dx}\left(\frac{dy}{dx}\right) \qquad \therefore \frac{d^2y}{dx^2} = 4$

Example 2:

Find the second derivative e^{kx}.

Solution:

Let $y = e^{kx}$

Differentiating w.r.t. x, $\frac{dy}{dx} = \frac{d}{dx}e^{kx}.\frac{d}{dx}(kx) = e^{kx}.k = ke^{kx}$

Differentiating once againw.r.t. x,

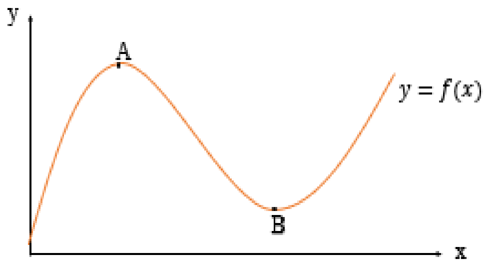
$\frac{d^2y}{dx^2} = \frac{d}{dx}\left(\frac{dy}{dx}\right) = \frac{d}{dx}ke^{kx}.\frac{d}{dx}(kx) = k\,e^{kx}.k = k^2e^{kx}$ $\quad\therefore \frac{d^2y}{dx^2} = k^2e^{kx}$

ACTIVITY 10

1. Find the second derivative of the following:
   (i) $\log x$ (ii) $e^x + \sin x$

Maximum and Minimum point of a function:

- A and B are called turning points, because at these points the slope of the function is zero $\left(\text{i. e.}, \frac{dy}{dx} = 0\right)$.
- Point A is maximum point of the function because at this point the second derivative of the function is negative $\left(\frac{d^2y}{dx^2} < 0\right)$.
- Point B is minimum point of the function because at this point the second derivative of the function is positive $\left(\frac{d^2y}{dx^2} > 0\right)$.



For a ***maximum point***: $\frac{dy}{dx} = 0$ and $\frac{d^2y}{dx^2} < 0$.

For a ***minimum point***: $\frac{dy}{dx} = 0$ and $\frac{d^2y}{dx^2} > 0$.

For a ***point of inflexion***: $\frac{dy}{dx} = 0$, $\frac{d^2y}{dx^2} = 0$ and, $\frac{d^3y}{dx^3} \neq 0$

Example:

Find the turning points on the curve $y = 2x^3 - 21x^2 + 36x - 20$ and distinguish between them.

Solution:

$\frac{dy}{dx} = 6x^2 - 42x + 36 \quad \frac{d^2y}{dx^2} = 12x - 42$

At turning point $\frac{dy}{dx} = 0$;

$6x^2 - 42x + 36 = 0$

$6(x^2 - 7x + 6) = 0$

$6\,(x^2 - 6x - 1x + 6) = 0$

$6(x-6)(x-1) = 0$

$x = 6$ and $x = 1$

The function has turning points at $x = 1$ and $x = 6$

Now let us calculate the value of second derivatives at these points;

$\frac{d^2y}{dx^2}$ at $x = 1 = 12(1) - 42 = -30$

Since $\frac{d^2y}{dx^2} < 0$, the function has maximum point at $x = 1$

$\frac{d^2y}{dx^2}$ at $x = 6 = 12(6) - 42 = 30$

Since $\frac{d^2y}{dx^2} > 0$, the function has minimum point at $x = 6$

Maximum or minimum value of the function is found by substituting the x value in y.

∴ Maximum value (the value of y at $x = 1$) = 2 – 21 +36 – 20 = −3.

∴ Minimum value (the value of y at $x = 6$) = 432 – 756 +216 – 20 = −128.

∴ $(1, -3)$ is the maximum point and $(6, -128)$ is the minimum point.

Summary

- Derivative = $\frac{dy}{dx}$ =Slope of the tangent at P (x, y) = Rate of change
- Differentiation from ***first principles*** can be defined as $f'(x) = \lim_{\delta x \to 0} \frac{f(x+\delta x) - f(x)}{\delta x}$
- Sum or difference rule: $\frac{d}{dx}(u \pm v) = \frac{du}{dx} \pm \frac{dv}{dx}$
- Product rule: $\frac{d}{dx}(u \times v) = u\frac{dv}{dx} + v\frac{du}{dx}$
- Quotient rule: $\frac{d}{dx}\left(\frac{u}{v}\right) = \frac{v\frac{du}{dx} - u\frac{dv}{dx}}{v^2}$
- Chain Rule: $\frac{dy}{dx} = \frac{dy}{du} \times \frac{du}{dx}$
- If $u = f(x)$ and $v = g(x)$ are the given two functions, then $\frac{du}{dv} = \frac{du}{dx} / \frac{dv}{dx}$
- If x and y are functions of a third variable t (parameter), then $\frac{dy}{dx} = \frac{dy}{dt} / \frac{dx}{dt}$
- $\frac{d^2y}{dx^2} = \frac{d}{dx}\left(\frac{dy}{dx}\right)$.
- For a *maximum point*: $\frac{dy}{dx} = 0$ and $\frac{d^2y}{dx^2} < 0$.
- For a *minimum point*: $\frac{dy}{dx} = 0$ and $\frac{d^2y}{dx^2} > 0$.
- For a *point of inflexion*: $\frac{dy}{dx} = 0$, $\frac{d^2y}{dx^2} = 0$ and, $\frac{d^3y}{dx^3} \neq 0$

Self-check for Learning

1. Find the gradient for the function $y = 4x^2 - 3x + 5$.
2. If $y = \tan^{-1}(\sec x + \tan x)$, Find $\frac{dy}{dx}$.
3. Differentiate the function log sec *x* with respect to tan *x*.
4. Find $\frac{d^2y}{dx^2}$, if $y = \frac{1}{x^2}$.
5. Find coordinates of the turning points on the curve of the function

   $2x^3 + 3x^2 - 12x + 7$.

3. Indefinite Integral

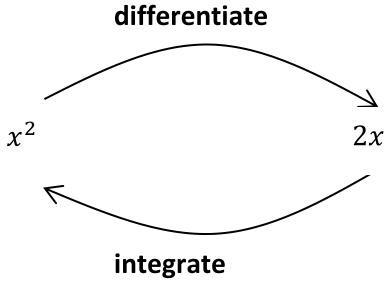
- Define the indefinite integral.
- State the standard forms of integration.
- Evaluate the indefinite integral of different functions.
- Use different methods to evaluate the integration.

Introduction

Discovery of calculus is attributed to two mathematicians, Sir Isaac Newton of England and Gottfried Leibniz of Germany, who independently developed its foundations in 17th century. Newton found that there was no mathematics to describe the increasing speed of the object every split second, which led to his work in calculus. Integral can be used for computing the area of a two – dimensional region that has a curved boundary, as well as computing the volume of a three – dimensional object that has a curved boundary. In physics, integration is used to calculate the centre of mass and centre of gravity. It is also used in engineering and chemistry.

Integral Calculus

Integration is the reverse process of differentiation. Differential calculus is process of finding differential coefficient, given its function. But integral calculus is process of finding a function, given its differential coefficient.



Definition of Integration

Let $f(x)$ be a given function of x. If we can find a function $g(x)$, such that $\frac{d}{dx}[g(x)] = f(x)$, then $g(x)$ is called an integral of $f(x)$. It is denoted by $\int \boldsymbol{f(x)dx = g(x)}$.

Example:

$Let\ f(x) = \cos x$. Since $\frac{d}{dx}[\sin x] = \cos x$, $\sin x$ is an integral of $\cos x$.

Meaning of integration

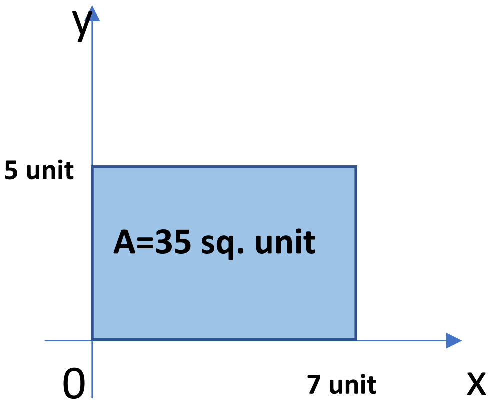


Fig 1

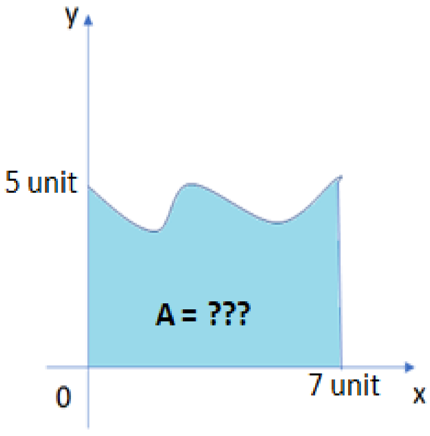


Fig 2

In Fig 1 the area of rectangle is given by formula $Area = lenght \times breadth$. Integration can be used to determine the area under the curve in Fig 2.

Definition of indefinite integral

Let $\frac{d}{dx}[g(x)] = f(x)$.

Then $\frac{d}{dx}[g(x)+c] = \frac{d}{dx}[g(x)] + \frac{d}{dx}(C) = f(x) + 0 = f(x)$.

$\therefore \int f(x)dx = g(x) + c$

The arbitrary constant c is called the constant of integration.

The expression $g(x) + c$ is called indefinite integral because of its indefiniteness (c may have any value).

Variable of integration

Integral

Integral sign → $\int f(x)dx = g(x) + c$

Integrand

Standard forms of integration

This form of integration is applied for algebraic functions.

1. $\int x^n dx = \frac{x^{n+1}}{n+1} + c, n \neq -1$ $\quad \because \frac{d}{dx}\left(\frac{x^{n+1}}{n+1} + c\right) = (n+1)\frac{x^n}{n+1} = x^n$

To find the integral of x^n, add one to the exponent, then divide by the new exponent.

Example

$$\int 3\,x^2 dx = 3.\frac{x^{2+1}}{2+1} + c = 3.\frac{x^3}{3} + c = x^3 + c$$

2.$\int (ax+b)^n dx = \frac{(ax+b)^{n+1}}{a(n+1)} + c, n \neq -1$

Example

3. $\int (2x+3)^3 dx = \frac{(2x+3)^{3+1}}{2(3+1)} + c = \frac{(2x+3)^4}{8} + c$

Note:$\boldsymbol{\int k\, dx = kx + c, where\ k\ is\ arbitary\ constant}$

ACTIVITY 1

1. Integrate the following $w.r.t.x$

i. x^{-3}

ii. $2\,x^{\frac{2}{3}}$

iii. $(5-x)^{23}$

Integral of different functions

1. Trigonometric functions
2. Algebraic and exponential functions
3. Inverse trigonometric functions

Integration of trigonometric functions

i. $\int \sin x\ \ dx = -\cos x + c\,, \because \frac{d}{dx}(-\cos x + c) = \sin x$

ii. $\int \cos x\, dx = \sin x + c\,, \because \frac{d}{dx}(\sin x + c) = \cos x$

iii. $\int \sec^2 x\ \ dx = \tan x + c, \because \frac{d}{dx}(tan\ x + c) = \sec^2 x$

iv. $\int cosec^2 x\, dx = -\cot x + c, \because \frac{d}{dx}(-\cot x + c) = cosec^2 x$

v.$\int \sec x \tan x\, dx = \sec x + c, \because \frac{d}{dx}(\sec x + c) = \sec x \tan x$

vi. $\int cosec\ x \cot x\, dx = -cosec\ x + c, \because \frac{d}{dx}(-cosec\ x + c) = cosec\ x \cot x$

vii. $\int \tan x\ \ dx = \log|\sec x| + c\,, \because \frac{d}{dx}(\log|\sec x| + c) = \tan x$

viii. $\int \cot x\ \ dx = \log|\sin x| + c\,, \because \frac{d}{dx}(\log|\sin x| + c) = \cot x$

ix. $\int \sec x dx = \log|\sec x + \tan x| + c = \log\left|\tan\left(\frac{x}{2} + \frac{\pi}{4}\right)\right| + c$

x.$\int cosec\ x\ dx = \log|cosec\ x - \cot x| + c = \log\left|\tan\frac{x}{2}\right| + c$

xi. $\int \frac{1}{x}\ dx = \ log|x| + c$

xii. $\int e^x dx = e^x + c$

xiii. $\int a^x dx = \dfrac{a^x}{\log_e a} + c$

Remember:

$\int \sin ax\, dx = -\frac{1}{a}\cos ax + c$, where a is coefficient of x

This concept shall apply for all other t – functions.

Example

Evaluate $\int \sec 5x \tan 5x\, dx$

$\int \sec 5x \tan 5x\, dx = \frac{1}{5}\sec 5x + c$

ACTIVITY 2

1. Integrate following function $w.r.t.x$

   i. e^{3x}

   ii. 10^{2x}

   iii. $\frac{5x+7}{x} + e^{2x+5}$

Integration of inverse trigonometric functions

i. $\int \frac{1}{\sqrt{1-x^2}} dx = \sin^{-1} x + c \quad Or \quad -\cos^{-1} x + c$

ii. $\int \frac{1}{1+x^2}\, dx = \tan^{-1} x + c \;\; Or \quad -\cot^{-1} x + c$

iii. $\int \frac{1}{x\sqrt{x^2-1}} dx = \sec^{-1} x + c \quad Or - cosec^{-1} x + c$

iv. $\int \frac{1}{\sqrt{a^2-x^2}} dx = \sin^{-1}\frac{x}{a} + c$

v. $\int \frac{1}{a^2+x^2}\, dx = \frac{1}{a}\tan^{-1}\frac{x}{a} + c$

vi. $\int \frac{1}{x\sqrt{x^2-a^2}} dx = \frac{1}{a}\sec^{-1}\frac{x}{a} + c$

Example:

Evaluate $\int \frac{x^2-1}{x^2+1} dx$

$\int \frac{x^2-1}{x^2+1} dx = \int \frac{x^2+1-2}{x^2+1} dx = \int \left(1 - \frac{2}{x^2+1}\right) dx = x - 2\tan^{-1} x + c$

ACTIVITY 3

1. Evaluate the following integral.

   i. $\int \frac{dx}{\sqrt{25-4x^2}}$ ii. $\int \frac{dx}{16+9x^2}$ iii. $\int \frac{x^2}{4+x^2} dx$

Methods of integration

1.Integration by substitution
2.Integration by parts
3.Integration by using partial fraction

Integration by substitution

It is used when an integral contains some function and its derivatives. It involves change of independent variables. The substitution rule formula is $\int f\big(t(x)\big)t'(x)dx = \int f(t)dt, where\ t = t(x)$. There are two important forms;

1.$\int [f(x)]^n f'(x)dx = \frac{[f(x)]^{n+1}}{n+1} + c, n \neq -1.$

2.$\int \frac{f'(x)}{f(x)} dx = \log|f(x)| + c$

Example

1.Evaluate $\int x \cos x^2 dx$

$let\ t = x^2$

$dt = 2xdx$

$xdx = \frac{dt}{2}$

$\int x \cos x^2 dx = \int \cos x^2\ xdx = \int \cos t \frac{dt}{2} = \int \frac{1}{2} \cos t\ dt = \frac{1}{2} \sin t + c = \frac{1}{2} \sin x^2 + c$

2.Integrate $\int \frac{x^2}{\sqrt{x+1}} dx$

$let\ t^2 = x + 1$

$2tdt = dx$

$\int \frac{x^2}{\sqrt{x+1}} dx = \int \frac{(t^2-1)^2}{t}.2tdt = 2\int (t^4 - 2t^2 + 1)dt = 2\left(\frac{t^5}{5} - 2.\frac{t^3}{3} + t\right) + c$

$= 2t\left(\frac{t^4}{5} - \frac{2}{3}t^2 + 1\right) + c = 2\sqrt{x+1}\left[\frac{(x+1)^2}{5} - \frac{2}{3}(x+1) + 1\right] + c$

ACTIVITY 4

1. Evaluate the following functions:

i.$\int \frac{2x-3}{x^2-3x-1} dx$

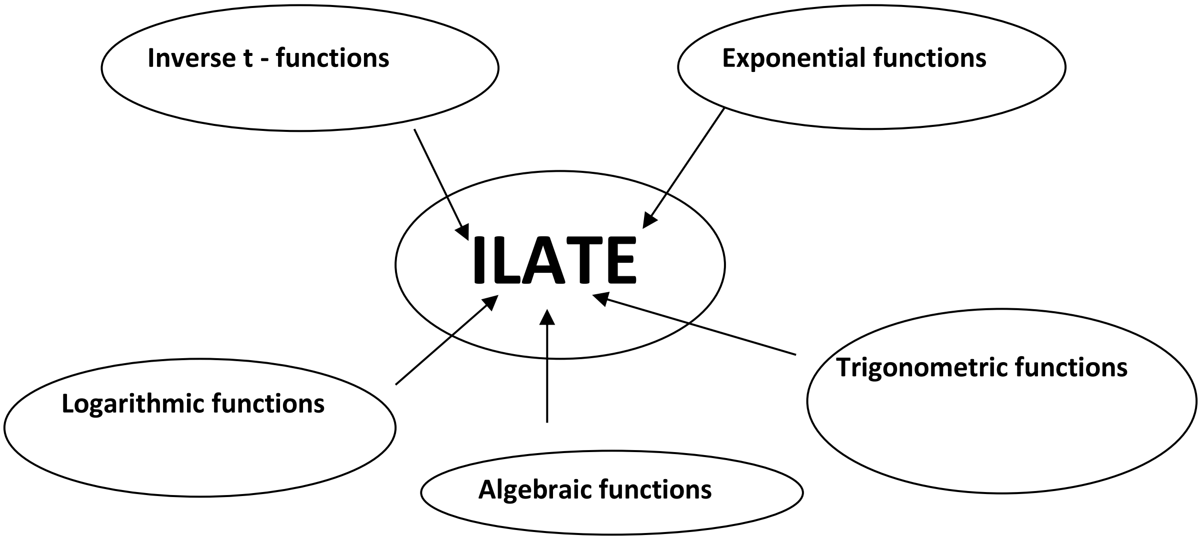
ii.$\int \frac{\tan^{-1} x}{1+x^2}\ dx$

Integration by parts

If u and v are any two differential functions of x, then

$$\int uv\, dx = u \int v\, dx - \int \left\{\frac{d}{dx}(u) \int v\, dx\right\} dx$$

If two functions are of different types, the first function is the one which comes first in the word **ILATE.**



Example:

1. Evaluate $\int x\sec^2 x\,dx$

$first\ function\ (u)\ is\ x, second\ function\ (v)\ is\ \sec^2 x$

$\int uv\,dx = u\int v\,dx - \int\left\{\frac{d}{dx}(u)\ \int v\,dx\right\}dx$

$\int x\sec^2 x\ \ dx = x\int \sec^2 x\,dx - \int\left\{\frac{d}{dx}(x)\ \int \sec^2 x\ \ dx\right\}dx$

$= x\tan x - \int 1.\tan x\,dx = x\tan x - \int \tan x\,dx$

$x\tan x - \log|\sec x| + c$

2. Integrate the function $\int \cos 2x\log\sin x\,dx$

$\log\sin x$ is first function and $\cos 2x$ is second function

$$\int \log\sin x\cos 2x\ \ dx = \log sinx\int \cos 2x\,dx - \int\left\{\frac{d}{dx}(\log\sin\ x)\ \int \cos 2x\ \ dx\right\}dx$$

$= \log sinx\,.\frac{\sin 2x}{2} - \int \frac{1}{\sin x}.\cos x\,.\frac{\sin 2x}{2}dx$

$= \frac{1}{2}\text{sin2x}\log sinx - \frac{1}{2}\int \frac{\cos x}{\sin x}.2\sin x\cos x\,dx$

$= \frac{1}{2}\text{sin2x}\log sinx - \int \cos^2 x\,dx$

$= \frac{1}{2}\text{sin2x}\log sinx - \int \frac{1+\cos 2x}{2}dx$

$= \frac{1}{2}\text{sin2x}\log sinx - \frac{1}{2}\left(x + \frac{\cos 2x}{2}\right) + c$

$= \frac{1}{2}\text{sin2x}\log sinx - \frac{x}{2} - \frac{\cos 2x}{4} + c$

$\sin 2x = 2\sin x\cos x\ \cos^2 x = \frac{1+\cos 2x}{2}$

ACTIVITY 5

1. Evaluate the following integral
   i. $\int (\log x)^2 dx$
   ii. $\int 2x\, e^{5x} dx$
   iii. $\int x^2 \cos^{-1} x\, dx$

Integration using partial fraction

In this case, we will use the concept of partial fractions

Example 1:

Evaluate $\int \frac{3x+2}{(x-1)(2x+3)} dx$

Resolve $\frac{3x+2}{(x-1)(2x+3)}$ into partial fractions

$\frac{3x+2}{(x-1)(2x+3)} = \frac{A}{x-1} + \frac{B}{2x+3} = \frac{(2x+3)A+(x-1)B}{(x-1)(2x+3)}$

$3x + 2 = (2x + 3)A + (x - 1)B$

Solving for A and B, we get $A = 1$ *and* $B = 1$.

$\therefore \frac{3x+2}{(x-1)(2x+3)} = \frac{1}{x-1} + \frac{1}{2x+3}$

$\int \frac{3x+2}{(x-1)(2x+3)} dx = \int \left(\frac{1}{x-1} + \frac{1}{2x+3}\right) dx = \log|x-1| + \frac{1}{2}\log|2x+3| + c$

Example 2:

Evaluate $\int \frac{x^2+2x+8}{(x-1)(x-2)} dx$

Solution:

Since the given fraction is an improper one (as the degree of numerator and denominator are same), we have to divide the numerator and denominator.

$\int \frac{x^2+2x+8}{(x-1)(x-2)} dx = \int 1 + \frac{5x+6}{(x-1)(x-2)}$.

Let $\frac{5x+6}{(x-1)(x-2)} = \frac{A}{(x-1)} + \frac{B}{(x-2)}$

$A(x-2) + B(x-1) = 5x + 6.$

Put $x = 2$ then, $A(2-2) + B(2-1) = 5(2) + 6$. $\therefore B = 16$

Put $x = 1$ then, $A(1-2) + B(1-1) = 5(1) + 6$. $\therefore -A = 11$ *and* $A = -11$.

$\int \frac{x^2+2x+8}{(x-1)(x-2)} dx = \int 1 + \frac{-11}{(x-1)} + \frac{16}{(x-2)} dx$

$= x - 11log|x-1| + 16log|x-2| + c.$

ACTIVITY 6

1. Evaluate the following integral

   i. $\int \frac{x^2+2x+8}{(x-1)(x-2)} dx$

   ii. $\int \frac{3x-2}{(x+1)^2(x+3)} dx$

Summary

1. Integration is reverse of differentiation
2. There are integral of algebraic functions, trigonometry, exponential and inverse trigonometric function.
3. There are three methods of integration:
   i. By substitution- It is used when an integral contains some function and its derivatives
   ii. By parts

   $$\int uv\, dx = u \int v\, dx - \int \left\{\frac{d}{dx}(u) \int v\, dx\right\} dx$$

   If two functions are of different types, the first function is the one which comes first in the word **ILATE.**

   iii. Using partial fraction

Self-check for Learning

1. Integrate the function $\frac{\sec x}{\sec x+\tan x}$
2. Evaluate $\int \frac{3\, e^{2x}+3e^{4x}}{e^x+e^{-x}} dx$
3. Find $\int \frac{\cot(\log x)}{x} dx$
4. Evaluate $\int x \log(1+x)\, dx$
5. Integrate $\int \frac{x-1}{x^2-x-2} dx$

4. Definite Integral

- Define and evaluate the definite integral of a function.
- Use substitution method to evaluate the integral.
- Define definite integral as the limit of sum and evaluate it.
- List and apply the properties of definite integral to evaluate.
- Apply the definite integral to determine the area of a curve and volume of solid of revolutions.

(This topic is NOT for Business Mathematics.)

Introduction

Integral calculus is applied in many scientific and engineering problems. Definite Integral in particular is applied across numerous real-world problems such as business firms in approximation of profit or loss, Power substations to determine the exact length of power cables needed to connect two substations which are miles away from each other, Medical science biologist to determine bacterial growth and so on. However, in your standard we are going to look at two basic applications which are fundamental to apply in real life problems namely determining area of the curve and volume of solid of revolutions.

Definite Integral-Definition

If $f(x)$ is a continuous function defined on the interval $[a, b]$ and if $F(x)$ is the anti-derivative of $f(x)$, i.e., $\frac{d}{dx}[F(x)] = f(x)$, then the definite integral of $f(x)$ over interval $[a, b]$ denoted by $\int_a^b f(x)dx$ is defined as

Upper limit

$$\int_a^b f(x)dx = [F(x)]_a^b = F(b) - F(a)$$

Lower limit

Where $F(b)$ is the value of $F(x)$ at $x = b$ and $F(a)$ is the value of $F(x)$ at $x = a$.

Evaluating definite integral

Definite integrals can be evaluated using the steps given below:

Step 1: Evaluate $\int f(x)dx$. [Omit the arbitrary constant]

Step 2: In the result, put $x = b$ (upper limit) and $x = b$ (lower limit)

Step 3: Subtract the second from the first

The subtrahend is the required value of the definite integral.

Example 1: Evaluate $\int_{2}^{4}(3x-2)^2\,dx$

Solution: Given $\int_{2}^{4}(3x-2)^2\,dx$

$$=\int_{2}^{4}(9x^2-12x+4)dx = 9\times\frac{x^3}{3}-12\times\frac{x^2}{2}+4x$$

$$=3x^3-6x^2+4x$$

$$=\left[3x^3-12x^2+4x\right]_2^4$$

Step 1

$$=[3\times4^3-12\times4^2+4\times4]-[3\times2^3-12\times2^2+4\times2]$$

Step 2

$$=(192-96+16)-(24-24+8)$$

$$=104$$

Step 3

Example 2: Evaluate $\int_{0}^{\pi/3}\frac{2+3\sin x}{\cos^2 x}dx$

Solution: Given $\int_{0}^{\pi/3}\frac{2+3\sin x}{\cos^2 x}dx$

$$=\int_{0}^{\pi/3}\left(\frac{2}{\cos^2 x}+3\times\frac{\sin x}{\cos^2 x}\right)dx=\int_{0}^{\pi/3}\left(2\sec^2 x+3\sec x\tan x\right)dx$$

$$=[2\tan x+3\sec x]_0^{\pi/3}$$

Step 1

$$=(2\tan\frac{\pi}{3}+3\sec\frac{\pi}{3})-(2\tan 0+3\sec 0)$$

Step 2

$$=(2\sqrt{3}+3\times2)-(2\times0+3\times1)$$

$$=2\sqrt{3}+6-3$$

$$=2\sqrt{3}-3$$

Step 3

ACTIVITY 1

1. Evaluate following definite integral:

i. $\int_{4}^{9}\sqrt{x}\,dx$ *ii.* $\int_{\frac{\pi}{4}}^{\frac{\pi}{2}} cos\,\theta\; cos\,e\,c^2\theta d\theta$ *iii.*If $\int_{0}^{a}3x^2dx = 8$.Find the value of a.

Evaluation of definite integral using substitution

When evaluating the definite integral $\int_a^b f(x)dx$ by the substitution, the limit of the integration must also be changed (substituted).

Example 3: Evaluate $\int_0^9 \frac{dx}{1+\sqrt{x}}$

We need to substitute the limit of integration.

Solution: Given $\int_0^9 \frac{dx}{1+\sqrt{x}}$

Put $x = t^2$, so that $dx = 2tdt$

When $x = 0,\ t^2 = 0 \Rightarrow t = 0,$

$x = 9,\ t^2 = 9 \Rightarrow t = 3$

$$\therefore \int_0^9 \frac{dx}{1+\sqrt{x}} = \int_0^3 \frac{2tdt}{1+\sqrt{t^2}} = \int_0^3 \frac{2tdt}{1+t}$$

$$= 2\int_0^3 \left(1 - \frac{1}{1+t}\right)dt = 2\left[t - \log(1+t)\right]_0^3$$

$$= 2[(3-\log 4) - (0-\log 1)]$$

$$= 2[3 - \log 4 + \log 1] = 2[3 - \log 4] \qquad (\because \log 1 = 0)$$

$$= 6 - 2\log 4$$

ACTIVITY 2

1. Evaluate the following integrals

$$i.\ \int_0^1 \frac{x^5}{1+x^6}dx \qquad ii.\ \int_0^{\frac{\pi}{2}} \frac{\cos x}{(1+\sin x)(2+\sin x)}dx$$

Definite integral as limit of sum

Limit of sum method is another way to evaluate definite integral. This method is used if and only if in the question, it is stated to use. Otherwise, we use other suitable method of integration.

Definition: If $f(x)$ is continuous function in the interval $[a, b]$, where a and b are finite and $b > a$ and if the interval is divided into n equal parts, each of width h so that, $h = \frac{b-a}{n}$, then

$$\int_a^b f(x)dx = \lim_{n\to\infty} \frac{b-a}{n}\left[f(a)+f(a+h)+f(a+2h)+...+f(a+(n-1)h)\right]$$
$$= \lim_{h\to 0} h[f(a)+f(a+h)+f(a+2h)+...+f(a+(n-1)h)]$$
$$\text{Since, } n\to\infty \Rightarrow \frac{b-a}{n}\to 0 \Rightarrow h\to 0$$

is called the definite integral of $f(x)$ between the limits a and b.

Example 4: Evaluate the integral as a limit of sum

$$\int_2^3 x dx$$

Solution: Given $\int_2^3 x dx$

Here, $f(x) = x,\ a = 2,\ b = 3,\quad nh = b-a = 3-2 = 1 \quad \left[\because h = \frac{b-a}{n} \Rightarrow nh = b-a\right]$

$$\therefore \int_2^3 x dx = \lim_{h\to 0} h\left[f(2)+f(2+h)+f(2+2h)+...+f(2+(n-1)h)\right]$$

Here, $f(2) = 2$

$f(2+h) = 2+h$

$f(2+2h) = 2+2h, ...$

$f(2+(n-1)h) = 2+(n-1)h$

$$= \lim_{h\to 0} h\left[2+(2+h)+(2+2h)+...+(2+(n-1)h)\right]$$
$$= \lim_{h\to 0} h\left[2n+h(1+2+3+...+(n-1)\right]$$
$$= \lim_{h\to 0} h\left[2n+h\frac{n(n-1)}{2}\right]$$

Since, $1+2+3+...+(n-1) = \frac{n(n-1)}{2}$

$$= \lim_{h\to 0}\left[2nh+\frac{n^2h^2}{2}-\frac{nh}{2}.h\right]$$
$$= \lim_{h\to 0}\left[2\times 1+\frac{1^2}{2}-\frac{1}{2}\times h\right] \quad \because nh = 1 \Rightarrow n^2h^2 = 1^2$$
$$= 2+\frac{1}{2}-\frac{1}{2}\times 0 = \frac{5}{2}$$

Simplifying and Applying limit

Method 2: (Alternative method for limit of sum)

Solution: Given $\int_2^3 x dx$

Here $nh = b - a = 3 - 2 = 1$

$$nh = 1 \Rightarrow h = \frac{1}{n},\ \text{As } h \to 0,\ n \to \infty$$

By definition,

$$\int_2^3 x dx = \lim_{h\to 0} h\left[2 + (2+h) + (2+2h) + \ldots + (2 + (n-1)h)\right]$$

$$= \lim_{h\to 0} \frac{1}{n}\left[2 + (2 + \frac{1}{n}) + (2 + \frac{2}{n}) + \ldots + \left[2 + \frac{n-1}{n}\right]\right]$$

Substituting $h = \frac{1}{n}$

$$= \lim_{h\to 0} \frac{1}{n}\left[2n + \frac{1}{n}\{1 + 2 + \ldots + (n-1)\}\right]$$

$$= \lim_{h\to 0} \frac{1}{n}\left[2n + \frac{1}{n}.\frac{n(n-1)}{2}\right]$$

Applying the formula $1 + 2 + 3 + \ldots + (n-1) = \frac{n(n-1)}{2}$

$$= \lim_{h\to 0}\left[2 + \frac{(n-1)}{2n}\right]$$

$$= \lim_{h\to 0}\left[2 + \frac{1}{2} - \frac{1}{2n}\right]$$

$$= 2 + \frac{1}{2}$$

$$= \frac{5}{2}$$

ACTIVITY 3

Evaluate following integral as limit of sums:

1. $\int_0^3 (3x^2 - 4)dx$

Hint: $1^2 + 2^2 + 3^2 + \ldots + (n-1)^2 = \frac{(n-1)n(2n-1)}{6}$

2. $\int_3^5 (2 - x)dx$

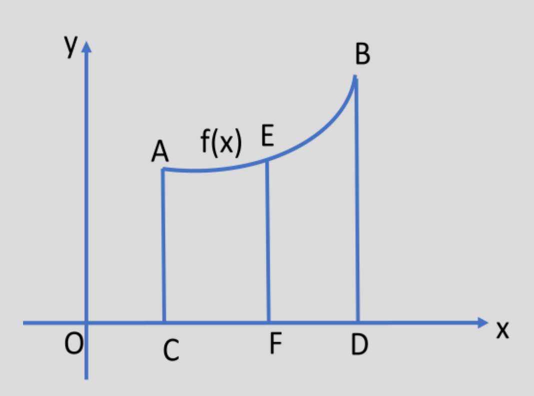
Properties of definite integrals

Property 1. $\int_a^b f(x)dx = \int_a^b f(y)dy$

Property 2. $\int_a^b f(x)dx = -\int_b^a f(x)dx$ **(Interchange of limits)**

Property 3.

$\int_a^c f(x)dx = \int_a^c f(x)dx + \int_c^b f(x)dx$, Where $a < c < b$



Note: This property is generally used to evaluate modulus function or cases where a function is expressed by two or more rules.

Property 4. $\int_0^a f(x)dx = \int_0^a f(a-x)dx$

Note: This property is extremely important and is frequently used in evaluating definite integral as it enables us to evaluate definite integral without having to evaluate the indefinite integral which it may be difficult or even impossible to find.

Property5.

$\int_{-a}^{a} f(x)dx = 0$ or $\int_{-a}^{a} f(x)dx = 2\int_0^a f(x)dx$ according as $f(x)$ is an odd or even function of x.

i.e. 1. If $f(x)$ is an odd function, then $\int_{-a}^{a} f(x)dx = 0$.

2. If $f(x)$ is an even function, then $\int_{-a}^{a} f(x)dx = 2\int_0^a f(x)dx$

Example 5: Evaluate the integral: $\int_2^8 |x-5|dx$

Solution: Given $\int_2^8 |x-5|dx$

$$|x-5| = \begin{cases} x-5 & if \quad x-5 \geq 0 \\ -(x-5) & if \quad x-5 < 0 \end{cases}$$

$$= \begin{cases} x-5 & if \quad x \geq 5 \\ -(x-5) & if \quad x < 5 \end{cases}$$

Using moduls function definition,

since $|x| = \begin{cases} x \ if \ \ x \geq 0 \\ -x \ if \ \ x < 0 \end{cases}$

$\int_2^8 |x-5|dx = \int_2^5 |x-5|dx + \int_5^8 |x-5|dx$ → Using property 3

$$= \int_2^5 -(x-5)dx + \int_5^8 (x-5)dx$$

$$= \int_2^5 (-x+5)dx + \int_5^8 (x-5)dx$$

$$= \left[\frac{-x^2}{2} + 5x\right]_2^5 + \left[\frac{x^2}{2} - 5x\right]_5^8$$

$$= \left[\left(\frac{-25}{2} + 25\right) - \left(\frac{-4}{2} + 10\right)\right] + \left[\left(\frac{64}{2} - 40\right) - \left(\frac{25}{2} - 25\right)\right]$$

Simplifying the expression, we get

$= 9$

ACTIVITY 4

Evaluate the following integral

1. Show that $\int_0^6 |x-2|\,dx = 10$
2. Evaluate $\int_1^4 f(x)dx$ where $f(x) = \begin{cases} 4x+3 \text{ if } 1 \le x \le 2 \\ 3x+5 \text{ if } 2 \le x \le 4 \end{cases}$

Application of Definite Integral

Geometrical interpretation of a definite integral

Geometrically the definite integral $\int_a^b f(x)dx$ is the area bounded by the curve $y = f(x)$ and the ordinates $x = a$ and $x = b$.

So, the definite integral is applied to evaluate

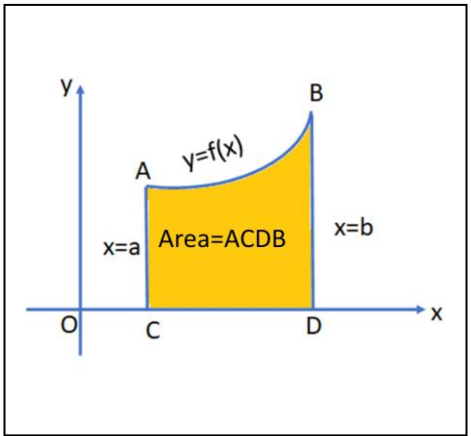
1. Area of a curve included between the x-axis or the y-axis.
2. Volume of solid of revolution

Area of the region bounded by curve and axis

The area of the region bounded by the curve $y = f(x)$ and the ordinates $x = a$ and $x = b$ (as indicated in Figure 2) is given by

$$A = \int_a^b f(x)dx = \text{ Area ACDB}$$

$$A = \int_a^b ydx$$



The unit of area of region bounded between the curve and axis is sq. units.
The area of the region bounded by the curve $x = f(y)$ and the abscissae $y = c$ and $y = d$ (as indicated in Figure 3) is given by

$$A = \int_c^d f(y)dy = \text{ Area ACDB}$$
$$A = \int_c^d xdy$$

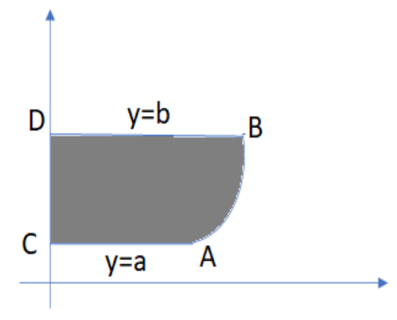


Figure 3

Sign of an Area

The sign of an area can be either positive or negative depending upon the direction of area enclosed by the curve and the region of enclosure.

1. Area enclosed by a curve in counter-clockwise direction & lies above *x-axis* is positive
2. Area enclosed by a curve in clockwise direction & lies below *x-axis* is negative
3. If curve crosses *x-axis*, the area will be the sum of the area above and below the *x-axis*

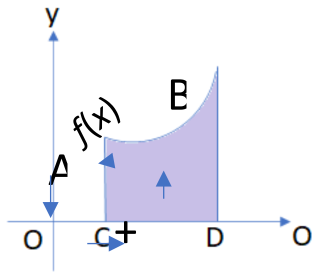


Fig 1

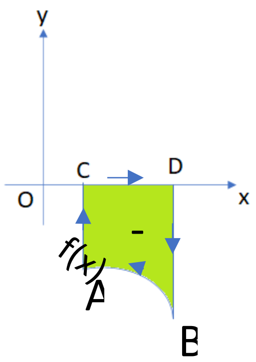


Fig 2

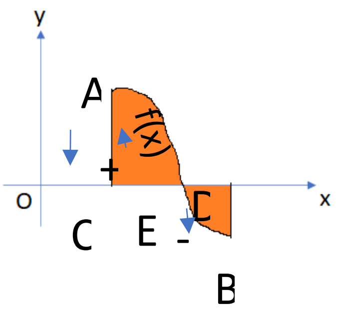


Fig 3

Example 6: Find the area between the curve $y = x(x-3)$ and the $x -$ axis.
Solution: Given $y = x(x-3)$
We know that area bounded between curves and $x -$ axis is given by

$$A = \int_a^b ydx$$

To obtain the limit of integration we need to find x-intercept in case of area bounded between the curve and x-axis and y-intercept in case of area bounded between the curve and y-axis

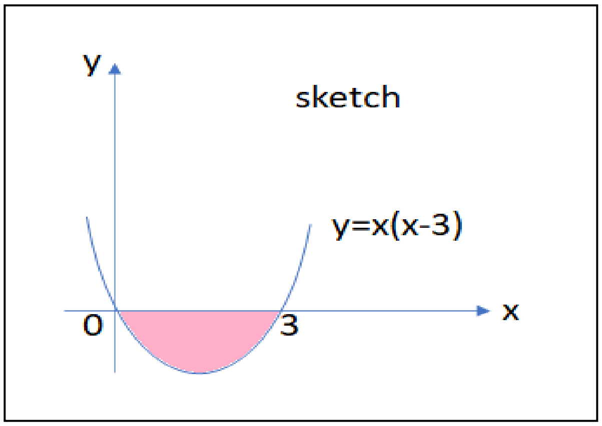
X-intercept

$y = 0 \Rightarrow x(x-3) = 0$

$\therefore x = 0$ and $x = 3$ are the required x-intercept.

Table of values

x	y
0	0
1	-2
2	-1
3	0



(Roughly sketch the curve and shade the region which is bounded between curve and the x-axis. The shaded region represents the area bounded between the curve and the axis)

The shaded region represents the area bounded between the curve and the x-axis.

Required area $A = \int_0^3 x(x-3)dx$

$$A = \int_0^3 (x^2 - 3x)dx \quad = \left[\frac{x^3}{3} - 3\frac{x^2}{2}\right]_0^3$$

$$= \left(9 - \frac{27}{2}\right) - 0$$

$$= -4\frac{1}{2}$$ (The area has a negative sign as the area bounded between the curve and axis lie below x-axis. Therefore negative sign is anticipated.)

Required area is

$$A = 4\frac{1}{2} \text{ sq.units}$$

ACTIVITY 5

1. Find the area of the region bounded by the line $3y = 2x + 4$, the x-axis and the lines $x = 1$ and $x = 3$.
2. Find the area bounded by the curve $y = 4 - x^2$ and the line $y = 0$ and $y = 3$.

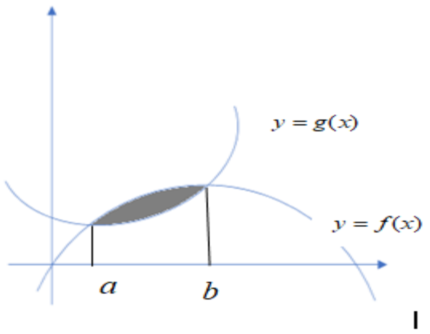
Area defined by two curves

The area enclosed between two curves will be obtained by working rule given below:

1. Calculate the point of intersections of the curves to give limits of integration. The x-coordinate of the points of integration of the curve is the limit of integration.
2. Calculate area under each curve separately

3. Calculate difference between the areas. The difference between the areas gives you the required area between two curves.

   i.e. Area between two curves $= \int_a^b y \text{ of } f(x)dx - \int_a^b y \text{ of } g(x)dx$



Example 7: Find the area enclosed between the curves $y = 2x^2 + 3$ and $y = 10x - x^2$.

Solution: Given $y = 2x^2 + 3$ and $y = 10x - x^2$.

Point of intersection

$2x^2 + 3 = 10x - x^2 \Rightarrow 3x^2 - 10x + 3 = 0$

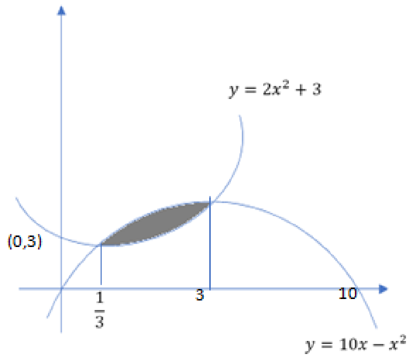
Solving for x, we get

$(3x-1)(x-3) = 0$

$\Rightarrow x = \frac{1}{3}$ *and* $x = 3$

The curve $y = 2x^2 + 3$ intersects the $y - axis$ at (0, 3) and does not cut $x - axis$ and the curve $y = 10x - x^2$ intersects the $x - axis$ at (0, 0) and at (10, 0). We can roughly sketch the curve as

The shaded region represents the area enclosed between the two curves.



Required area

= Area bounded by upper curve − area bounded by lower curve.

$$= \int_{1/3}^{3} (10x - x^2)\,dx - \int_{1/3}^{3} (2x^2 + 3)\,dx$$

$$== \int_{1/3}^{3} (10x - x^2 - 2x^2 - 3)\,dx = \int_{1/3}^{3} (10x - 3x^2 - 3)\,dx$$

$$= \left[10 \times \frac{x^2}{2} - 3 \times \frac{x^3}{3} - 3x\right]_{1/3}^{3}$$

Substituting the limit and simplifying, we get

$$= (45 - 27 - 9) - \left(\frac{5}{9} - \frac{1}{27} - 1\right)$$

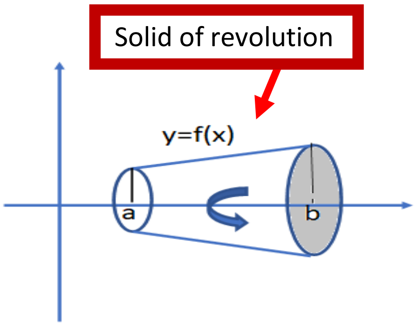
$$= 9\frac{13}{27}\ sq.units$$

ACTIVITY 6

1. Find the area included between the curve $y^2 = 8x$ and $x^2 = 8y$.
2. Find the area bounded by the curve $x^2 = 4y$ and the straight line $x = 4y - 2$.

Volume of solid of revolution

When a portion of the curve $y = f(x)$ between the ordinates $x = a$ and $x = b$ is rotated, a solid will be obtained called solid of revolution. So, we can use integral calculus (definite integral) to find the volume of solid of revolution.

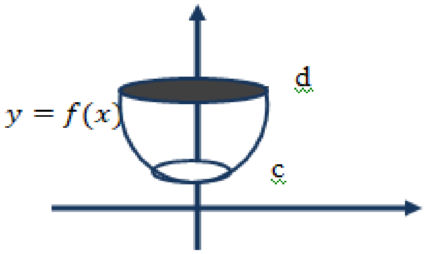


If a portion of the curve $y = f(x)$ is rotated about x-axis, the volume of solid of revolution is given by

$V = \pi \int_a^b y^2 dx$ Where a and b are the limits on the x-axis.

Similarly, if a portion of the curve $y = f(x)$ is rotated about y-axis, the volume of solid of revolution is given by

$V = \pi \int_c^d x^2 dy$ Where c and d are the limits on the y-axis.

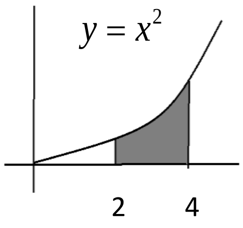


Note: The unit of volume of solid of revolution obtained is cubic units denoted as cu. units.

Example 8: Find the volume of the solid formed when the area between the x-axis, the lines $x = 2$ and $x = 4$ and the curves $y = x^2$ is rotated about x-axis.

Solution: Given curve $y = x^2$, Line $x = 2$ and $x = 4$

Volume of solid of revolution, when a portion of the curve $y = f(x)$ between the ordinates $x = a$ and $x = b$ is rotated is given by



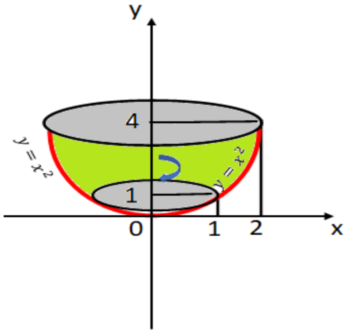
$$V = \pi\int_a^b y^2 dx$$

$$V = \pi\int_2^4 \left(x^2\right)^2 dx \Rightarrow V = \pi\int_2^4 x^4 dx$$

$$V = \pi\left[\frac{x^5}{5}\right]_2^4 = \frac{\pi}{5}\left[4^5 - 2^5\right] = \frac{\pi}{5}[1024 - 32]$$

$$= \frac{992}{5}\pi \text{ cu. units}$$

Example 9: The portion of the curve $y = x^2$ between $x = 1$ and $x = 2$ is rotated through 360° about y-axis. Find the volume created.



Solution: Given curve $y = x^2$, Line $x = 1$ and $x = 2$

Roughly sketch the curve. The limits are 1 and 2 corresponding to $x = 1$ and $x = 2$. So, we need to find the limits corresponding to y.

When $x = 1, y = 1^2 \Rightarrow y = 1$

$x = 2, y = 2^2 \Rightarrow y = 4$

The Volume of solid of revolution when a portion of the curve $y = x^2$ between $y = 1$ and $y = 4$ is rotated through 360° about y-axis is given by

$V = \pi\int_c^d x^2 dy$ Where c and d are the limits on the y-axis.

$$V = \pi\int_1^4 x^2 dy \Rightarrow V = \pi\int_1^4 y dy$$

$$V = \pi\left[\frac{y^2}{2}\right]_1^4$$

$$V = \pi\left[\frac{4^2}{2} - \frac{1^2}{2}\right] = \pi\left[8 - \frac{1}{2}\right] \qquad V = \frac{15}{2}\pi \text{ cu. units}$$

ACTIVITY 7

1. Find the volume made by rotating the parts of the curve $y = \sqrt{x}$, $0 \le x \le 9$ about the y – axis.
2. The part of the curve $y = x^2 - 2x - 3$ which lies below the x – axis is rotated completely about that axis. Find the volume of the solid figure formed.

Summary

- The difference in the values of an integral of function $f(x)$ for any two assigned values of independent variables x say, a and b is definite integral of $f(x)$ over the range $(a,\ b)$ and is defined by

$$\int_a^b f(x)dx = F(b) - F(a)$$

- Concepts and evaluation of definite integral is same like integration of indefinite integral. Only thing is we need to take care of the limits of integration.
- Limit of sum method is a method to evaluate definite integral.
- Properties of definite integrals are useful tools to easily evaluate the integral value.
- The property generally used to evaluate modulus function or cases where a function is expressed by two or more rules is:

$$\int_a^c f(x)dx = \int_a^c f(x)dx + \int_c^b f(x)dx, \text{ Where } a < c < b$$

- Definite integral has wide application across numerous discipline and two basic applications are to find the area of regions and volume of solid of revolution.
- The area of the region bounded by the curve $y = f(x)$ and the ordinates $x = a$ and $x = b$ is given by

$$A = \int_a^b f(x)dx = \int_a^b ydx$$

- The area of the region bounded by the curve $x = f(y)$ and the abscissae $y = c$ and $y = d$ is given by

$$A = \int_c^d f(y)dy = \int_c^d xdy$$

- The sign of area can be positive or negative depending upon whether it lies above or below the axis.

- If a portion of the curve $y = f(x)$ is rotated about x-axis, the volume of solid of revolution is given by

  $V = \pi \int_a^b y^2 dx$ Where a and b are the limits on the x-axis.

- If a portion of the curve $y = f(x)$ is rotated about y-axis, the volume of solid of revolution is given by

  $V = \pi \int_c^d x^2 dy$ Where c and d are the limits on the y-axis.

- The unit of area of the curve is Sq. units and the area of volume of solid of revolution is Cu. Units.

Self-check for Learning

1. Evaluate $\int_0^{\pi/6} \sin 3x dx$.
2. Evaluate $\int_0^1 \sqrt{\frac{1-x}{1+x}} dx$
3. Find the integrals as limit of sum for $\int_1^3 (2x^2 + 5x) dx$.
4. Find the area of the region bounded by $2y = -x + 6$ and the lines $x = 2$ and $x = 4$.
5. The part of the curve $y = x^2 + 1$ between $x = 1$ and $x = 2$ is rotated about the y-axis through 360°. Find the volume of solid formed.

5. Points and their Coordinates in Two Dimensions and Straight Lines

- Calculate the distance between two points.
- Find the coordinates of the point which divides join of two points.
- Apply the section formula to find the ratio of point dividing join of two points.
- Write the equation of straight line.
- Apply the condition of parallelism and perpendicular to prove that given lines are parallel and perpendicular.
- Find the angle between two lines.

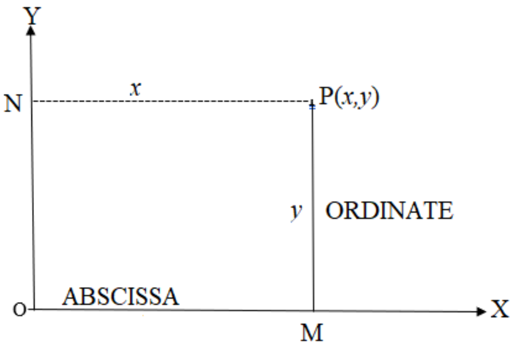
Introduction

Coordinate geometry earlier known as Analytical geometry was invented by French philosopher Rene Descartes in 1637. It was known as Analytical geometry because geometrical figures are represented using algebraic equations. The equation of geometric curves represents the fundamental properties of different points on the curve which is located using coordinates, so later it was named as coordinate geometry or plane cartesian geometry. Coordinate geometry enables mathematics to assist in investigation of process taking place in space.

Coordinate geometry is branch of geometry which deals with coordinates to indicate the position of points in a plane and which make use of algebraic methods in study of geometric figures.

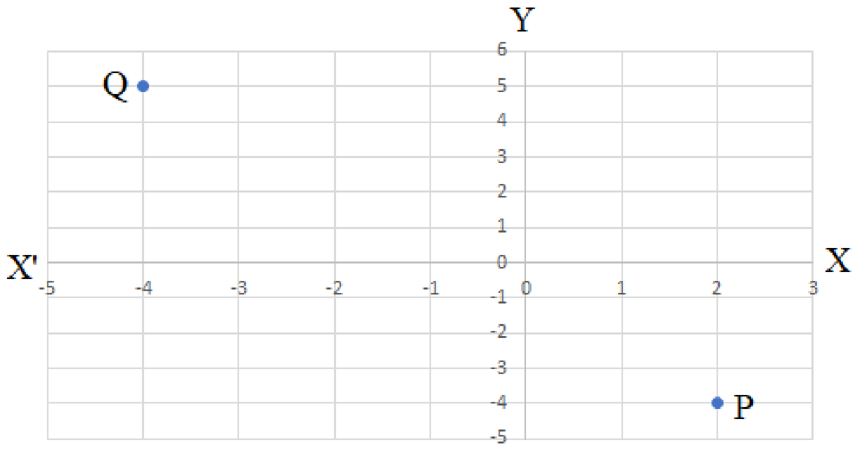
Coordinates

The position of each point of the plane is determined with reference to rectangular axes by pair of numbers called coordinates which are the distance of the point from the axes. The distance of the point from y-axis is called x- coordinates or **abscissa** and the distance of the point from x-axis is called the y- coordinates or **ordinate.** Refer the figure below to get the clear concept on coordinates.

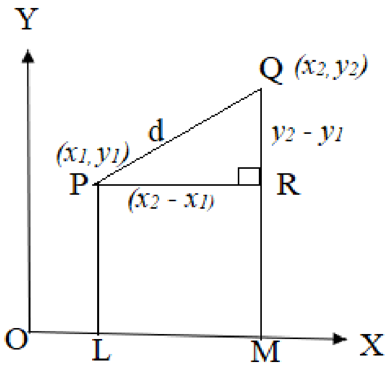


In a diagram, let p is any point in rectangular axes, x is the distance of point from y-axis an y is distance of point from x-axis. Then the coordinate of point P is denoted as (x, y).

For example, point P (2, -4) and Q (-4,5) would be plotted as shown below.



Distance Formula



Distance formula is used to find the distance between any two points in the coordinate system. Let us derive the distance formula. Let d be the distance between the points P (x_1, y_1) and Q (x_2, y_2) as shown in the diagram.

Using Pythagorean theorem in triangle PQR,

$$PQ^2 = PR^2 + RQ^2$$

$$d^2 = (x_2 - x_1)^2 + (y_2 - y_1)^2$$

$$\therefore d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

Example: Find the distance between the points (6, -8) and (2,5).

Solution:

$let\ (x_1, y_1) = (6, -8)\ and\ (x_2, y_2) = (2, -5)$

using distance formula

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

substituting the values

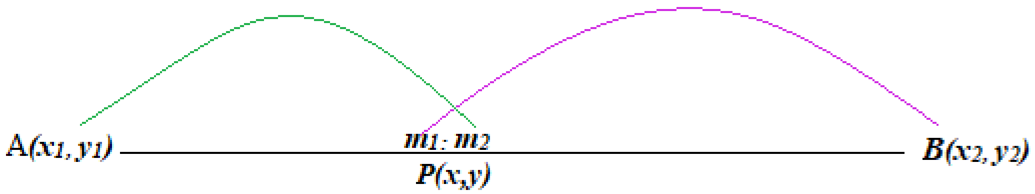
$$d = \sqrt{(2-6)^2 + (-5--8)^2}$$

$$= \sqrt{(-4)^2 + 3^2} = \sqrt{16+9} = \sqrt{25} = 5\ units$$

Division or Section Formula

Division or Section formula is applied to find the coordinate of the point which divides the line joining two points at certain ratio.

Let $\mathrm{P}(x,y)$ divides the line joining the points $\mathrm{A}(x_1,y_1)$ and $\mathrm{B}(x_2,y_2)$ in the ratio $m_1:m_2$ as shown below.



Then coordinate of $P(x,y)=\left(\dfrac{m_1x_2+m_2x_1}{m_1+m_2},\dfrac{m_1y_2+m_2y_1}{m_1+m_2}\right)$

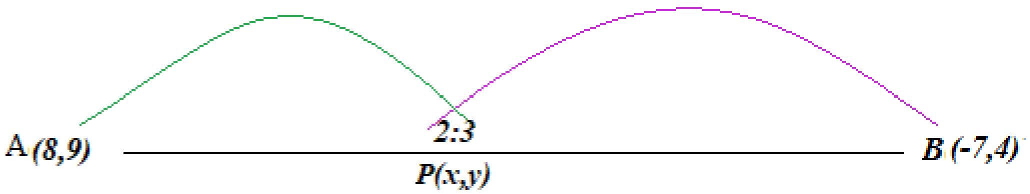
Keynote: Use this formula when the dividing point divides the join of two points at certain ratio. If dividing points lies exactly at centre then we will make use of mid-point formula to find the coordinate of dividing point. You will see mid-point formula in next topic.

Application of Division or Section Formula

Example 1: Finding the coordinates of the point dividing the join of two points.

Find the coordinates of the point which divides the join of the points (8,9) and (-7,4) in the ratio 2:3.

Solution: Let P divides the join of AB as shown in the diagram



Using Section formula,

Coordinate of $P(x,y)=\left(\dfrac{m_1x_2+m_2x_1}{m_1+m_2},\dfrac{m_1y_2+m_2y_1}{m_1+m_2}\right)$

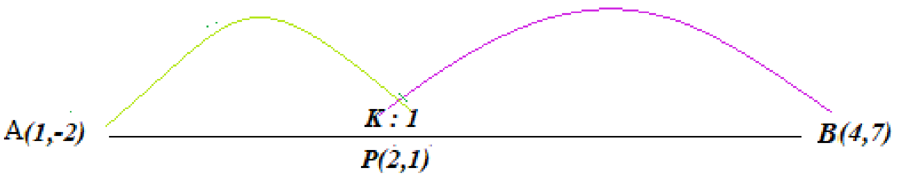
Substituting the Values, we get

$$P(x,y)=\left(\frac{2\times -7+3\times 8}{2+3},\frac{2\times 4+3\times 9}{2+3}\right)$$

$$=\left(\frac{-14+24}{5},\frac{8+27}{5}\right)$$

$$\therefore P(x,y)=(2,7)$$

Example 2: Finding the ratio when the given point divides the join of two given points
Find the ratio in which the point (2,1) divides the join of the points (1, -2) and (4,7).
Solution:
Let the required ratio be K:1…………… Assuming the ratio, where K is any real number
Then it can be represented in diagram as;



Then by section formula,

$$P(2,1)=\left(\frac{k\times 4+1\times 1}{k+1},\frac{k\times 7+1\times -2}{k+1}\right)$$

$$P(2,1)=\left(\frac{4k+1}{k+1},\frac{7k-2}{K+1}\right)$$

You can compare any one of the coordinates to find the value of k.
let us compare the x – coordinates here, then

$$2=\frac{4k+1}{k+1}$$

$$2(K+1)=4k+1$$

$$2k+2=4k+1$$

$$2k-4k=1-2$$

$$-2k=-1$$

$$k=\frac{1}{2}$$

Therefore the required ratio is $\frac{1}{2}:1$ *or* $1:2$

Mid-point Formula

The coordinates of the midpoint P (x,y) of the line joining A(x_1,y_1) and B(x_2,y_2) are

$$P(x,y)=\left(\frac{x_1+x_2}{2},\frac{y_1+y_2}{2}\right)$$

Example: Find the mid-point of the join of the points (-1,5) and (7,3).
Solution:

$$\text{Coordinates of mid-point}=\left(\frac{-1+7}{2},\frac{5+3}{2}\right)=(3,4)$$

ACTIVITY 1

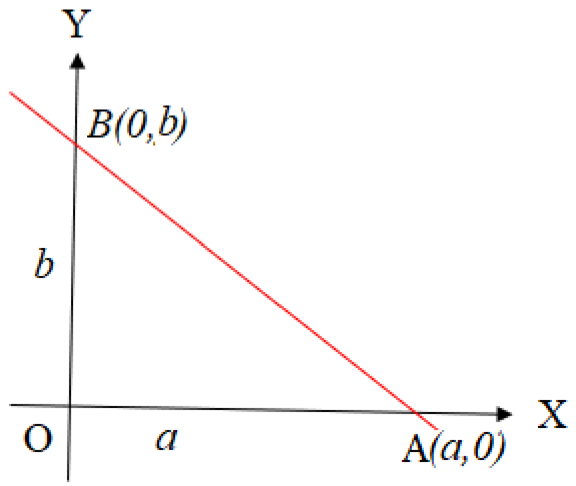
1. Solve the following questions using the distance formula, Section formula and mid-point formula.
   i. Calculate the distance between the two points (3,5) and (-1,2)
   ii. Find the coordinates of the point which divides the line segment joining the point (4, -3) and (8,5) in the ratio 3:1.
   iii. Find the ratio in which the line joining the points (-2, -4) and (2, $-\frac{10}{3}$) is divided by a point (1, $-\frac{7}{2}$).
   iv. What is the midpoint of two points (3,2) and (1,4)?

The Straight Line

The straight line is the simplest geometry curve and the general equation of line is $\boxed{ax+by+c=0}$ We will learn about three special form of equations of the straight line under this activity. But before we look into the forms of straight line, let us learn the following terminologies to understand the form of equations of straight lines.

1. Intercepts

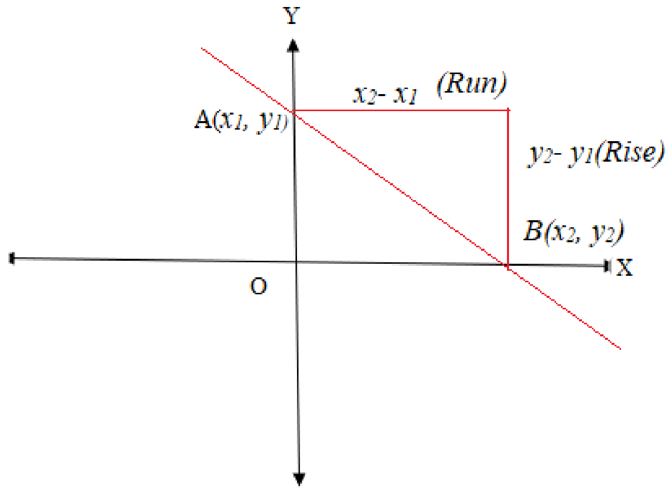
Intercepts are the points at which the line crosses the axes. A point at which the line crosses the x-axis is known as x-Intercept and the point at which the line crosses y-axis is known as y-Intercept. Diagram below represents the points of x-intercept and y-Intercept. From the diagram OA and OB are the x-intercept and y-intercept respectively. Coordinate of x-intercept is a point A $(a,0)$ and y-intercepts.is point B $(0,b)$.



From the given equation of straight line, you can find x-intercept by substituting y=0 and similarly by substituting x=0, you will get y-intercept of a particular line given to you.

2. Slope(m)

Slope (or gradient) of the straight is a measure of inclination of line. Slope is a number that indicates both direction and steepness of a line. It is denoted by letter "m". Numerically, slope of line is ratio of change in y- coordinates to x-coordinates.



Let A(x_1, y_1) and B(x_2, y_2) any two points on a straight line, then

$$slope = m = \frac{rise}{run}$$

$$\therefore m = \frac{y_2 - y_1}{x_2 - x_1}$$

Special forms of equations of straight line

I. Slope-intercept form.

The equation of straight line with given slope "m" and y-intercept "c" is represented as

$$\boxed{y = mx + c}$$

II. Point-slope form

The equation of line which passes through a point (x_1, y_1) having a gradient "m" is represented as

$$\boxed{y - y_1 = m(x - x_1)}$$

III. Two-point form

The equation of line passing through two given points (x_1, y_1) and (x_2, y_2) is represented as

$$\boxed{y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_1)}$$

Refer the following examples below to understand and analyse the properties of equations of straight line in different form.

Example 1: What is the slope and y-intercept of the equation of straight line $y=\sqrt{3}x-7$?

Solution: The given equation is slope and y-intercept form. Comparing the equation with $y=mx+c$, $m=\sqrt{3}$ *and* $y-\text{intercept}=-7$

Example 2: Write the equation of straight line whose y-intercept is 2 and slope is 7.

Solution:

Given

m=2 and c=7.

Since m and c is given it is in slope intercept form, substituting value in equation $y=mx+c$, the required equation is $\boxed{y=7x+2}$

Example 3: Find the equation of straight line passing through the point (-1, -5) and having slope equals to $\frac{9}{5}$.

Solution:

Given;

(x_1, y_1) = (-1, -5) and m= $\frac{9}{5}$

Since one of the points and the slope is given, it is in point slope form, substituting the values in equation $y-y_1=m(x-x_1)$, the required equation is

$$y-(-5)=\frac{9}{5}(x-(-1))$$

$$y+5=\frac{9}{5}(x+1)$$

$$5(y+5)=9(x+1)$$

$$5y+25=9x+1$$

$$\boxed{9x-5y-16=0}$$

Example 4: Determine the equation of straight line which passes through the points (5,7) and (-1,2).

Solution:

Given

(x_1, y_1) = (5,7) and (x_2, y_2) = (-1,2)

Since two points are given, it is in two-point form, substituting the values in equation $y-y_1=\frac{y_2-y_1}{x_2-x_1}(x-x_1)$, the required equation is

$$y-7=\frac{2-7}{-1-5}(x-5)$$

$$y-7=\frac{-5}{-6}(x-5)$$

$$y-7=\frac{5}{6}(x-5)$$

$$6(y-7)=5(x-5)$$

$$6y-42=5x-25$$

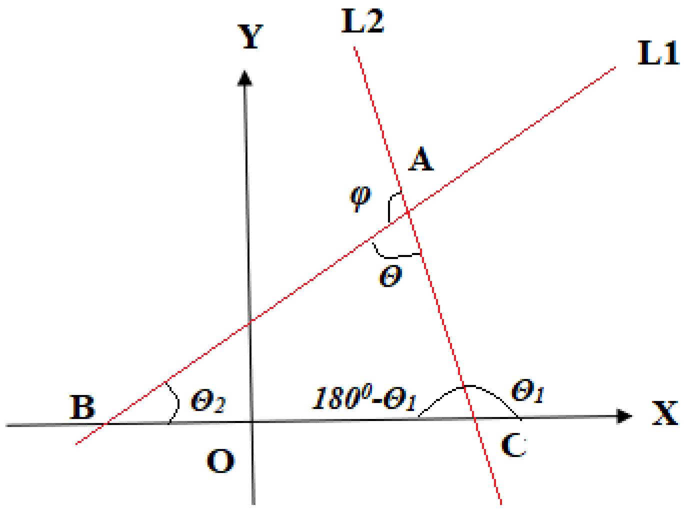
$$\boxed{5x-6y+17=0}$$

ACTIVITY 2

1. Using special form of equations of straight line, answer the following questions.
   i. State the equation of straight line which passes through point (-4, 7) and having the slope $m=-\sqrt{3}$.
   ii. What is the equation of straight line which has the y-intercept -3 and slope -4?
   iii. Find the equation of straight line passing through the points (4, -5) and (-1,2).

Angle between two lines

Suppose we have to find the angle between two lines whose inclination to the x-axis are θ_1 and θ_2. Let θ and ϕ be the interior and exterior angles respectively between the given line then,



In triangle ABC,
Sum of interior angle of triangle ABC=180^0

$$\theta+\theta_2+180^0-\theta_1=180^0$$
$$\theta+\theta_2-\theta_1=180^0-180^0$$
$$\theta+\theta_2-\theta_1=0$$
$$\theta=\theta_1-\theta_2$$

multiplying by tan *on both side*

$$\tan\theta=\tan(\theta_1-\theta_2)$$
$$\tan\theta=\frac{\tan\theta_1-\tan\theta_2}{1+\tan\theta_1\tan\theta_2}\text{.................using }\tan(A-B)=\frac{\tan A-\tan B}{1+\tan A\tan B}$$

substitute $m_1=\tan\theta_1$ *and* $m_2=\tan\theta_2$

$$\tan\theta=\frac{m_1-m_2}{1+m_1m_2}$$

Therefore the acute angle between two line is $\tan\theta=\left|\frac{m_1-m_2}{1+m_1m_2}\right|$

where m_1 and m_2 are the slopes of given lines.

Example: Find the angle between the line whose slopes are -3 *and* $-\frac{1}{2}$.

Solution:

Given

$$m_1=-3 \text{ and } m_2=-\frac{1}{2}$$

If θ is the angle between the lines, then we know that $\tan\theta=\left|\frac{m_1-m_2}{1+m_1m_2}\right|$

Substituting the value of slopes, we get

$$\tan\theta=\left|\frac{-3-\left(-\frac{1}{2}\right)}{1+(-3)\times\left(-\frac{1}{2}\right)}\right|$$

$$\tan\theta=\left|\frac{-\frac{5}{2}}{\frac{5}{2}}\right|=|-1|$$

$$\tan\theta=1$$

$$\theta=\tan^{-1}1=45^0$$

Therefore, the angle between the given lines is 45^0

Parallel and perpendicular lines

1.Parallel lines (condition of parallelism)

If two lines are parallel to each other, then angle between them 0^0, i.e., $\theta = 0^0$.

Substituting in the formula, $\tan\theta = \left|\frac{m_1 - m_2}{1 + m_1 m_2}\right|$,

we have

$$\tan 0 = \left|\frac{m_1 - m_2}{1 + m_1 m_2}\right|$$

$$0 = \frac{m_1 - m_2}{1 + m_1 m_2}$$

$$o = m_1 - m_2$$

$$\boxed{m_1 = m_2}$$

Hence two lines are parallel if their slopes are equal.

2.Perpendiular lines (condition of perpendicularity)

If two lines are perpendicular to each other, then angle between them is 90^0, i.e., $\theta = 90^0$.

Substituting in the formula, $\tan\theta = \left|\frac{m_1 - m_2}{1 + m_1 m_2}\right|$,

we have

$$\tan 90 = \left|\frac{m_1 - m_2}{1 + m_1 m_2}\right|$$

$$\infty = \frac{m_1 - m_2}{1 + m_1 m_2}$$

$$\infty \times 1 + m_1 m_2 = m_1 - m_2$$

$$1 + m_1 m_2 = \frac{m_1 - m_2}{\infty} \text{..................} \textit{Any number divided by a very big number approaches to } 0$$

$$1 + m_1 m_2 = 0$$

$$m_1 m_2 = -1$$

$$\boxed{m_1 = -\frac{1}{m_2}}$$

Hence two lines are perpendicular to each other if the slope of one line is negative reciprocal of slope of the other line.

Example 1: Find the slope of the line parallel to line which passes through the points (0,0) and (5,6).

Solution:

Given line passes through the points (0,0) and (5,6).

Let the slope of given line be m_1 and required line be m_2.

$$m_1 = \frac{y_2 - y_1}{x_2 - x_1} = \frac{6-0}{5-0} = \frac{6}{5}$$

Since the lines are parallel to each other $m_1 = m_2$

Therefore $m_2 = \frac{6}{5}$

Example 2: what is the slope of line perpendicular to the line whose slope is $-\frac{5}{6}$?

Solution:

Let the slope of given line be m_1 and required line be m_2.

Given $m_1 = -\frac{5}{6}$

Since the lines are parallel to each other $m_2 = -\frac{1}{m_1}$

Therefore, $m_2 = \frac{6}{5}$

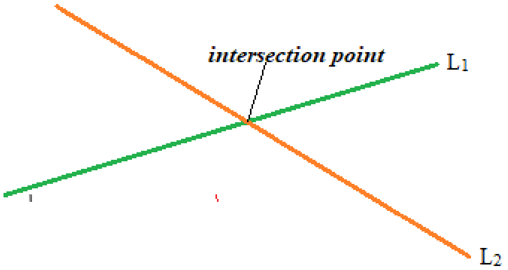
ACTIVITY 3

1. Solve the following question by using the concepts given above.
   i. Find the angle between the line whose slope are 2 and -1.
   ii. What is the slope of the line perpendicular to the line which passes through the points (0, 8) and (-5, 2)?
   iii. Find the slope of the line parallel to the line $y = -\frac{1}{2}x + 2$.

Pair of straight line

Let us consider two line $L_1: a_1x + b_1y + c_1 = 0$ and $L_2: a_2x + b_2y + c_2 = 0$ are intersecting at a particular point as shown in the figure. Then the equation of pair of straight line can be represented by the single equation which is obtained by multiplying the equations of given line.

Hence equation of pair of straight line is $\boxed{(a_1x + b_1y + c)(a_2x + b_2y + c) = 0}$



Example 1: Find the single equation representing a line $x = y$ and $x = 2y + 1$.

Solution:

Given

$L_1 : x = y \; or \; x - y = 0$

$L_2 : x = 2y + 1 \; or \; x - 2y - 1 = 0$

The single equation is

$$(x - y)(x - 2y - 1) = 0$$

$$x^2 - 2xy - x - xy + 2y^2 + y = 0$$

$$\boxed{x^2 - 3xy + 2y^2 - x + y = 0}$$

Example 2: Find the straight lines given by the equation $x^2 - 5xy + 4y^2 = 0$

Solution:

Given

$x^2 - 5xy + 4y^2 = 0$

$x^2 - xy - 4xy + 4y^2 = 0$

$x(x - y) - 4y(x - y) = 0$

$(x - 4y)(x - y) = 0$

$L_1 : x - 4y = 0$ and $L_2 : x - y = 0$

ACTIVITY 4

1. Using the equation of pair of straight line, solve the following questions in your notebook.
   i. Write the combined equation represented by the lines $x + y = 1 \; and \; x - y = 4$?
   ii. Find the straight line given by the equation $x^2 - y^2 = 0$.

Summary

- In a pair of coordinates, x-coordinate is known as abscissa and y-coordinate is known as ordinate.

- Distance between two points are calculated using the formula $d=\sqrt{\left(x_2-x_1\right)^2+\left(y_2-y_1\right)^2}$.
- The coordinate of point P which divides the join of two points at certain ratio is found using section formula.
- The straight line is the simplest geometry curve and the general equation of line is $\boxed{ax+by+c=0}$.
- There are 3 special form of straight namely intercept-slope form, point-slope form and two-point form.
- The interior angle formed at the intersection point of two lines are calculated using the formula $\tan\theta=\left|\frac{m_1-m_2}{1+m_1m_2}\right|$.
- Two lines are parallel if their slopes are equal.
- Two lines are perpendicular to each other if the slope of one line is negative reciprocal of slope of the other line.
- The equation of pair of straight line can be obtained by multiplying the equations of given lines.

Self-check for Learning

1. A line of the length 10, and one end is at the point (-3, 2). If the ordinate of the other end be 10, prove that the abscissa will be 3 or -9.
2. Find the radius of the circle that has its centre (0, -4) and passes through $\left(\sqrt{13},2\right)$.
3. What is the coordinate of centre of circle if the end points of diameter are (-5,7) and (3, -11)?
4. State the equation of three special form of straight line.
5. Find the intercepts of the line $3x+4y-12=0$.
6. Find the slope of the line which makes an angle of 45^0 with a line of slope $-\frac{6}{5}$?
7. Find the equation of a line that passes through (-5,3) and (0, -7).
8. Show that the lines

   $a.\ y=\frac{2}{3}x+8$ and $y=\frac{2}{3}x-3$ are parallel

   $b.\ y=2x+8\ \text{and}\ y=-\frac{1}{2}x+14\ \text{are perpendicular}$

6. Coordinate Geometry: Conic Section

- Definition of conics
- Standard form of parabola, ellipse and hyperbola.
- Change in the form when focus or centre is shifted from origin to another place.
- Find the equation for a conic when the basic information like focus directrix are given.
- Find the basic information from a given equation.

Introduction

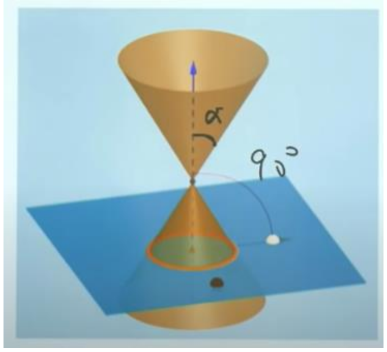
The knowledge of conic sections can be traced back to Ancient Greece. Menaechmus is credited with the discovery of conic sections around the years 360-350 B.C. following the work of Menaechmus, these curves were investigated by Aristaeus and of Euclid. The next major contribution to the growth of conic section theory was made by the great Archimedes. Apollonius, on the other hand, is known as the "Great Geometer" on the basis of his text *Conic Sections*.

The paths of the planets around the sun are ellipses with the sun at one focus. parabolic mirrors are used to converge light beams at the focus of the parabola. parabolic microphones perform a similar function with sound waves.

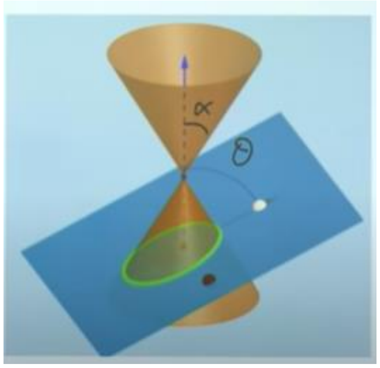
Conic sections are very important because they are useful in studying 3D geometry which has wide applications. In electromagnetic field theory it helps us study the nature of the field inside different shapes of conductors. Knowledge on conic sections is required for designing antennas like conical antenna, pyramidal antenna, parabolic reflectors etc.

The curve obtained by the intersection of a **plane** and a **double cone** in different orientation are called ***Conic section.*** The three types of conics are **parabola, ellipse and hyperbola.**

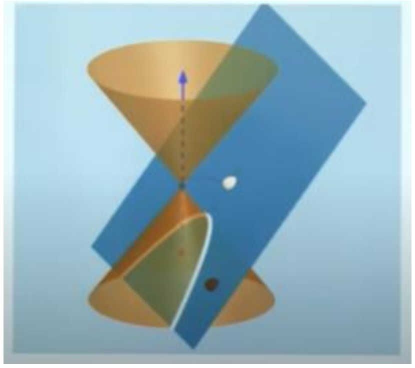
- When the cutting plane is at the right angels to the axis of the cone, the curve of intersection is **a circle.**



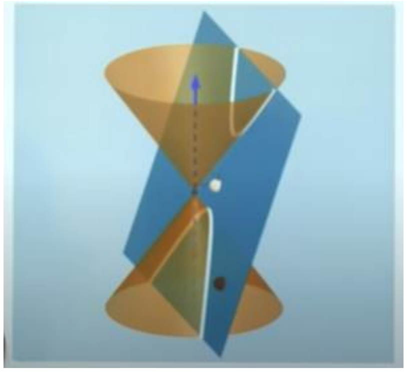
- When the cutting plane is somewhat inclined to the direction of axis and cuts only one cone, the curve of intersection is **an ellipse.**



- When the cutting plane is parallel to generating line of the cone, the conic formed is called a **parabola.**



- When the cutting plane is still more inclined and intersects both nappes, the curve of intersection is a **hyperbola.**



A conic section or a conic, is the locus of a point which moves so that its distance from a fixed point **(focus**) is in a constant ratio **(eccentricity, *e*)** to its distance from a fixed straight line **(directrix).**

If *e* = 1, the curve is a *parabola*.

If *e* < 1, the curve is an *ellipse.*

If *e* > 1, the curve is a *hyperbola.*

The straight line passing through the focus and perpendicular to the directrix is called ***axis.***

A point of intersection of a conic with its axis is called ***vertex*.**

PARABOLA:

A parabola is the locus of the point(P) which moves such that its distance from a fixed point (focus,S),bears a constant ratio equal to 1(e=1), to its distance from a fixed line (directrix)

Let S be the focus and DD_1 be directrix. Draw SZ perpendicular to the directrix. Bisect SZ at A such that $|SA| = |AZ| = a$. Take A as the origin and AS be the positive x-axis.

Then the coordinates of the focus S are (a,0) and the equation of directrix DD_1 is

$x = -a$. or $x + a = 0$

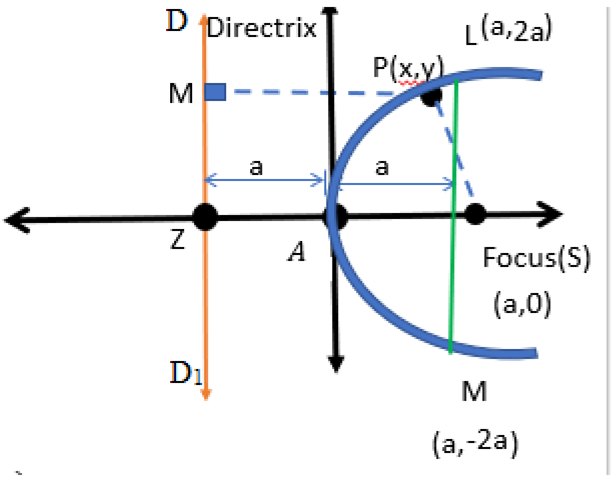
Let P (x,y) be any point on the locus .

By using distance formula

$$PS = \sqrt{(x-a)^2 + (y-0)^2}$$

Since PM is perpendicular to the line $x + a = 0$,

$$PM = \left|\frac{x+a}{1}\right|$$



By definition of the parabola, PS = PM

$$\sqrt{(x-a)^2 + (y-0)^2} = \left|\frac{x+a}{1}\right|$$

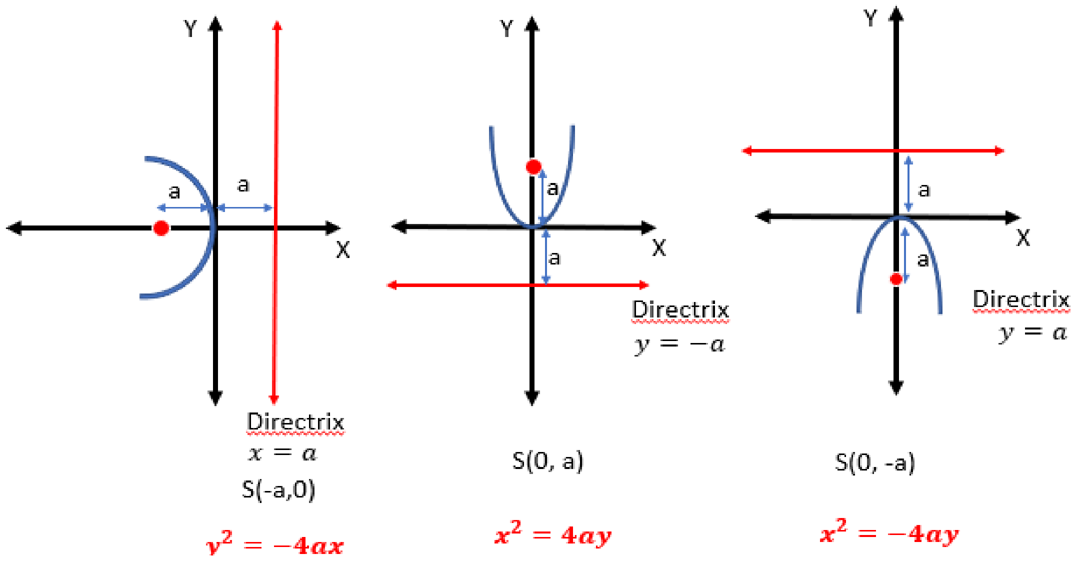
$$(x-a)^2 + (y-0)^2 = (x+a)^2$$

$$x^2 - 2ax + a^2 + y^2 = x^2 + 2ax + a^2$$

$$y^2 = 4ax$$

Standard equation of a parabola is $y^2 = 4ax$

Other standard forms of the parabola:



Summary of the main facts about parabolas in standard form:

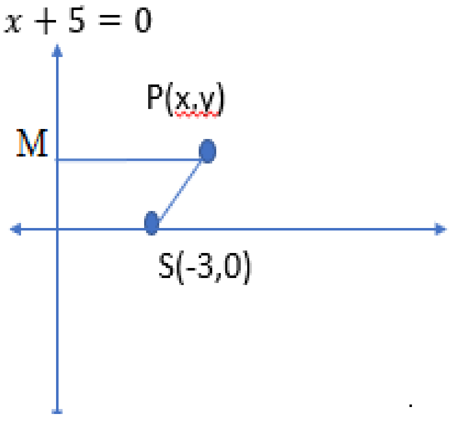
Equation	$y^2 = 4ax$	$y^2 = -4ax$	$x^2 = 4ay$	$x^2 = -4ay$
Axis	$y = 0$	$y = 0$	$x = 0$	$x = 0$
Directrix	$x + a = 0$	$x - a = 0$	$y + a = 0$	$y - a = 0$
Vertex	(0,0)	(0,0)	(0,0)	(0,0)
Focus	(a, 0)	(- a,0)	(0,a)	(0, -a)
Length of latus rectum	4a	4a	4a	4a
Equation of latus rectum	$x - a = 0$	$x + a = 0$	$y - a = 0$	$y + a = 0$
Equation of tangent	$x = 0$	$x = 0$	$y = 0$	$y = 0$

The equations of the parabola when the vertex is shifted from origin to another point (h,k).

Equation at (0,0).	Equation at (h,k)
$y^2 = 4ax$	$(y-k)^2 = 4a(x-h)$
$y^2 = -4ax$	$(y-k)^2 = -4a(x-h)$
$x^2 = 4ay$	$(x-h)^2 = 4a(y-k)$
$x^2 = -4ay$	$(x-h)^2 = -4a(y-k)$

Example 1

Find the equation of parabola if the focus is (-3,0) and directrix $x + 5 = 0$.



Solution:

$PS = PM$

$$\sqrt{(x+3)^2 + (y-0)^2} = \frac{x+5}{\sqrt{1^2+0^2}}$$

Squaring both the sides

$$(x+3)^2 + (y-0)^2 = \frac{(x+5)^2}{1}$$

$x^2 + 9 + 6x + y^2 = x^2 + 25 + 10x$

$y^2 = 25 + 10x - 6x - 9$

$y^2 = 4x + 16.$

Example 2

For the parabola $y^2 = 16x$, find the coordinates of the focus, length of the latus rectum and the equation of the directrix.

Solution:

The equation $y^2 = 16x$ is of the standard form $y^2 = 4ax$, and can be written as $y^2 = 4.4.x$.

Here $a = 4$.

Hence the coordinates of the focus are $(a,0) = (4,0)$.

Length of the latus rectum is $4a = 4\times4 = 16$ units.

The equation of the directrix is $x = -a$, hence $x = -4$ or $x + 4 = 0$.

Example 3

Find the vertex, focus, length latus rectum and directrix of the parabola $y^2 - 2y + 8x - 23 = 0$.

Solution:

The equation, $y^2 - 2y + 8x - 23 = 0$ can be written as

$y^2 - 2y = -8x + 23 \Rightarrow y^2 - 2y + 1 = -8x + 23 + 1$

$\Rightarrow (y-1)^2 = -8x + 24,$

$\Rightarrow (y-1)^2 = -8(x-3).$

Shifting the origin to the point (1,3) by putting $X = (x-3)$ and $Y = (y-1)$, the above equation becomes $Y^2 = -8X \Rightarrow Y^2 = -4(2)X$, which can be compared to the form $y^2 = -4ax$

$\therefore a = 2$. Length of L.R(latus rectum) $= 4a = 8$ units.

With respect to new axes X and Y,

Vertex is (0,0), focus is (-a,0) and equation of directrix is X = a.

We have $X = x - 3$ and $Y = y - 1$

$\Rightarrow x = X + 3$ and $y = Y + 1$

So, with respect to original axes x and y,

Vertex is (0+3, 0+1) = (3,1).

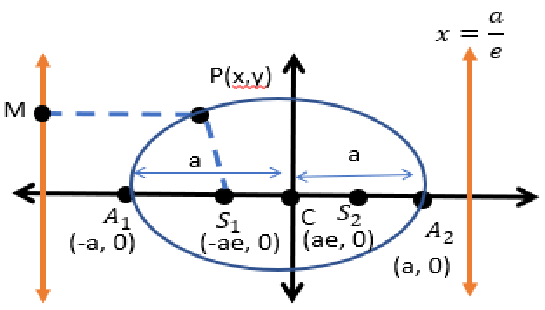
Focus is (-2 +3, 0+1) = (1,1) and equation of directrix is $x - 3 = 2 \Rightarrow x = 5 \Rightarrow x - 5 = 0$.

ACTIVITY 1

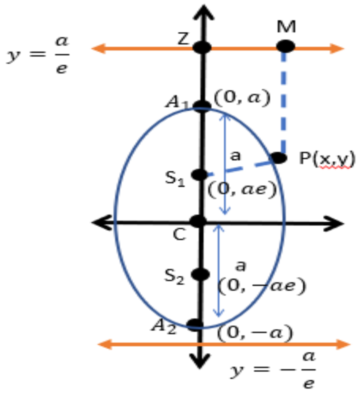
1. Solve the following questions.
   (i) Find the equation of the parabola: The focus at (1,1), the directrix $x - y = 3$.
   (ii) The equation $y^2 - 4y - 4x + 16 = 0$ represents a parabola. Find its vertex, focus length of latus rectum and equation of directrix.

Ellipse

An ellipse is the locus of the point which moves such that its distance from a fixed point (focus), bears a constant ratio less than 1(e < 1), to its distance from a fixed line (directrix).



The standard equation of an ellipse is $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ if the major axis is along X axis and $a > b$



The standard equation of an ellipse is $\frac{x^2}{b^2} + \frac{y^2}{a^2} = 1$ if the major axis along the Y axis, and $a > b$

Summary of the main facts about ellipses in standard form:

Equation	$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$	$\frac{x^2}{b^2}+\frac{y^2}{a^2}=1$
Co-ordinates of centre	(0,0)	(0,0)
Co-ordinates of foci	$(\pm ae, 0)$	$(0, \pm ae)$
Co-ordinates of vertices	$(\pm a, 0)$	$(0, \pm a)$
Equation of Major Axis	$y = 0$	$x = 0$
Equation of Minor Axis	$x = 0$	$y = 0$
Equation of Directrices	$x = \pm\frac{a}{e}$	$y = \pm\frac{a}{e}$
Length of Major axis	$2a$	$2a$
Length of Minor axis	$2b$	$2b$
Length of latus recta	$\frac{2b^2}{a}$	$\frac{2b^2}{a}$
Eccentricity	$e^2=1-\frac{b^2}{a^2}$	$e^2=1-\frac{b^2}{a^2}$

If the centre is shifted from the origin to (h,k) the equation changes as $\frac{(x-h)^2}{a^2}+\frac{(y-k)^2}{b^2}=1$, if the major axis is parallel to the x-axis and $\frac{(x-h)^2}{b^2}+\frac{(y-k)^2}{a^2}=1$, if the major axis is parallel to the y-axis

Example 1

Find the equation of the conic section whose focus is (1,-1), eccentricity is $(\frac{1}{2})$ and directrix is the line $x - y = 3$. Is the conic section an elipse?

Solution

$$PS = ePM$$

$$\sqrt{(x-1)^2+(y+1)^2} = \frac{1}{2}\frac{x-y-3}{\sqrt{1^2+(-1)^2}}$$

Squaring both the sides

$$(x-1)^2+(y+1)^2 = \frac{1}{4}\frac{(x-y-3)^2}{2}$$

$$x^2+1-2x+y^2+2y+1 = \frac{1}{8}(x^2-xy-3x-xy+y^2+3y-3x+3y+9)$$

$$8x^2+8y^2-16x+16y+16 = x^2-2xy-6x+y^2+9+6y$$

$$7x^2+7y^2-10x+10y+2xy+7=0$$

Yes, the conic section is an ellipse because e<1

Example 2

Find the equation of the ellipse whose foci are at the points (2,0) and (-2, 0) and whose latus rectum is 6.

Solution:

Let a,b be the semi major and semi minor axes of the ellipse and e its eccentricity. Since the foci lie on the x axis, the major axis lies along x axis. The centre is the midpoint of the distance between the foci, the origin.

$\therefore$ The equation of the ellipse is $\frac{x^2}{a^2}+\frac{y^2}{b^2}=1.$

The distance between the foci $2ae = 4$ or $ae = 2$.

Since the latus rectum = 6,

$\frac{2b^2}{a}=6$ or $b^2 = 3a$………... (i)

We know $b^2 = a^2 - (ae)^2 = a^2 - 4$ …………. (ii).

Using comparison strategy,

$a^2 - 4 = 3a$

$a^2 - 3a - 4 = 0$

$(a - 4)(a + 1) = 0$

$a = 4$ or $a = -1$(*ignored as distance cannot be in negative*). $\therefore$ $a = 4$.

$a^2 = 16$ and $b^2 = 3\times4 = 12$.

Hence the required equation is $\frac{x^2}{16}+\frac{y^2}{12}=1$

Example 3

Find the eccentricity, distance between the foci, equation of the directrices and the length of latera recta of the ellipse $25x^2 + 16y^2 = 400$.

Solution:

$25x^2 + 16y^2 = 400$.

This equation can be brought to the standard form by dividing both sides by 400 and thus becomes

$\frac{x^2}{16}+\frac{y^2}{25}=1$ $\Rightarrow$ $a^2 = 25$ and $b^2 = 16$ as $a^2 > b^2$

$\therefore$ $a = 5$ and $b = 4$.

(i) The eccentricity $e=\sqrt{1-\frac{b^2}{a^2}}=\sqrt{1-\frac{16}{25}}=\sqrt{\frac{9}{25}}=\frac{3}{5}$

(ii) The distance between the foci $2ae = 2 \times 5 \times \frac{3}{5} = 6$ units.

(iii) Equation of the directrices $y = \pm\frac{a}{e} = \pm 5 \times \frac{5}{3} = \pm\frac{25}{3}$.

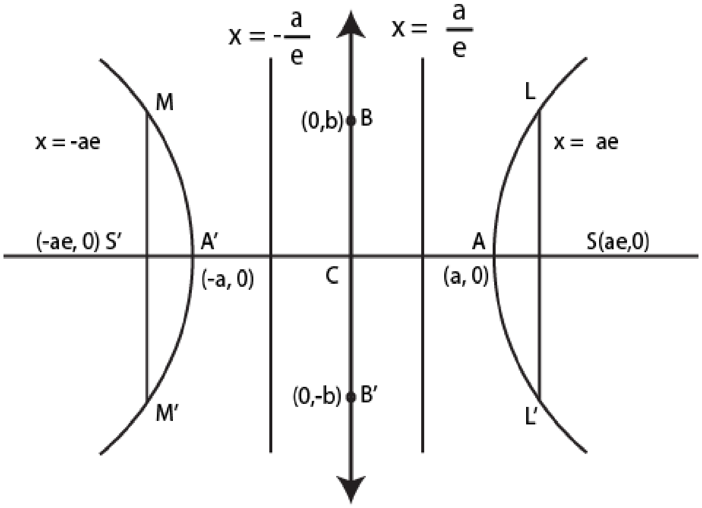
(iv) Length of latus rectum = $\frac{2b^2}{a} = \frac{2\times16}{5} = \frac{32}{5}$

ACTIVITY 2

1. Find the equation of the ellipse with focus at (0,0), eccentricity is $\frac{5}{6}$ and the directrix is $3x + 4y - 1 = 0$.
2. Find the eccentricity, coordinates of foci, length of the latus rectum of the ellipse $4x^2 + 9y^2 = 36$.

Hyperbola

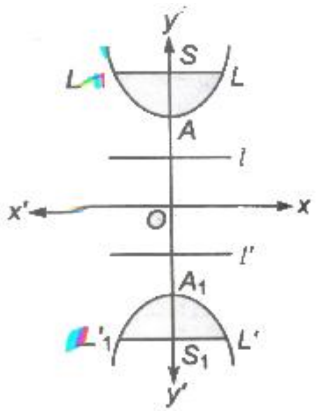
A hyperbola is the locus of the point which moves such that its distance from a fixed point (focus), bears a constant ratio greater than 1(e > 1), to its distance from a fixed line (directrix)



The standard equation of a hyperbola is $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$ if the transverse axis is along X axis.

Conjugate hyperbola

The hyperbola whose transverse axis is along the *y*- axis is called conjugate hyperbola



The standard equation of a conjugate hyperbola is $\frac{y^2}{a^2} - \frac{x^2}{b^2} = 1$

If the centre is shifted from the origin to (h,k) the equation changes as $\frac{(x-h)^2}{a^2} - \frac{(y-k)^2}{b^2} = 1$, if the transverse axis is parallel to the *x*-axis and $\frac{(y-k)^2}{a^2} - \frac{(x-h)^2}{b^2} = 1$, if the transverse axis is parallel to the y-axis

Summary of the main facts about ellipses in standard form:

Equation	$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$	$\frac{y^2}{a^2} - \frac{x^2}{b^2} = 1$
Co-ordinates of centre	(0,0)	(0,0)
Co-ordinates of foci	$(\pm ae, 0)$	$(0, \pm ae)$
Co-ordinates of vertices	$(\pm a, 0)$	$(0, \pm a)$
Equation of Transverse axis	$y = 0$	$x = 0$
Equation of Conjugate axis	$x = 0$	$y = 0$
Equation of Directrices	$x = \pm\frac{a}{e}$	$y = \pm\frac{a}{e}$
Length of Transverse axis	$2a$	$2a$
Length of Conjugate axis	$2b$	$2b$
Length of latus recta	$\frac{2b^2}{a}$	$\frac{2b^2}{a}$
Eccentricity	$e^2 = 1 + \frac{b^2}{a^2}$	$e^2 = 1 + \frac{b^2}{a^2}$

Example 1

Find the equation of hyperbola whose focus is (2,0), directrix $x - y = 0$ and eccentricity 2.

Solution:

PS=$\sqrt{(x-2)^2 + (y-0)^2}$

$$d = \frac{ax + by + c}{\sqrt{a^2 + b^2}}$$

PM=$\frac{x-y}{\sqrt{1^2+(-1)^2}}$

PS = ePM

$$\sqrt{(x-2)^2 + (y-0)^2} = 2\times \frac{x-y}{\sqrt{2}}$$

Squaring both the sides

$$(x-2)^2 + (y-0)^2 = 4\text{x} \frac{(x-y)^2}{2}$$

$$x^2 + 4 - 4x + y^2 = 2(x^2 + y^2 - 2xy$$

$$x^2 + 4 - 4x + y^2 = 2x^2 + 2y^2 - 4xy.$$

Hence the equation is

$$x^2 - 4xy + y^2 + 4x - 4 = 0$$

Example 2

Find the axes, vertices foci, eccentricity, equation of the directrices and length of the latus rectum of the hyperbola $9x^2 – 16y^2 = 144$.

Solution:

The given equation can be written in the form $\frac{x^2}{16} - \frac{y^2}{9} = 1$by dividing all the terms by 144.

Here $a = 4$, $b = 3$, $e^2 = 1+\frac{9}{16} = \frac{25}{16}$ $\quad\therefore e = \frac{5}{4}$ and $ae = 5, \frac{a}{e} = \frac{16}{5}$.

The transverse axis is along x axis.

(i) The centre is (0,0) (ii) the foci are $(\pm ae, 0), i.e., (\pm 5,0)$

(i) The vertices are $(\pm a, 0), i.e., (\pm 5,0)$.

(ii) Equations of the directrices are $x = \pm\frac{a}{e}$, $i.e., x = \pm\frac{16}{5}$.

(iii) Length of latus rectum = $\frac{2b^2}{a} = \frac{2\times 9}{4} = \frac{9}{2}$.

Example 3

Find the equation of the hyperbola whose centre is (-4,1), vertex (2,1) and semi conjugate axis is equal to 4.

Solution:

The distance between the centre to vertex $a = 6$. Semi conjugate $b = 4$.

Hence the equation of the hyperbola is $\frac{(x+4)^2}{36} - \frac{(y-1)^2}{16} = 1$

Summary

- A conic section or a conic, is the locus of a point which moves so that its distance from a fixed point **(focus)** is in a constant ratio **(eccentricity, *e*)** to its distance from a fixed straight line **(directrix).**
- If $e = 1$, the curve is a *parabola*.
  If $e < 1$, the curve is an *ellipse*.
  If $e > 1$, the curve is a *hyperbola***.**
- Standard equation of a parabola is $y^2 = 4ax$
- The standard equation of an ellipse is $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ if the major axis is along *X* axis and $a^2 > b$
- The standard equation of a hyperbola is $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$ if the transverse axis is along *X* axis.
- The standard form changes if the vertex or centre is shifted from origin to another point (h,k).

Self-check for Learning

1. The parabola $y^2 = 4px$ passes through the point (3, - 2). Obtain the length of latus rectum and the coordinates of the focus.
2. Find the latus rectum and eccentricity of the ellipse whose semi axes are 5 and 4.
3. Find the equation of the ellipse with its centre at (3,1), vertex at (3, -2) and eccentricity is $\frac{1}{3}$.
4. Find the equation of the hyperbola whose focus is (2,0), directrix is $x - y = 0$ and eccentricity is 2.
5. Find the centre, vertices, foci, eccentricity and latus rectum of the hyperbola

$$9x^2 - 16y^2 - 18x - 64y - 199 = 0$$

SCIENCE STREAM

1. BIOLOGY

1.1 Human Heart

- Describe the structure of the human heart.
- Identify major blood vessels of the heart.
- Explain the origination and conduction of heartbeat.
- Tell some ways to keep the heart healthy.

Introduction

Let us think for a while on the following questions.

1. *What makes our blood move continuously throughout the body?*
2. *How does oxygen reach our toes and head from the respiratory system?*
3. *People touch left side of the chest to feel their heart beats. Does it mean our heart is on the left side of the chest?*

Human Heart:

The human heart is one of the most important organs responsible for sustaining life. It is situated in the middle of the thoracic cavity between the lungs. It is a hollow muscular and cone-shaped organ about the size of a clenched fist. The conical part of the heart is tilted toward the left side that is why we feel our heart beats at the left side of the chest.

External Structure of Heart:

The heart is enclosed in the *pericardium* that protects the heart and fastens it inside the chest. Pericardium is a thin-walled structure composed of a serous visceral layer (epicardium) and a fibrous parietal layer, both of which surround and protect the heart. Between these layers, parietal cavities are found filled with pericardial fluid**. Pericardial fluid** lubricates heart to prevent friction with tissues around it and absorbs physical shocks.

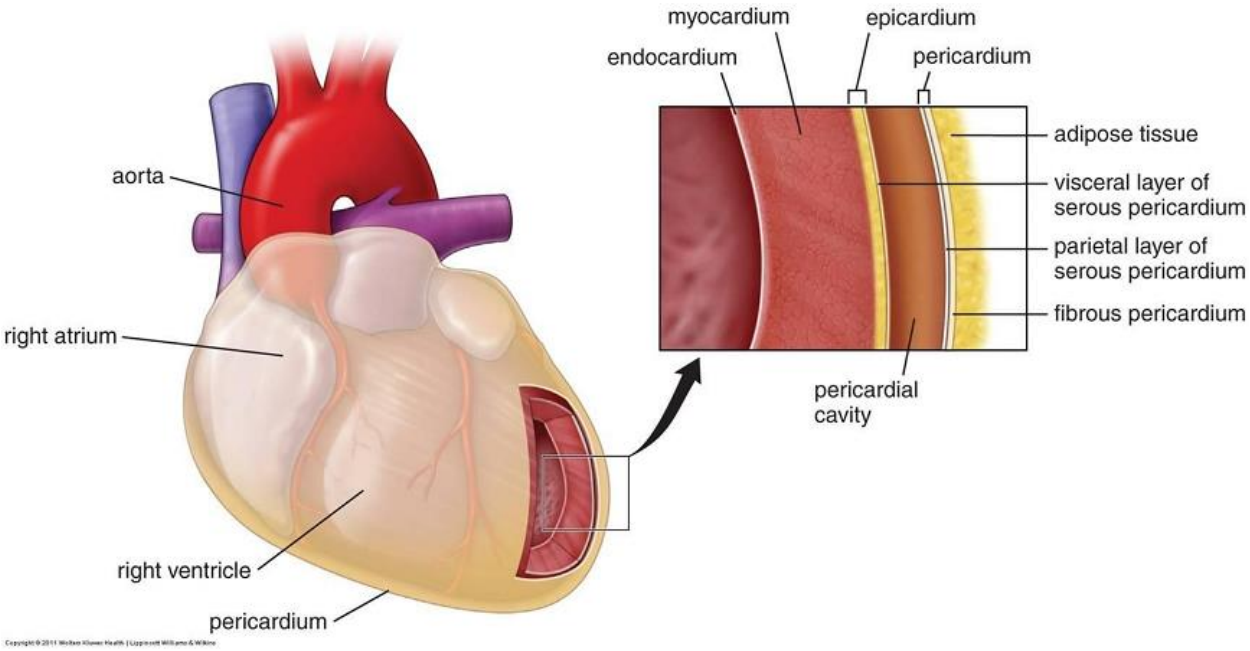


Figure: Layers of Heart Wall
Source: https://www.toppr.com/ask/question/what-is-epicardium-endocardium-and-myocardium/

Cardiac muscle cells are located in the walls of the heart and consists of the epicardium (external layer), the myocardium (middle layer) and the endocardium (inner layer) as shown in figure 2.

Chambers are internally separated by a wall called S***epta*** and the separation looks like grooves or depressions also known as ***Sulcus.*** Grooves are classified into three depending upon their position.

- *Coronary Sulcus* is the groove which divides the *auricular part* and *ventricular part.*
- *Inter ventricular Sulcus* can be seen in between ventricles.
- *Internal groove* separates *Right* and *Left atrium.*

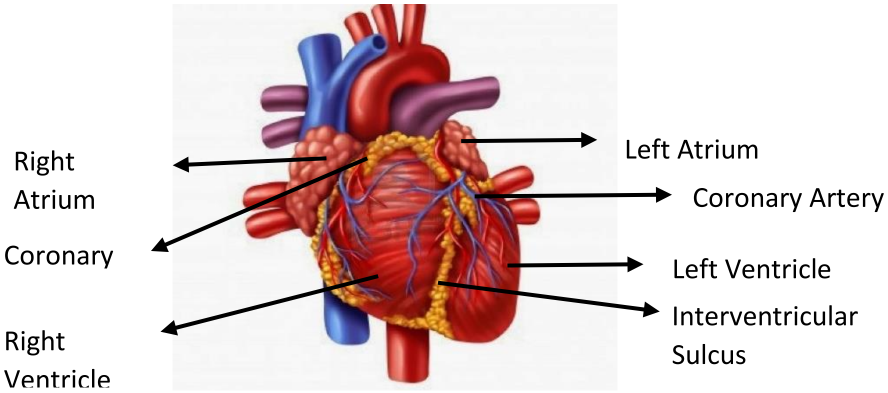


Figure: External structure of the human heart

Source: http://clipart-library.com/heart-diagram-unlabeled.html

ACTIVITY 1

1. Name the fluid that protects heart from physical shock and friction
2. How many heart chambers do you see in Figure 3.? Name all the heart chambers.
3. Name the groove which divides the heart into anterior auricular part and posterior ventricular part.
4. Name the groove which divides the ventricular chamber of heart into two.

Internally human heart is also divided into two auricles. They are divided into left and right auricle and two ventricles are divided into left and right ventricles by inter-ventricular septum.

ACTIVITY 2

Instruction: Study the Figure and the information given below carefully and complete the table.

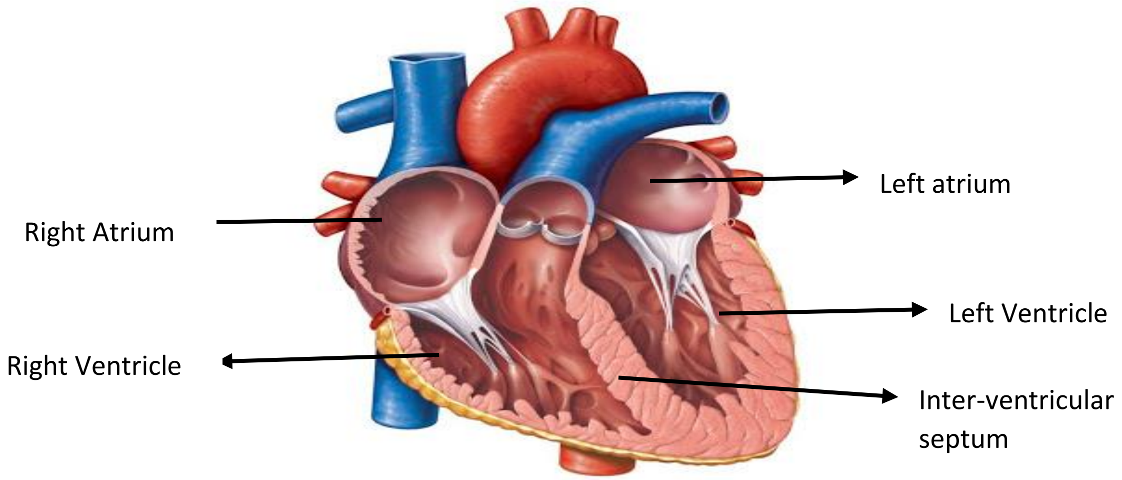


Figure: Internal Structure of Human Heart

Source: https://quizlet.com/268209055/internal-anatomy-of-the-heart-diagram/

Atria (singular: atrium)	The two upper chambers of the heart	They are thin-walled chambers that receive blood from the parts of the body and deliver it into the adjacent ventricles.
Ventricles	The two lower chambers of the heart	They are thick-walled chambers that receive blood from the adjacent atria and deliver to the rest of the body.

Characters	**Atria**	**Ventricles**
Chamber wall	Thin muscular wall	Thick muscular wall
Function		
Pumps blood into		

Human heart pumps the blood throughout the body via the blood vessels, supplying oxygen and nutrients to the tissues and removing carbon dioxide and other wastes. The blood vessels that enter and leave the heart are called **great blood vessels**.

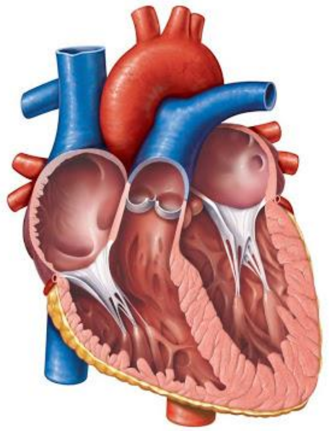


Figure: Human heart

Source:https://quizlet.com/268209055/internal-anatomy-of-the-heart-diagram/

Clues

Superior Venacava: brings deoxygenated blood from upper portion of the body into the right atrium.

Inferior Venacava: brings deoxygenated blood from lower portion of the body into the right atrium.

Pulmonary artery: carries deoxygenated blood from the right ventricle into the lungs, for oxygenation.

Pulmonary vein: The pulmonary veins bring oxygen-rich blood to the left atrium.

Aorta: Carries oxygen-rich blood from the left ventricle to the different parts of the body.

Remember:

- **Coronary artery** supplies blood to the walls of the heart.
- **Coronary sinuses** bring blood from the heart walls back to the atria.

Valves of Mammalian Heart

A heart valve allows the blood to flow only in one direction by preventing the back flow of the blood.

Tricuspid valve: This valve guards the right atrio-ventricular (AV) aperture that opens between the right atrium and the right ventricle.

Bicuspid or mitral valve: This valve guards the left atrio-ventricular (AV) aperture opens between left atrium and the left ventricle.

Eustachian valve: This valve guards the opening of inferior vena cava.

Semilunar Valves: These are the half–moon shaped valves located at the base of pulmonary artery and right ventricle (known as pulmonary semilunar valve) and aorta and the left ventricle (known as aortic semilunar valve).

ACTIVITY 3

Now let us label the diagram!

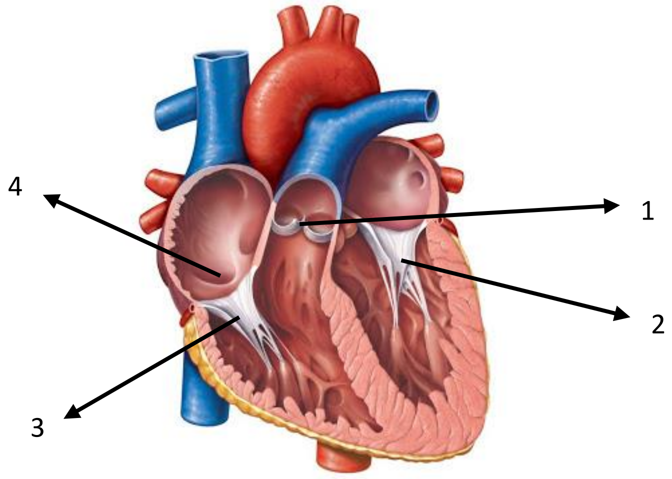


Figure: Human heart showing valves

Remember

There is one more valve, **thebesius valve** which guards the opening of coronary sinus.

Origination and Conduction of Heart Beat

Put your hand on the chest, close your eyes and feel your heartbeat. How does it sound?
In reality, the sound of heart heartbeat is 'Lub Dub'. These are produced by the closure of AV valves (Tricuspid and bicuspid valves) and semilunar valves.
Let us explore more on how heartbeat is originated and conducted in the heart.
Our heartbeat is controlled by a tissue called nodal tissue. It is formed by the modification of cardiac muscle. Nodal tissue is also called conducting system of the heart.
The cardiac muscle of sino atrial node is self-excitable and act as pace maker. Cardiac electrical signals arising in the sino-atrial node (located in the right atrium) stimulate the atria to contract.

Then the signals travel to the atrioventricular node (AV node), where it is amplified, which is located in the interatrial septum. After a delay, the electrical signal diverges and is conducted through the left and right bundle of His to the respective Purkinje fibres to each side of the heart, as well as to the endocardium at the apex of the heart, then finally to the ventricular epicardium; causing its contraction. These signals are generated rhythmically, which in turn results in the coordinated rhythmic contraction and relaxation of the heartbeats.

ACTIVITY 4

Instruction: Carefully study the Figure which shows the conduction of heartbeat. Then complete the sentences.

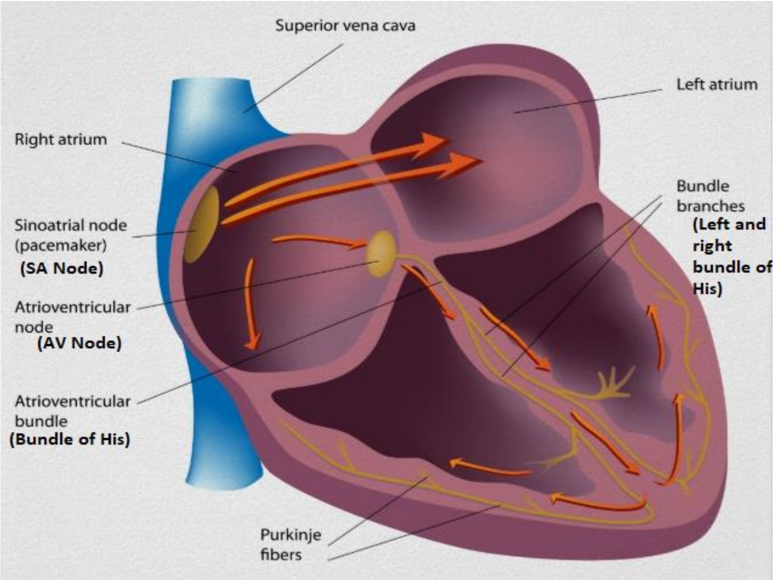


Figure: Origin and Conduction of Heartbeat

Source: https://www.canstockphoto.com/heart-cross-section-labeled-6231800.html

i. __________________ are self-excitable. It generates an electric impulse (wave of contraction), called a cardiac impulse, every 0.8 sec.
ii. The wave then passes through the conducting system of the heart.
iii. The waves, first spreads to the muscles of ____________________.
iv. Then it passes to the ___________________ which amplifies the impulse.
v. The amplified impulse then passes downward along the two side of interventricular septum through the left and right _____________________.
vi. The impulse is then passing on to ____________________, which are in connected to the ventricular muscles.
vii. The ventricular muscles contract from the tip toward the base.

Importance of Healthy Heart

It is very important to keep our heart healthy for proper circulation of blood. Dysfunction of heart leads to diseases including atherosclerosis (hardening of the arteries), hypertension (high blood pressure), and high cholesterol. Some of the ways to keep our heart healthy are by:

1. Exercising regularly.
2. Taking nutritious food.
3. Saying No to smoke and drugs.
4. Managing stress.

Summary

- Human heart is four chambered with two auricles and two ventricles.
- Primary function of the heart is to pump the blood throughout the body.
- Heart is located in the centre of our thoracic cavity.
- Blood in the pulmonary artery picks up oxygen and become oxygenated and travels back to the heart through the pulmonary veins into the left atrium.
- Human heart involves in transportation of gases, food, wastes, distribution of blood etc.
- Our heartbeat is controlled by a tissue called as nodal tissue.

Self-check for Learning

1. How does the heart get its blood supply?
2. What carries blood away from the heart?
3. Explore some more ways to maintain a healthy heart.

1.2 Sexual Reproduction in Flowering Plants

- To differentiate pollination and fertilisation.
- State the importance of pollination.
- Explain the process of fertilisation.
- Explain the significance of double fertilisation.

Sexual Reproduction in Flowering Plants

Sexual reproduction involves the formation and fusion of haploid male and female gametes. A male and female gamete fuse to form a diploid zygote. Rudolph Jacob Camerarius, the German Botanist demonstrated sexuality in plants.

Let us now explore more on sexual reproduction in plants.

Animals have reproductive organs to help in sexual reproduction. Sperm and ovum are the male and female gametes in human. Do plants have such kind of system to help in their reproduction?

Flower

Flowers are organ of sexual reproduction. The four whorls of the flower are:

1. Calyx: It is formed of green sepals.
2. Corolla: It is formed of coloured or white petals.
3. Androecium: It is the male reproductive whorl formed of stamens.
4. Gynoecium: It is the female reproductive whorl formed of carpels.

Out of the four whorls, calyx and corolla are termed as non-essential or accessory whorls they are not directly associated with sexual reproduction. Whereas, Androecium and gynoecium are directly involved in sexual reproduction and are called essential or reproductive whorls.

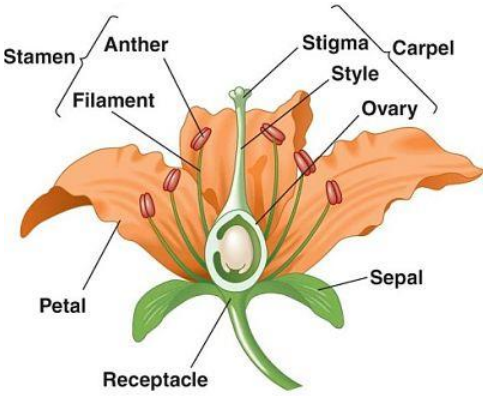


Figure: Internal Structure of Flower

Source: https://www.askiitians.com/biology/sexual-reproduction-in-flowering-plants/

Pollination

It is the process of transference of pollen grains from the anther to the stigma of the flower. It is broadly classified as:

1. **Self-pollination**

   It is the transfer of pollen grain from the anther to the stigma of the same flower or another flower borne on the same plant. Self-pollination is classified into two they are autogamy and geitonogamy.

   i. **Autogamy** is the transfer of pollen grains from the anther to the stigma of the same flower.

   ii. **Geitonogamy** is the transfer of pollen grains from one flower to another flower borne on the same plant but a different flower.

2. **Cross-pollination**

   It is the transference of pollen grains from the anther to the stigma of the flowers of different plants but of the same species.

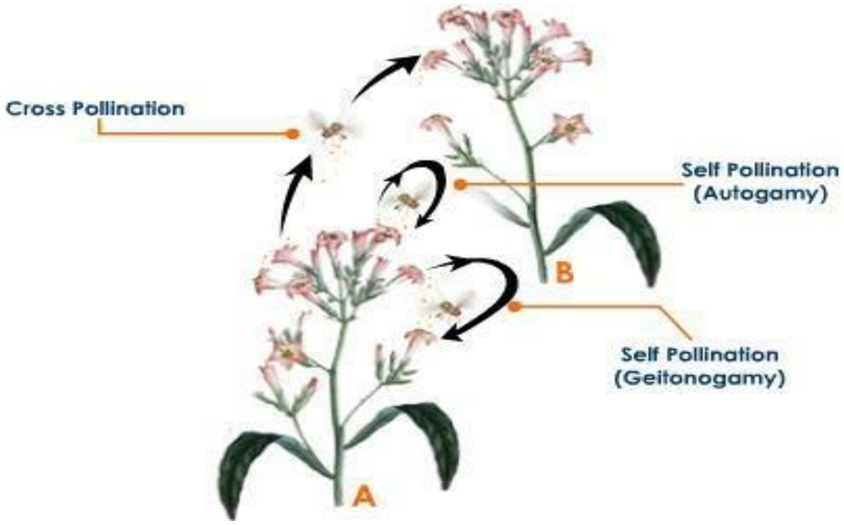


Figure: Pollination in plants

Source: https://www.serenataflowers.com/pollennation/guide-to-flower-pollination/

Cross-pollination takes place with the help of an external agency referred to as vectors. They may be abiotic or biotic factors. Abiotic factors are non-living factors like wind or water. Biotic factors are living factors like insects, birds, bats, etc.

Advantages of Cross-pollination

- It leads to the formation of individuals with new useful characters.
- It is used for developing new varieties of vegetables and fruits.
- It enables the plants to adapt to the new environment.
- It helps to produce healthier seeds for better yield.

ACTIVITY 1

1. What would happen if pollination does not occur in flowering plants?
2. In which kind of flowers does geitonogamy take place?
3. How is self-pollination different from cross-pollination?

Did you know that some plants do not fertilise by their pollen grains though they bear bisexual flowers? Let us find out the reasons.

Adaptations to ensure Cross-pollination

Some of the adaptive features that some of the plants have to avoid self-pollination are:

1. **Unisexuality**: When flowers are unisexual, self-pollination is not possible. These flowers may be two types monoecious or dioecious.
   - **Monoecious:** Plants with both male and female flowers are borne on the same plant like in pumpkin, maize and cucumber.
   - **Dioecious plants:** Plants with male and female flowers are borne on separate plants like in papaya and mulberry.
2. **Dichogamy:** It is a condition where anthers and stigma in a bisexual flower mature at different times. It may be two types:
   a. **Protandry** is a condition in which anthers mature earlier so that its stigma is not ready to receive pollen from its anthers. For example: Salvia, sunflower, cotton, etc.
   b. **Protogyny** is a condition in which stigma matures earlier so that it gets pollinated before the anthers of the same flower mature and develop pollen grains. For example: Gloriosa, Plantago, Mirabilis Jalapa, etc.
3. **Heterostyly:** The condition of flowering plants in which flowers of the same species have styles of different length, so that the stigma is positioned below the anthers in some flowers and above them in others. For example: Primola, lathyrus and oxalis.
4. **Herkogamy**: The condition in which some physical barriers prevent them from self-pollination even if the stigma and anthers mature at the same time.
5. **Prepotency:** Pollen grains coming from some other flowers grow faster than the pollen grains of their flowers. For example: Apple and grape.
6. **Self-sterility**: In some bisexual flowers pollen grains of one flower fails to grow on the stigma of the same flower to avoid self- pollination.

ACTIVITY 2

1. How is protandry different from protogyny?
2. What are the two types of heterostyly?

Main events in Sexual Reproduction

1. Pre fertilisation event: is the development of male and female gametophyte.
2. Fertilisation event: Fusion of male and female gametes.
3. Post Fertilisation event: Formation and development of endosperm, embryo and fruit.

Pollen grain

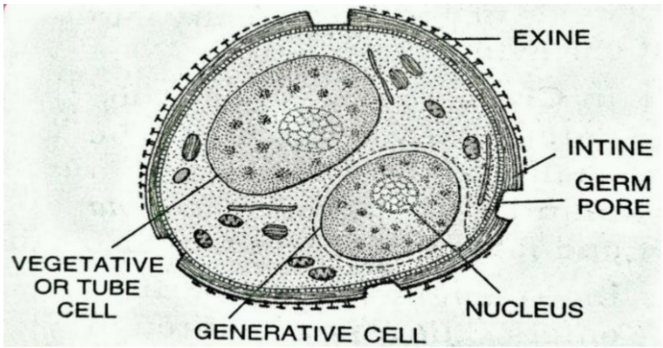


Figure: Matured pollen grain

Pollen grains are microscopic **structures** that carry the male reproductive nucleus of plants. Inside of the **grain** contains cytoplasm along with the tube nucleus and the generative cell. It has an outer coating called exine and inner coating called intine with germ pore through which the pollen tube emerges.

Ovule

The **ovule** is the structure that gives rise to seed after fertilization. It contains the female reproductive cells. A matured ovule consists of nucellus which provides nourishment to the growing embryo and is covered with integuments. It has a small opening called micropyle which permits the pollen tube to enter and discharge its male nuclei into the embryo sac. The embryo sac is a large oval cell in which fertilization and development of embryo occur. Each ovule is attached by its base to the stalk (funiculus) that bears it.

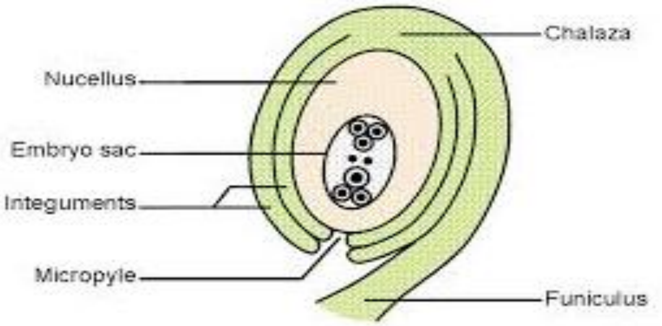


Figure: Cross-section of Ovule

Source:*https://lookfordiagnosis.com.mesh_info.*

ACTIVITY 3

1. Name the male gamete of flowering plants.
2. In which part of the flower will the male and female gametes develop?

Fertilization

Once the pollen grains land on the stigma, they absorb water and nutrient. Then they begin to germinate. A pollen tube begins to grow out from the pollen grain and the two nuclei (tube nucleus and generative nucleus). The pollen tube brings the male nuclei to the ovary. The pollen tube continues to grow down through the style towards the ovule through micropyle, chalaza or integument as shown in the diagram.

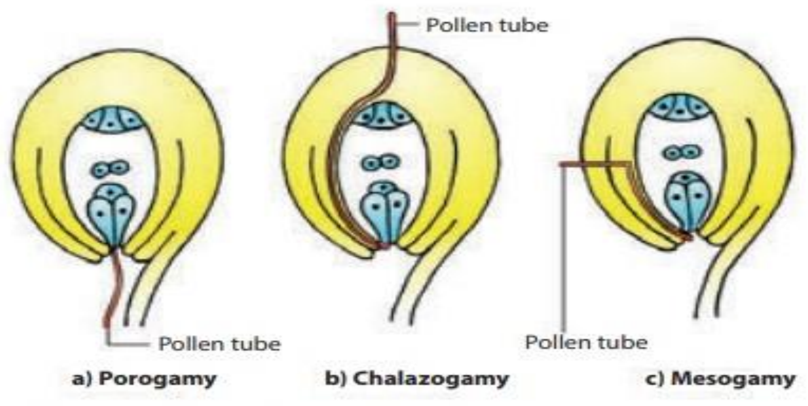


Figure: Entry of pollen from different parts

Source: http://www.brainkart.com/article/Fertilization_38202/

As the pollen tube grows, the generative nucleus starts dividing mitotically to produce two haploid male gametes.

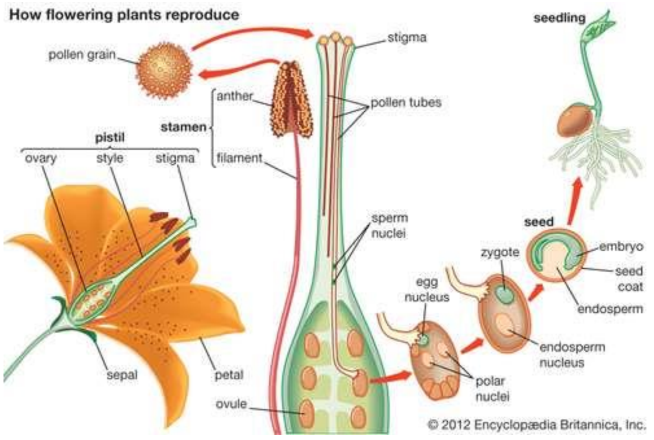


Figure: Reproduction in Flowering Plants

Source**:** https://kids.britannica.com/students/assembly/view/53831

Post Fertilization Event

One of the male gametes fuses with the female egg cell to produce a diploid zygote and is called **syngamy**. Zygote later grows into an embryo and the process of zygote growing into an embryo is called embryogeny.

The other male gamete fuses with two polar nuclei resulting in triple fusion forming the primary endosperm. The primary endosperm acts as the source of food for the growing embryo and later becomes the endosperm. The syngamy and triple fusion together make the double fertilization in flowering plants.

Importance of Double Fertilisation

Triple fusion leads to the formation of endosperm which provides nourishment to the developing embryo resulting in the formation of healthy seeds. Double fertilisation gives stimulus to the plant due to which ovary develops into fruit and ovule develops into seeds.

ACTIVITY 4

1. What is double fertilisation? What role does double fertilization play in the life cycle of a flowering plant?
2. Give a short note on the formation of endosperm.
3. Define syngamy.

Summary

- Pollination is the process of transfer of pollen grains from the anther to stigma.
- Pollination is classified into self and cross-pollination.
- A fusion of compatible male and female gametes leads to fertilisation.
- The syngamy and triple fusion together make the double fertilization in flowering plants.
- Porogamy is the condition when the pollen tube enters the ovule from the micropyle.

Self-check for Learning

1. What is self in-compatibility? Why self-pollination does not lead to seed formation?
2. Where does fertilization take place in plants?

1.3 Feedback Mechanisms of Hormonal Action

- Define the general components of regulatory systems.
- Differentiate positive and negative feedback mechanism.
- Describe hormonal control of menstrual cycle.

Introduction

Feedback mechanisms help to control the production of hormone and also maintains homeostasis. Homeostasis is important for the survival of living organisms because it provides optimum conditions for the functioning of body cells and tissues. It keeps the body environment under control to provide the right conditions for cells to function such as enzyme action, cell permeability and transport of oxygen and carbon dioxide.

To achieve homeostasis, animals have regulatory systems that constantly monitor internal conditions such as temperature, blood pressure, blood pH and glucose etc., and maintain a variable at or near a particular value or set point.

The regulatory systems consist of:

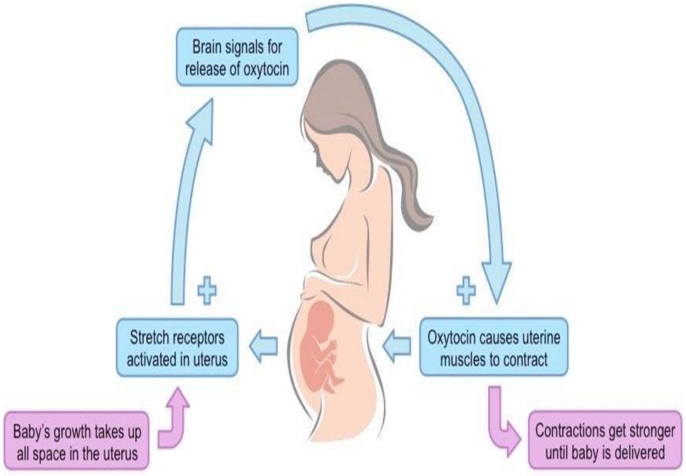
- **Receptor or sensor** detects stimulus and directs to control centre
- **Integrator or control centre or integration centre** integrates incoming information and issues motor impulses to effector
- **Effector** responds to control centre and helps restore the desired internal condition.

Positive feedback Mechanism

Example 1

In this type of control, the effector amplifies the original stimulus so that activity is accelerated.

In the diagram, the child exerts a force (stimulus) on the cervix and the signal is sent to the brain. The brain releases oxytocin to cause uterus contraction. More oxytocin will be released as the baby keeps exerting force on the cervix. The process will continue until the baby is delivered.



Source: pinterest.com

Figure: Regulation of hormone during child birth

ACTIVITY 1

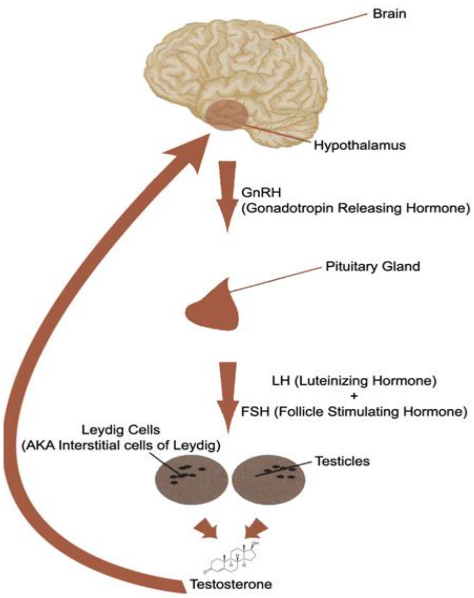
1. Adrenaline release is also an example of positive feedback control. How does the release of adrenaline help in coping up with emergency situation?

Negative feedback control

In this type of control, the effector of a process reduces the effect of the stimulus, which in turn, decreases the production of the product.

Example 1

At the onset of puberty, gonadotropin-releasing hormone (**GnRH**) from the hypothalamus stimulates the release of luteinizing hormone (LH) and follicle stimulating hormone (FSH) from the pituitary gland. These gonadotropins (LH and FSH) stimulate testosterone production and spermatogenesis. However, negative feedback will occur with the rising level of testosterone acting on hypothalamus and pituitary gland to inhibit the GnRH secretion and gonadotropins. Subsequently, testosterone production will be slowed down.



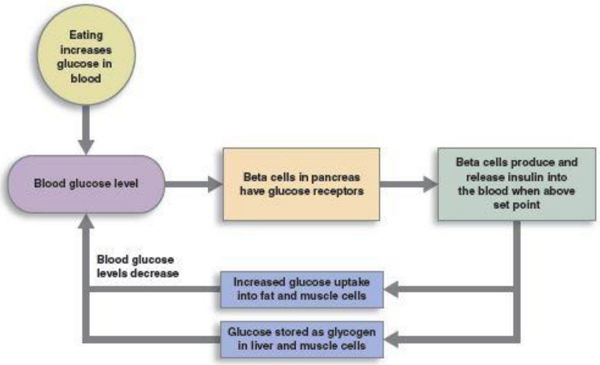
Source: google

Example 2

The control of blood sugar (glucose) by insulin

After meals, the blood glucose level rises. The increased blood glucose levels stimulate beta cells of the pancreas to produce insulin.

Insulin makes glucose available to the body cells and the excess of it is stored in the liver and muscles as glycogen. So, once the blood glucose level drops below a threshold, beta cells stop releasing insulin.



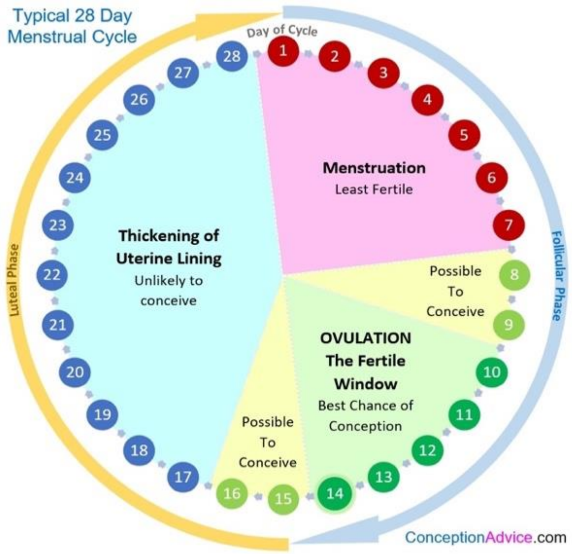
Source: courses.lumenlearning.com

Figure: Negative feedback action of insulin

ACTIVITY 2

1. How is positive feedback mechanism different from negative feedback mechanism? Explain with an example each.
2. What will be the consequences if the blood glucose levels cross the normal range in the body?

Menstrual cycle



Brief events:

1. **Menstruation** is the shedding of the thickened lining of uterus from the vagina take place in this phase. It lasts for about 3 days to one week but varies depending upon individuals.
2. **Follicular phase** starts on the first day of menstruation and ends with ovulation. In this phase, activated by the hypothalamus, the pituitary gland releases FSH that stimulates the ovary to produce follicles (Follicles contain immature egg). This leads to an increase in the estrogen level (positive feedback to the hypothalamus)
3. **Ovulatory phase** occurs around 14th day of the menstrual cycle. LH level peaks at this stage and causes LH surge, an event which leads to ovulation. Ovulation is the release of a matured egg from the ovary. Ovulatory phase is the fertile window (Best chance of conception).
4. **Luteal phase** occurs once the matured egg has been released. The ruptured follicle transforms into corpus luteum which produces progesterone along with the small amount of estrogen. This leads to inhibition of FSH and LH (negative feedback). In case of fertilization, progesterone prepares the uterus for an implant. If no fertilization occurs, the

corpus luteum degenerates leading to a drop in progesterone and estrogen level (causes menstruation). This phase lasts anywhere from 11 to 17 days.

ACTIVITY 3

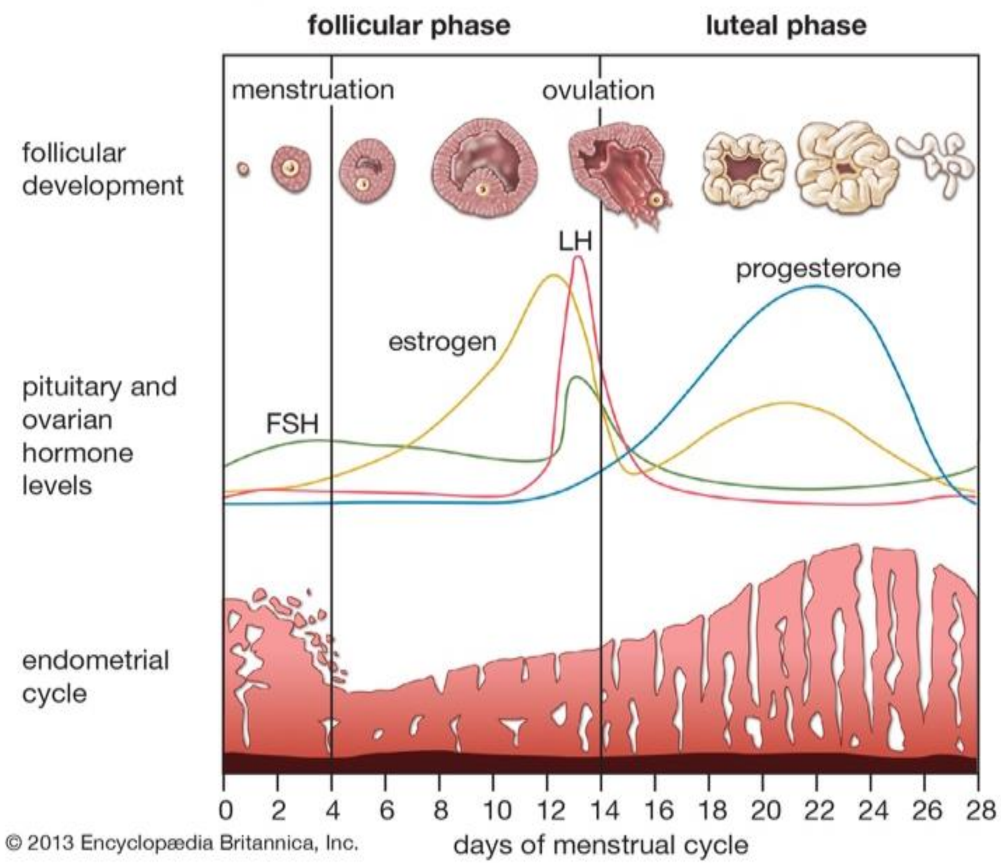
1. Why do gynaecologists check urine to detect pregnancy?

ACTIVITY 4

1. Study the graph shown on the left carefully and, in your own words, explain the various events that are taking place in the follicular and the luteal phase?

Note: if you can't understand the graph, please refer the notes of brief events of menstrual cycle.

Hormonal profiles during the menstrual cycle



Summary

- A feedback mechanisms help to control the production of hormone and also maintains homeostasis.
- An increase or decrease in the levels of hormones triggers the feedback mechanism.
- The body has two types of feedback mechanisms, positive and negative mechanism.
- The regulatory systems consist of:
  - i. Receptor or sensor which detects stimulus and directs to control centre
  - ii. Integrator or control centre or integration centre which integrates incoming information and issues motor impulses to effector
  - iii. Effector which responds to control centre and helps restore the desired internal condition.
- The four phases of menstrual cycle are:
  - i. Menstruation
  - ii. Follicular phase
  - iii. Ovulatory phase
  - iv. Luteal phase

Self-check for Learning

1. Can a person with diabetes donate blood to another person? Explain.
2. Which phase of the menstrual cycle has the best chance of conception? Give reason.
3. Adrenaline is called fight or flight hormone. Justify.
4. If a woman starts taking estradiol and progesterone tablets immediately after the start of menstrual cycle, what would be its effect on ovulation?
5. How are insulin and glucagon hormones antagonistic?

2. CHEMISTRY

1.1 Raoult's Law and Vapour Pressure

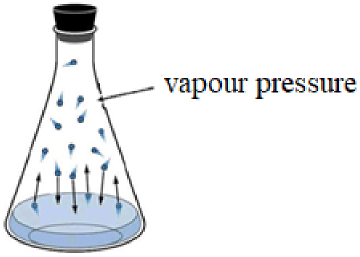
- Define vapour pressure.
- State Raoult's Law.
- Determine the molecular mass of solute.

Introduction

Imagine water being kept in a closed container. When the water molecules gain enough kinetic energy, they evaporate and get accumulated in vapour form in the space above the surface of water. At the same time, some of these water molecules in the vapour state will lose their kinetic energy and condense back to water when they collide with the other molecules. There will be evaporation and condensation occurring simultaneously inside the closed container and at certain stage the system reaches the state of equilibrium (rate of condensation and evaporation becomes equal). The vapour present above the liquid surface exerts a pressure at certain temperature and this pressure is known as vapour pressure.

Vapour pressure of liquids

Vapour pressure is the pressure exerted by the vapour of a liquid in a state of dynamic equilibrium at a particular temperature.



Vapour pressure of a liquid depends on factors such as nature of liquids, temperature and nature of solute present in the solution. The vapour pressure of a liquid increases with increase in temperature.

Vapour Pressure of Solution

A solution comprises of a mixture of solute and a solvent. In reference to the dilute homogeneous solutions, we have two types of solutions in order to understand their vapour pressure behaviour.

a. Solution of two miscible volatile liquids.
b. Solution of non-volatile solute in a volatile solvent.

In 1887, François-Marie Raoult, a French chemist, studied the vapour pressure of solutions and proposed a law which is known as Raoult's Law.

a. Solution obtained by mixing two miscible volatile liquids

The vapour pressure of a solution containing two miscible liquids is equal to the sum of partial pressures of the volatile liquids in the solution.

According to Raoult's law, the partial pressure of each volatile liquid is directly proportional to its mole fraction in the solution.

Let us take a solution prepared by mixing two volatile liquids A and B.

Let,

P_A – partial vapour pressure of A

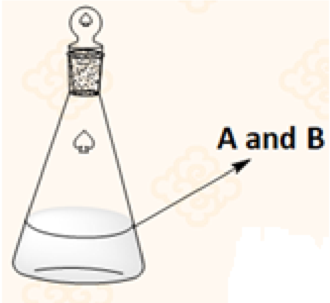
P_B- partial vapour pressure of B

P^o_A - vapour pressure of pure A

P^o_B - vapour pressure of pure B

X_A - mole fraction of A in the solution

X_B - mole fraction of B in the solution



Then, according to Raoult's Law,

$P_A \propto X_A$ $\qquad$ $P_B \propto X_B$

$P_A = P^o_A X_A$ $\qquad$ $P_B = P^0_B X_B$

Thus, Raoult's law can be stated as follows.

For a solution containing miscible liquids, the partial pressure of each liquid in the solution is equal to the product of its vapour pressure in pure state and its mole fraction in the solution.

The total vapour pressure (P) of the solution is the sum of partial pressures of the liquids in the solution.

$$P = P_A + P_B$$

$$P = P^o_A X_A + P^0_B X_B \qquad (X_A + X_B = 1)$$

Ideal Solution:

A solution which obeys Raoult's law under all the conditions of temperatures and concentrations is called ideal solution.

Numerical problem:

The vapour pressure of ethanol at 298K is 40 mm Hg. Its mole fraction in a solution with methanol is 0.80. What is the partial pressure of ethanol in the solution if the mixture obeys Raoult's Law?

Given;

$P^o_{ethanol} = 40$ mm Hg $\quad X_{ethanol} = 0.80$

$P_{ethanol} = P^o_{ethanol}\ X_{ethanol} = 40 \times 0.80 = 32.0$ mm Hg

Therefore, the partial pressure of ethanol in the solution is 32 mm Hg.

ACTIVITY 1

1. Toluene and benzene are two arenes that form ideal solution. At 310 K the vapour pressure of benzene is 160 mm Hg and that of toluene is 60 mm Hg respectively. Calculate the partial pressure of each component and the total pressure of three moles of benzene mixed with three moles of toluene.

b. Vapour pressure of a solution containing non-volatile solute

On addition of a non-volatile solute to a volatile solvent, the vapour pressure of the solvent in the solution gets lowered. This is because the solute particles tend to occupy certain part of the surface area occupied by solvent particles, thereby reducing the tendency of the molecules of solvent to evaporate into gas. The solute particles obstruct the evaporation of solvent, as a result, fewer molecules change from the liquid to the gas phase, thus reducing the vapour pressure. In such solutions, the vapour consists of only solvent molecules.

According to Raoult's Law, the vapour pressure of a solution containing a non-volatile solute in a volatile solvent is directly proportional to the mole fraction of solvent in the solution.

$$P_{solution} \propto X_{solv}$$

$$\mathbf{P_{solution} = P^o_{solv}\ X_{solv}}$$

Where, $P_{solution}$ = vapour pressure of solvent in the solution

X_{solv} = mole fraction of solvent

P^0_{solv} = vapour pressure of pure solvent

Thus, Raoult's Law, can be stated as – the vapour pressure of solvent in a solution containing non- volatile solute is equal to the product of vapour pressure of pure solvent and its mole fraction in the solution.

$$P_{solution} = P^o_{solv}\ X_{solv} \text{ ....} \mathbf{1}$$

$$X_{solvent} + X_{solute} = 1$$

So, $\quad X_{solvent} = 1 - X_{solute}$

Substituting the value of $X_{solvent}$ in equation 1, we get

$$P_{solution} = P^0_{solv}\ (1 - X_{solute})$$

$$P_{solution} = P^0_{solv} - P^0_{solv}\, X_{solute}$$
$$P^0_{solv} - P_{solution} = P^0_{solv}\, X_{solute}$$
$$\Delta P = P^0_{solv}\, X_{solute}$$

$P^0_{solv} - P_{solution}$ or ΔP is known as the lowering of vapour pressure which is equal to the product of vapour pressure of pure solvent and the mole fraction of solute in the solution.

$$P^0_{solv} - P_{solution} = P^0_{solv}\, X_{solute}$$

$$\frac{P^0 solv - Psolution}{P^0\ solv} = X_{solute}$$

$\frac{P^0\ solv - Psolution}{P^0\ solv}$ is the relative lowering of vapour pressure which is equal to mole fraction of solute. This is another form of Raoult's Law.

We know;

$$X_{solute} = \frac{\text{number of moles of solute}}{\text{number of moles of solute} + \text{number of moles of solvent}}$$

$$\frac{P^0\ solv - Psolution}{P^0 solv} = \frac{n_{solute}}{n_{solute} + n_{solvent}}$$

$$\frac{P^0\ solv - Psolution}{P^0 solv} = \frac{w/m}{w/m + W/M}$$

Where, m = molecular mass of solute
M = molecular mass of solvent
w =mass of solute
W = mass of solvent.

If a solution is very dilute then the number of moles of the solute in the solution is very small and can be ignored in the denominator.

$$\frac{P^0 solv - Psolution}{P^0 solv} = \frac{w/m}{W/M}$$

$$\frac{P^0 solv - Psolution}{P^0\ solv} = \frac{w \times M}{m \times W}$$

This equation can be used in determining the molecular mass of an unknown solute in the solution.

Numerical problem

The vapour pressure of pure water at 40°C is 55.3 mm Hg. A solution containing 10 g of a solute in 90 gram of water has the vapour pressure of 53.457 mmHg. Calculate the molecular weight of the solute.

Given:

$w_{solute} = 10g$, $W_{solvent(water)} = 90g$,
$P^0_{solvent} = 55.3$ mm Hg   m =?
$P_{solution} = 53.457$ M = 18

We have,

$$\frac{P^0\ solvent - Psolution}{P^0 solvent} = \frac{w \times M}{m \times W}$$

$$\frac{55.3-53.457}{55.3} = \frac{10\text{x } 18}{\text{m x } 90}$$

$$\frac{1.843}{55.3} = \frac{10}{m} \times \frac{1}{5}$$

$$m = 60\text{g/mol}$$

ACTIVITY 2

1. The vapour pressure of water at 20^0C is 17.51 mm Hg and lowering of vapour pressure of a sugar solution is 0.0614 mm Hg. Calculate:
    a. Relative lowering of vapour pressure
    b. Mole fraction of water.

Summary

- Vapour pressure is the pressure exerted by the vapour of a liquid in a state of dynamic equilibrium at a particular temperature.
- The vapour pressure of a solution containing two miscible liquids is equal to the sum of partial pressures of the volatile liquids in the solution.
- According to Raoult's law, for a solution containing miscible liquids, the partial pressure of each liquid in the solution is equal to the product of its vapour pressure in pure state and its mole fraction in the solution.
- A solution which obeys Raoult's law under all the conditions of temperatures and concentrations is called ideal solution.
- The vapour pressure of a solution containing a non-volatile solute in a volatile solvent is directly proportional to the mole fraction of solvent in the solution.

Self-check for Learning

1. A mixture of ethyl alcohol and propyl alcohol has a vapour pressure of 290 mm Hg at 300 K. If the mole fraction of ethyl alcohol is 0.65, calculate the vapour pressure of ethyl alcohol at the same temperature when vapour pressure of propyl alcohol is 210 mm Hg.
2. Why is Raoult's law applicable only for the binary solutions?

1.2 Amino Acids

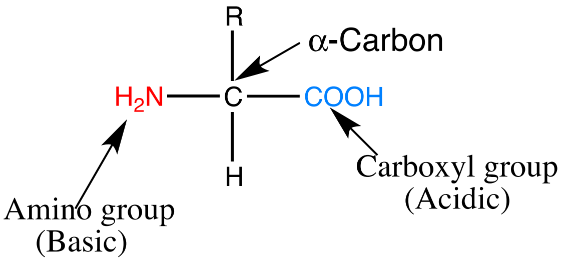
- Define amino acids.
- Identify and draw the structure of amino acids.
- Explain that the amino acids move towards different electrode when electrolysed.
- Explain optical activity of amino acid.

Introduction

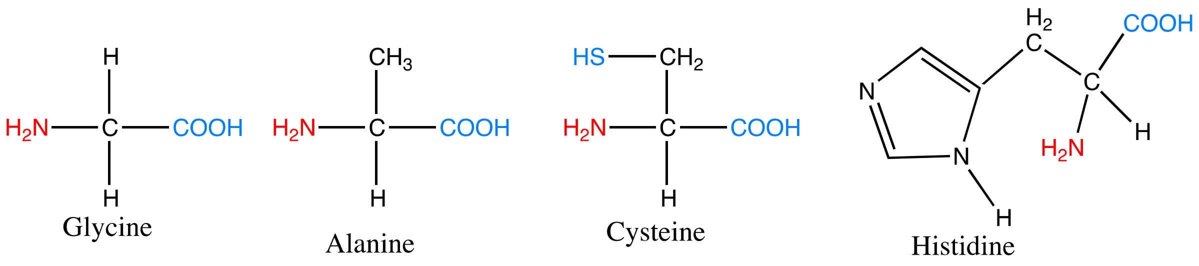
Amino acids are the organic compounds which combine to form proteins; hence they are referred to as the building blocks of proteins. These biomolecules are involved in several biological and chemical functions in a human body and are the necessary ingredients for the growth and development of human beings. There are 20 common amino acids of which glycine is the simplest.

Structure of Amino Acid

Amino acids are di-functional organic compound containing a basic amino group (-NH_2) and an acidic carboxyl group (-COOH). Both peptides and proteins are the long chains of amino acids. The general structure of amino acids can be written as:



There are about 20 naturally occurring amino acids. These amino acids differ from each other in their side-chain called R (alkyl) group. Each amino acid has 4 different groups attached to its α-carbon *viz.* amino group, carboxyl group, hydrogen atom, and side-chain (R) as shown in the examples below.



Essential and non-essential amino acids

The amino acids which human body cannot synthesize and must be supplied in the diet are called essential amino acids, while those which are synthesized by the human body are termed as non-essential amino acids. The lack of essential amino acids in diet can cause diseases such as kwashiorkor.

ACTIVITY 1

1. What are essential amino acids?
2. Write the functional groups present in amino acids?

Nomenclature of amino acids

1. **Common or trivial names:** Amino acids are generally named as amino-substituted aliphatic carboxylic acids and are designated by Greek letters α, β, γ, etc, depending on the position of $-NH_2$ group on the carbon chain.
2. **IUPAC names:** While writing the IUPAC name of amino acids, the position of $-NH_2$ group is indicated by the number of C-atom on which it lies, taking carbon of $-COOH$ as 1.

Table 1: Common and IUPAC names of some amino acids

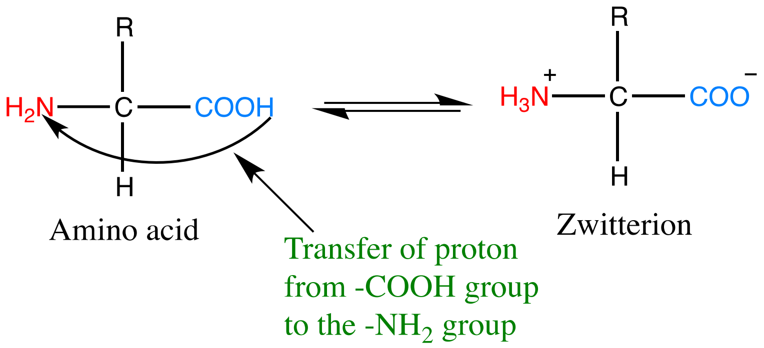
Amino Acid structure	Common Name	IUPAC Name
$H_2N-\underset{2}{\overset{\alpha}{CH_2}}-\underset{1}{COOH}$	**Aminoacetic acid (Glycine)**	**2 – Aminoethanoic acid**
$H_2N-\underset{2}{\overset{\alpha}{CH}}(\overset{3\ \beta}{CH_3})-\underset{1}{COOH}$	**α – Aminopropionic acid (Alanine)**	**2 – Aminopropanoic acid**
$H_2N-\underset{3}{\overset{\beta}{CH_2}}-\underset{2}{\overset{\alpha}{CH_2}}-\underset{1}{COOH}$	**β – Aminopropionic acid**	**3 – Aminopropanoic acid**
$H_2N-\underset{4}{\overset{\gamma}{CH_2}}-\underset{3}{\overset{\beta}{CH_2}}-\underset{2}{\overset{\alpha}{CH_2}}-\underset{1}{COOH}$	**γ – Aminobutyric acid**	**4 – Aminobutanoic acid**

Physical properties of amino acids

- They have very high melting and boiling point.
- Amino acids are white crystalline solid substances.
- Most of the amino acids are soluble in water and are insoluble in organic solvents.

Amino acid in solution

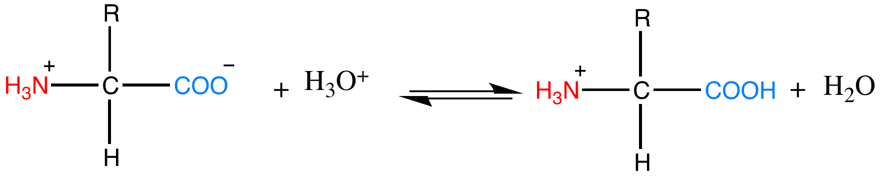
Amino acid when dissolved in water exists as dipolar ion or zwitterion. There is internal transfer of a proton from – COOH group to the – NH_2 group to leave an ion with both a negative charge and a positive charge.



Amino acids are amphoteric and they can react either as acids or as bases.

In acidic solution (pH < 7), the zwitterion will act as a base and accept a proton to yield a cation. Thus, it will move towards cathode (the negative electrode) if electrolyzed.

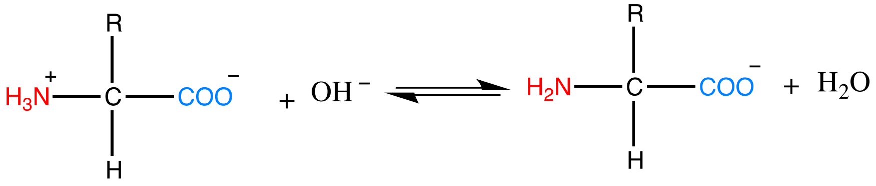
In acidic solution



Zwitterion

In basic solution (pH > 7), the zwitterion will act as an acid that loses a proton to form an anion. Thus, it will move towards anode (the positive electrode) if electrolyzed.

In basic solution

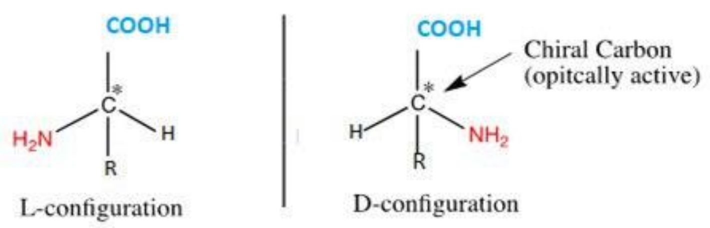


Zwitterion

At a certain pH, zwitterion does not travel towards any of the electrodes due to neutrality or no net electrical charge, which is known as isoelectric point. For example, glycine at pH 6.1, does not move to any of the electrode. Thus, 6.1 is isoelectric point of glycine.

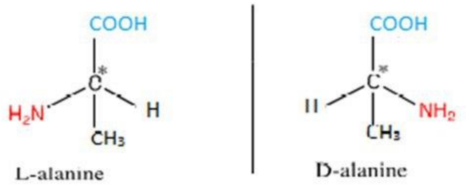
Amino acid and optical isomerism

Except glycine, all other amino acids are optically active because α-Carbon atom is asymmetric and forms chiral centre (given by asterisk). They exist in D – and L – forms. Most naturally occurring amino acids have L–configuration.



The asymmetric carbon is bound to four different atomic groups (-H, -CH_3, -NH_2, and –COOH). The spatial arrangement results in two molecules, each of which is the mirror image of the other. These two molecules are called optical isomers or enantiomers.

For example:



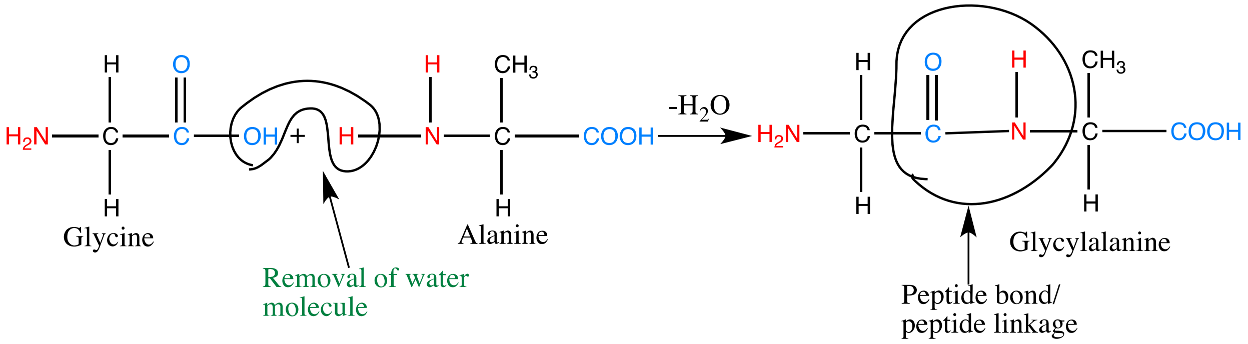
ACTIVITY 2

1. What is zwitterion of amino acids?
2. Amino acids behave as zwitterions in neutral solutions. Towards which electrode will amino acids migrate in a basic solution? Why? Write the chemical equation.
3. Why does glycine do not show optical activity?

Peptides and peptide bonds

The compounds obtained by the condensation of two or more amino acids are called peptides. The condensation reaction takes place by removal of simple molecules like water.
The new bond formed by the condensation of two amino acid molecules is called a peptide bond/ peptide linkage and the condensation product is referred to as dipeptide.

For example, when —COOH group of glycine combines with the —NH_2 group of alanine dipeptide, glycylalanine is obtained.

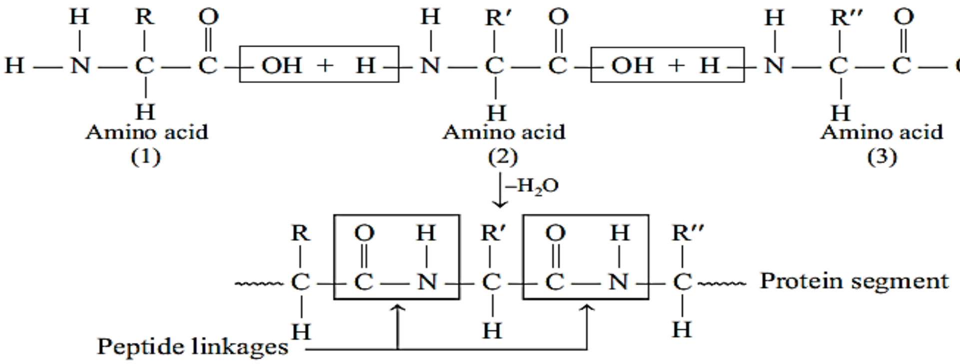


Classification of peptides

Dipeptides: The peptides formed by the condensation of two same or different amino acids.
Tripeptides: The peptides formed by the condensation of three same or different amino acids.
Polypeptides: The peptides obtained by the condensation of large number of same or different amino acids are called polypeptides.

Proteins

Proteins are long polymers of amino acids linked together by peptide bonds.



Denaturation of Proteins

The process which leads to a change in the physical and biological properties of a protein without affecting its chemical composition is called denaturation of proteins. It causes loss in biological activity of protein.
For example: Boiling of egg, preparation of cheese from milk, etc.

ACTIVITY 3

1. What are proteins?
2. Draw a polypeptide formed between alanine and aspartic acid
3. What do you understand by the term denaturation of protein?

Summary

- Amino acids are organic compounds containing a basic amino group (-NH_2) and an acidic carboxyl group (-COOH).
- Each amino acid has four different groups attached to its α- carbon viz. amino group, carboxyl group, hydrogen atom, and side-chain (R).
- Both peptides and proteins are the long chains of amino acids.
- While writing the IUPAC name of amino acids, the position of –NH_2 group is indicated by the number of C-atom on which it lies, taking carbon of -COOH as 1.
- Zwitter ion is the dipolar ion of amino acids which has both negative and positive charge formed due to internal transfer of H^+ from -COOH group to -NH_2 group.
- In acidic solution (pH < 7), the zwitterion will act as a base and accept a proton to yield a cation. Thus, it will move towards cathode (the negative electrode) if electrolyzed.
- In basic solution (pH > 7), the zwitterion will act as an acid that loses a proton to form an anion. Thus, it will move towards anode (the positive electrode) if electrolyzed.
- At a certain pH, zwitterion does not travel towards any of the electrodes due to neutrality or no net electrical charge, which is known as isoelectric point.
- Glycine is optically inactive.
- Amino acids link together by peptide bond.

Self-check for Learning

1. Why are amino acids amphoteric in nature?
2. What is zwitter ion and how is it formed?
3. Represent the formation of peptide bond between glycine and alanine.
4. Towards which electrode will the amino acid migrate if electrolysed in HCl and NaOH solutions respectively? Why?

1.3 Aromatic Compounds – Electrophilic Substitution Reaction

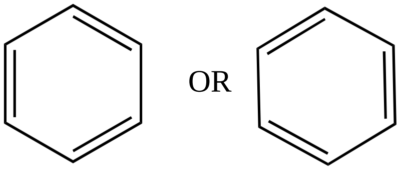
- Define aromatic compounds.
- Explain the resonance structure of benzene.
- Write and explain the mechanism of electrophilic substitution reaction of benzene.

Introduction

The word *aromatic* is used to describe fragrant substances such as benzaldehyde (from cherries, peaches and almonds), toluene (from Tolu balsam tree) and benzene (from coal distillate). Therefore, aromatic refers to the class of organic compounds that contain six-membered benzene-like rings with three alternate double bonds. These compounds have pleasant odour.

Structure of benzene (Kekule's structure)

In 1865, August Kekule suggested the following structure of benzene:

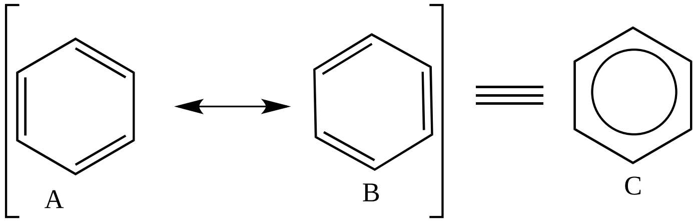


Kekule's structure

Benzene molecule is made up of hexagonal ring of 6 C-atoms joined alternately by double and single bonds with each C-atom attached to a H-atom.

Resonance structure of benzene

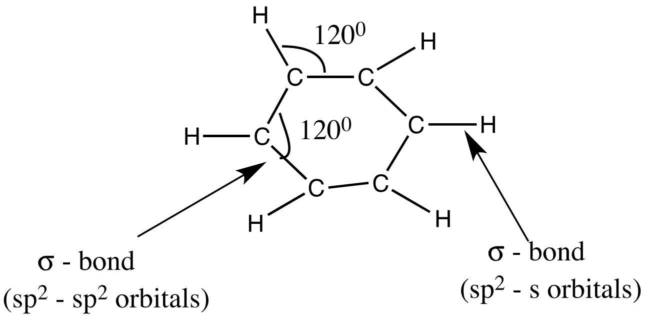
Structure of benzene can be explained on the basis of the concept of resonance. It can be represented by the following resonance or canonical structures.



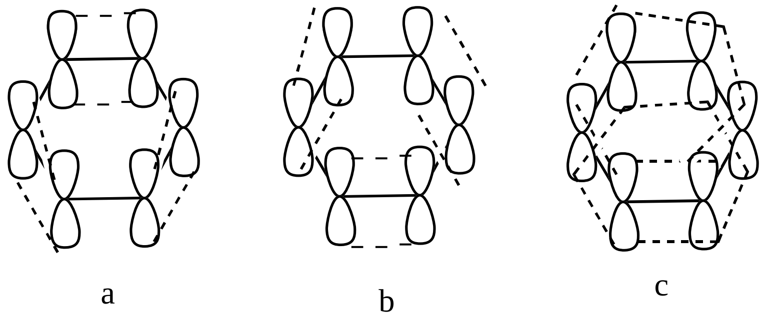
In structure A and B, Carbon and Hydrogen atoms are identical but the two differ in the positions of double bond. Benzene is a resonance hybrid of the canonical forms (A, B) and is represented by structure C. Structure C is more stable as compared to structures A and B because the resonance hybrid possesses lesser energy as compared to that possessed by A and B.

Molecular orbital structure of benzene

Each carbon atom in benzene is sp^2 hybridized. The half -filled one 2s and two 2p orbitals of each carbon mix up together and redistribute their energy to form three sp^2 hybrid orbitals. The three sp^2 hybrid orbitals arrange themselves in a plane at an angle of 120^0. Each sp^2 carbon atoms form sigma bonds with two other carbons and one hydrogen atom.



Now each C-atom is left with one unhybridized 2p orbital lying perpendicular to the plane of the ring. Each of them contains an unpaired electron. On account of cyclic nature of benzene ring, the unhybridized 2p orbital of either of its 2 neighbouring C-atom, results in the following structures:



Since there are equal chances of overlapping on both sides, all the 6 unhybridized 2p orbitals along with the 6 electrons present in them join together to form a continuous π-molecular orbital (structure c). This is known as delocalized π-molecular orbital where the 6 π electrons are spread over the entire C – skeleton and no particular electron is associated with no particular C – atom. These delocalized electrons have lower energy as compared to localized electrons; thus, benzene molecule acquire extra stability.

ACTIVITY 1

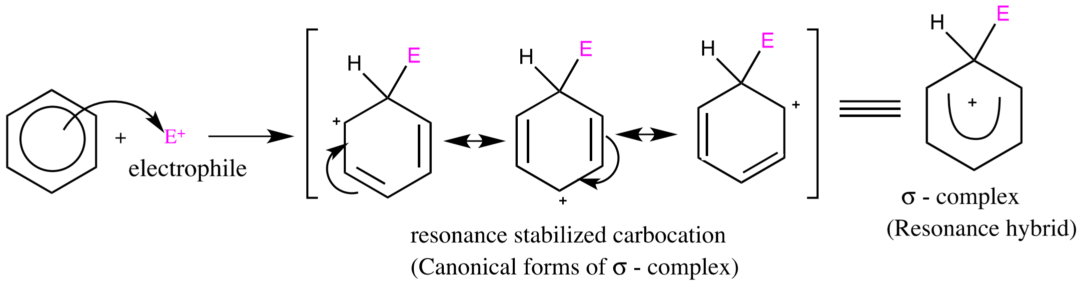
1. Draw Kekule's structure of benzene.
2. What makes benzene more stable than alkenes although both possess double bonds?

Electrophilic aromatic substitution

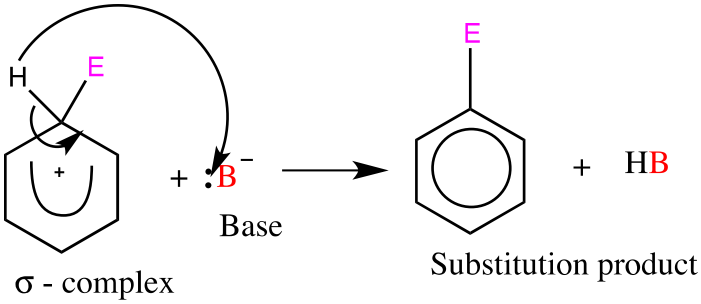
The most common reaction of aromatic compounds is electrophilic aromatic substitution. Benzenes undergo electrophilic substitution reactions readily because benzene ring contains a delocalized π- molecular orbital containing 6 π- electrons and thus acts as a source of electrons for attacking electrophile. An electrophile reacts with benzene and substitutes one or more H-atoms of the ring.

General mechanism of electrophilic substitution reaction

When an electrophile attacks the benzene ring, a σ complex is formed, which is a resonance-stabilized carbocation.



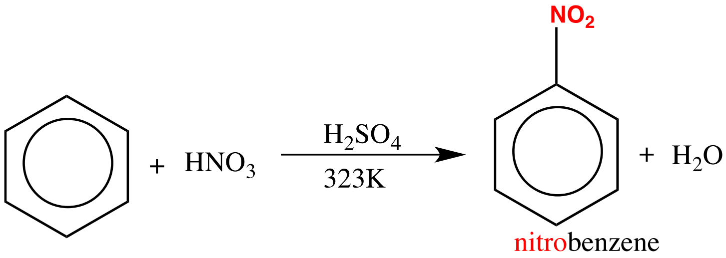
The σ complex thus formed eliminates a proton by the action of a base to yield the final substitution product.



For example:

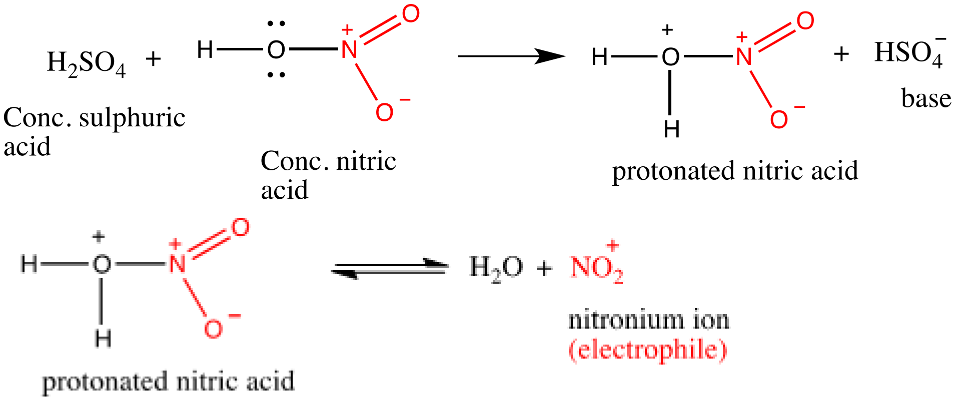
1. Nitration of benzene

It is the replacement of a H-atom in the benzene ring by nitro (- NO_2) group in presence of mixture of concentrated nitric acid and concentrated sulphuric acid at 323K.

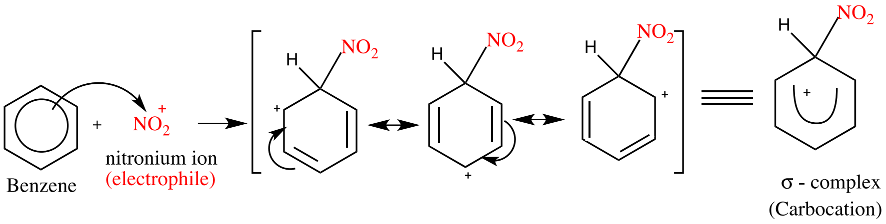


Mechanism

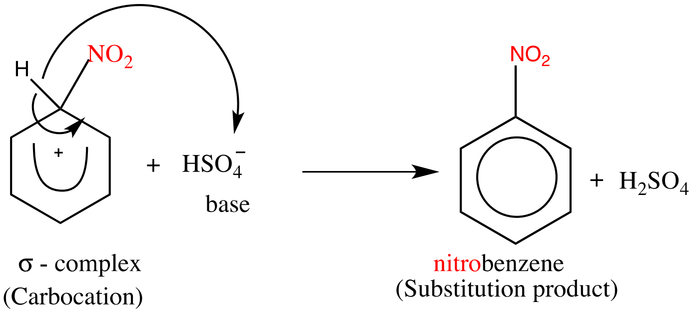
Step 1. Generation of electrophile, NO_2^+ ion.



Step 2. Formation of Carbocation (σ complex)



Step 3. Abstraction of proton from the carbocation



ACTIVITY 2

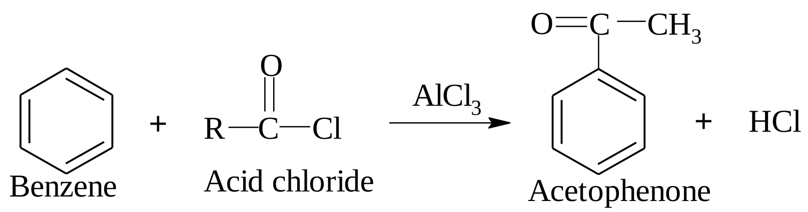
1. *Halogenation is replacement of H-atoms with a halogen atom*. Predict the product of reaction between chlorine and benzene in presence of ferric chloride with the help of reaction mechanism.

2. Friedel – Crafts reaction

These reactions were developed by Charles Friedel and James Crafts in 1877 to attach substituents to an aromatic ring. It is of two types.

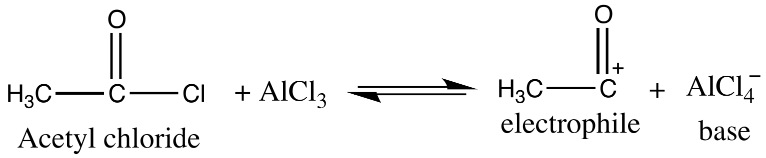
a) Friedel – Crafts Acylation

Acylation is substitution of an acyl group (RCO-) by replacing H-atom from benzene. This reaction is used for preparation of aromatic ketones. Benzene is treated with acid chloride in presence of anhydrous aluminium chloride.

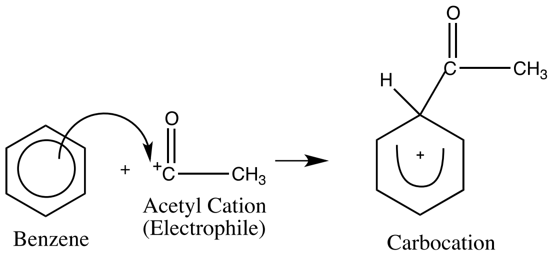


For example: Reaction of benzene with acetyl chloride

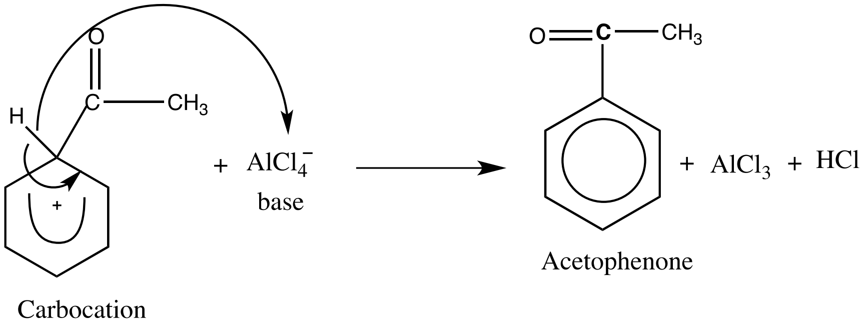
Step 1. Generation of electrophile, $CH_3 – CO^+$ ion



Step 2. Formation of Carbocation

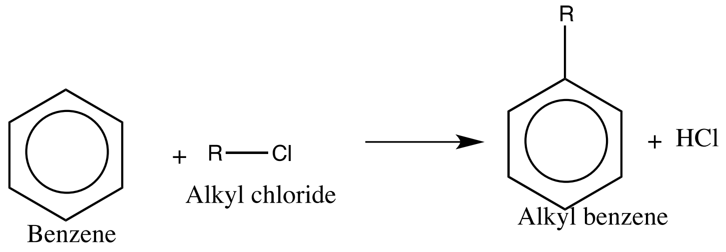


Step 3. Abstraction of proton from the carbocation

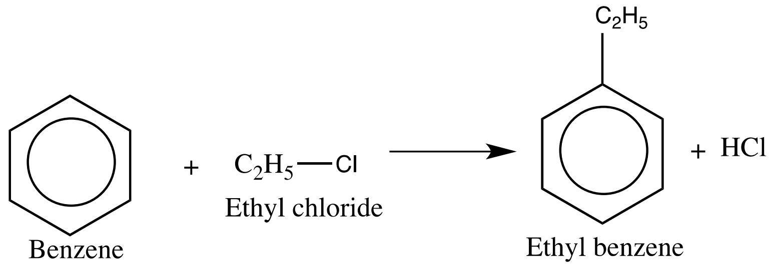


b) Friedel – Crafts Alkylation

Alkylation is substituting an alkyl group by replacing one of the H – atoms present in benzene. Benzene when treated with an alkyl halide in presence of small amount of Lewis acids ($AlCl_3$, BF_3, $FeCl_3$, etc) leads to direct introduction of an alkyl group into the benzene ring.



For example: Formation of ethyl benzene



ACTIVITY 3

1. Write Friedel-Crafts alkylation mechanism for formation of ethyl benzene.
2. What is the function of $AlCl_3$ in Friedel-Crafts acylation reaction?

Summary

- Aromatic compounds are class of organic compounds that contains six-membered benzene-like rings with three alternate double bonds.
- Benzene molecule is made up of hexagonal ring of six C-atoms joined alternately by double and single bonds with each C-atom attached to a H-atom.
- The stability of benzene molecule is due to its resonance structure.
- Benzenes undergo electrophilic substitution reactions readily because benzene ring contains a delocalized π- molecular orbital containing 6 π- electrons.
- An electrophile reacts with benzene and substitutes one or more H-atoms of the ring.

Self-check for Learning

1. Explain how do the delocalized π – electrons affect the reactivity of benzene.
2. What is the function of H_2SO_4 in nitration of benzene?
3. Convert benzene into nitrobenzene.

1.4 Chemical Thermodynamics

- Define chemical thermodynamics.
- Explain system and surrounding.
- Calculate the work done.
- Explain the enthalpy of a system.
- Explain the entropy of a system.

Introduction

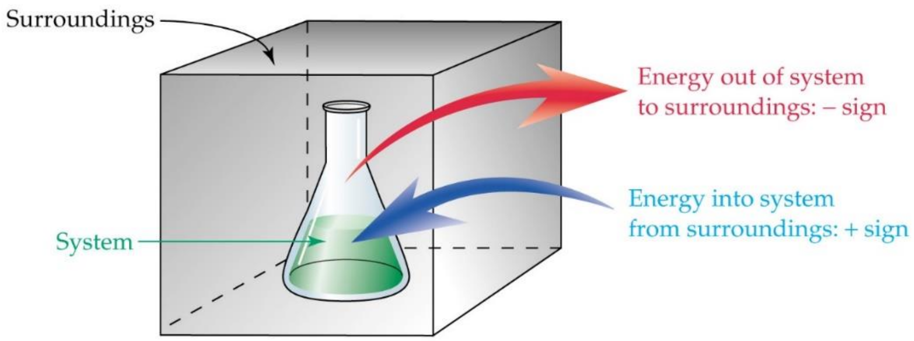
Chemical Thermodynamics is the branch of chemistry which deals with various chemical and physical processes that involve energy changes. The thermodynamics deals only with the energy changes during the process and not with the total energy of the body. Most of the physical laws (Raoult's law, lowering of vapour pressure, etc.) are deduced from the laws of thermodynamics. It is useful in predicting the feasibility of the process (whether the given process will occur or not under the given set of conditions of temperature, pressure and concentration) and also in determining the extent to which the process takes place.

Limitations of thermodynamics

- The laws of thermodynamics are applicable only to matter in bulk and not to individual atom and molecules.
- It predicts the feasibility of the process but not its rate (speed of the reaction).
- It deals only with the initial and final state of the system and not the mechanism of the process.

System

- A specific portion of the matter under study and is separated from the rest of the universe.
- The exchange of energy and the mass take place between the system and the surrounding.



Types of system

i. Open system

A system which transfers and exchanges both mass and the energy with its surrounding.

Example: warm water in a cup without a lid

ii. Closed system

A system which exchanges energy but not mass with its surrounding.

Example: Lemon tea in a glass with lid

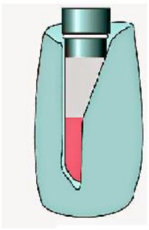
example : lemon tea in a glass with lid

iii. Isolated system

A system which exchanges or transfers neither the energy nor the mass with its surrounding.

Example: Warm water in a thermos flask

Example: warm water in a thermosflask



Macroscopic properties of a system

Those properties which are associated with the bulk of matter are called macroscopic properties. It is of two types:

- **Intensive properties:** The properties which do not depend upon the number of particles in the system.
  Examples: Temperature, density, viscosity, boiling point, freezing point, pressure, etc.
- **Extensive properties:** The properties which depend upon the amount of substance (number of particles) present in the system.
  Examples: Moles, volume, mass, enthalpy, entropy, free energy, etc.

Reversible and Irreversible processes

Reversible processes: They are those processes that occur so slowly that driving force is infinitesimally greater than the opposing force. In reversible process several equilibrium states are established before attaining the final state.

Irreversible processes: They are those processes which occur so rapidly that a system does not get chance to attain equilibrium (a system which cannot be retraced back in opposite direction). All naturally occurring processes are irreversible process.

Thermodynamic processes

The operation which brings about the change in the state of a system is called a thermodynamic process.

i. **Isothermal process:** It is the process in which the temperature of the system remains constant although heat enters or leaves the system.

   dT (change in temperature) = 0

In order to maintain the constant temperature of the system, the heat produced by the system in exothermic process, is released to the surrounding and the heat required by the system in endothermic process, is absorbed from the surrounding.

Example of isothermal processes: freezing, melting, boiling and condensation which take place at constant temperature. (The boiling of water takes place at constant temperature of 100°C)

ii. **Adiabatic process:** It is a process during which no heat enters or leaves the system. In this process, the temperature of the system either increases or decreases. Such processes are carried out in a closed heat insulating compartment such as thermos flask (isolated system).

   For adiabatic process dq = 0

iii. **Isobaric process:** It is the process during which the pressure of the system remains constant.

Example:

- Vaporization of water at its boiling point which takes place at constant atmospheric pressure.
- Expansion of gas in an open system or in a cylinder with movable piston.

For isobaric process dp = 0

iv. **Isochoric process:** It is the process during which the volume of the system remains constant.

   Example: heating of substance in a closed container (closed system)

v. **Cyclic process:** It is the process during which the system comes to its initial state through number of different processes.

For cyclic process, **dE =0, dq=dw.**

ACTIVITY 1

1. Differentiate between closed system and isolated system with an example each. (provide the examples other than ones given in the material)

Internal energy (E):

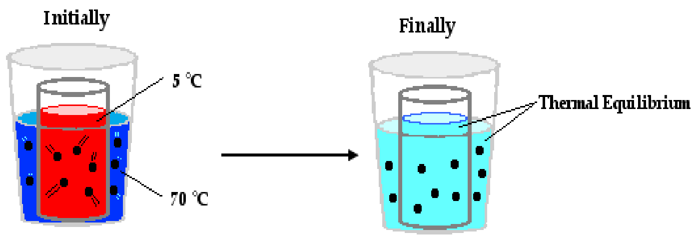
- It is the energy stored in a substance by virtue of its chemical nature.
- The internal energy is the sum of translational energy, rotational energy, vibrational energy, electronic energy and, nuclear energy in atoms and molecules.
- Internal energy is a state function as its value depends upon the initial and final state of a system and not upon how it is achieved (the path).
- It is not possible to determine the absolute value of internal energy of the system. However, change in internal energy of a process can be measured or calculated.

$\Delta E = E_{Products} - E_{Reactants}$

For an exothermic reaction $E_R > E_p$, so ΔE is negative
For an endothermic reaction $E_R < E_p$, so ΔE is positive.
Unit of internal energy: Joule (J)
$1\ J = 10^7$ ergs
1 cal = 4.184 J

Heat and work

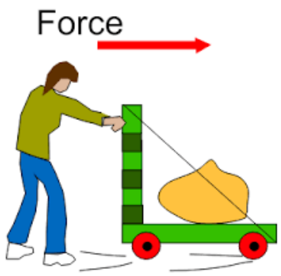
The transfer of energy between the system and surrounding takes place in the form of heat, work or light.
Heat (q) is exchanged between the system and surroundings due to the difference in temperature. The flow of heat takes place from the body at higher temperature to a body at lower temperature.
If heat is released by the system to the surrounding, it is taken as *negative* and if it is absorbed by the system, it is taken as *positive.*



Example: 10 J of heat is released by the system to the surrounding.
For system, q = -10J
For surrounding, q = 10J
Units of heat: joule, erg or calorie.

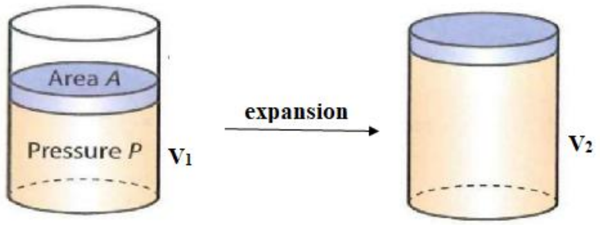
Work (W)

Work is said to be done when an object is displaced in the direction of applied force. In thermodynamics, work is the mode of transfer of energy between the system and the surrounding due to the difference in pressure.



Pressure – volume mechanical work

Let the gas with volume V_1 absorb heat from the surrounding and expand up to volume V_2 against an external pressure P_{ext}. The expansion is brought about by a force exerted by the gas molecules on the piston of area, A.



We know,

$$\text{work done} = \text{Force (F)} \times \text{displacement(dl)}$$

$$\text{pressure (p)} = \frac{\text{force}}{\text{area}}$$

$$F = p \times A$$

$W = -p \times A \times dl$ (-ve sign is to indicate that work is done against external pressure)

$dW = -p \times dv$, (as $A \times dl = dv$, dw is small work done during small change in volume.)

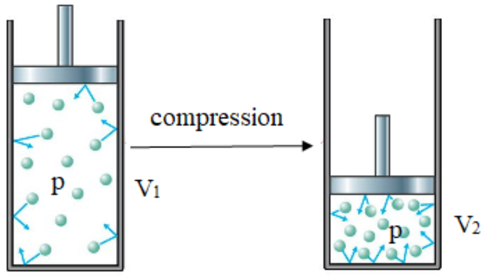
$$\int dW = -p\int_{v_1}^{v_2} dv$$

$$W = -p\,(v_2 - v_1)$$

$W = -P\Delta V$ (work of expansion)

If the pressure of the gas is higher than external pressure, expansion takes place. The work is done by the system. The work done is negative.

If the pressure of the gas is slightly lower than external pressure, compression takes place. The work is done on the system. The work done is positive. $W = P\Delta V$ (as $V_1 > V_2$)



Work done during the isothermal and reversible expansion of an ideal gas

Let 'n' moles of an ideal gas enclosed in a cylinder fitted with frictionless piston absorb heat and expand from volume V_1 to V_2. The work done is calculated as follows.

$W = -2.303nRT \log \frac{V_2}{V_1}$ (at constant pressure)

$W = -2.303nRT \log \frac{P_1}{P_2}$ (at constant volume), $R = 8.\ 314\ JK^{-1}mol^{-1}$

Work done during isothermal irreversible process

$$w_{irre} = -P_2\,(V_2 - V_1)$$

Where P_{2} = final pressure.

First law of thermodynamics: (Law of Conservation of Energy)

It states that energy can neither be created nor be destroyed but can be converted from one form to equivalent amount of other form.
The sum of all forms of energies of the universe (system + surroundings) remains constant.
Whenever a certain amount of energy of one form disappears, an equivalent amount of other form of energy must appear.
For example, to decompose one mole of water, 68.4 kcal of electrical energy is required.

$H_2O + 68.4\ kcal \rightarrow H_2 + ½O_2$

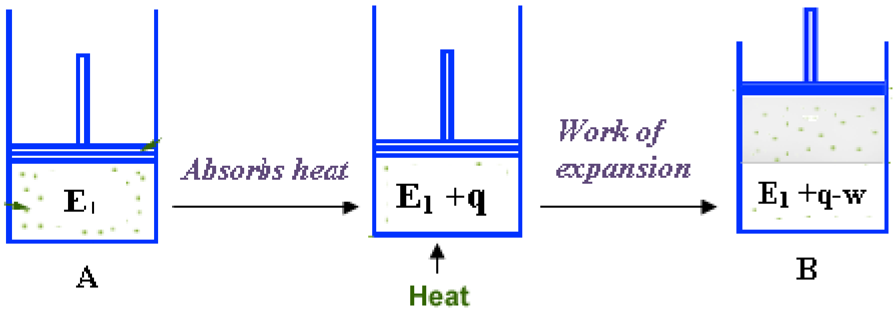
During formation of one mole of water, 68.4 kcal of heat energy is released

$½O_2 + H_2 \rightarrow H_2O + 68.4\ kcal.$

Thus, we see that the energy neither gets destroyed nor created.

Mathematical form of first law of thermodynamics

Let a system at state A with internal energy E_1, absorb heat 'q' and does the work 'w' to change to final state B with internal energy E_2.



$$E_2 = E_1 + q - w$$

$$E_2 - E_1 = q - w$$

$$\Delta E = q - w \ (\Delta E \text{ is change in internal energy})$$

$$\Delta E = q - w \ (\text{for work done by the system}) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(i)}$$

$$\Delta E = q + w \ (\text{for work done on the system}) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(ii)}$$

(i) and (ii) are mathematical forms of first law of thermodynamics.

Numerical problems based on work done and first law of thermodynamics

i. A system absorbs 200 joules of heat and performs work equal to 100 joules. Calculate the change in the internal energy of the system.

$q = 200$ J, $w = 100$J
$\Delta E = q - w$
$\Delta E = 200 - 100$
$= 100$ J

ii. The gas in a cylinder is allowed to expand from 1 litre to 5 litres against a constant pressure of 1 atm. During this process 450 J of heat is absorbed from the surrounding. Calculate the change in the internal energy of the system.
$P = 1$ atm, $V_2 = 5$ L, $V_1 = 1$ L

$W = -P(V_2 - V_1)$
$W = -1(5-1) = -4.0$ L atm
$= -4 \times 101.32$ (1 L atm = 101.32 J)
$= -405.28$ J
$\Delta E = q - w$
$= 450 - 405.28$
$= 44.72$ J

ACTIVITY 2

1. Two moles of an ideal gas at 10 atm. pressure is compressed isothermally and reversibly at 100°C to $^5/_2$ of its initial pressure. Calculate the work done.

Enthalpy (H)

Enthalpy is defined as the total heat content of a system at constant pressure.
Mathematically: $H = E + PV$
Enthalpy is a state function, its absolute value of a system cannot be determined. Instead change in enthalpy can be determined, which depends on the enthalpies of initial and the final state of a system. Enthalpy is extensive property.

$\Delta H = H_{final} - H_{initial}$

Enthalpy change in a chemical reaction
$\Delta H = \Delta E + P\Delta V$ (at constant pressure P)
We know, $\Delta E = q - w$ (for expansion work)
Then, $\Delta H = q - w + P\Delta V$
$\Delta H = q - P\Delta V + P\Delta V$ (as $w = P\Delta V$)
$\Delta H = q_p$ (heat at constant pressure)

If 'q' is the heat absorbed or evolved, then
$\Delta E = q_v$ (at constant volume) and $\Delta H = q_p$ (at constant pressure).

Relationship between enthalpy and internal energy

a. For solid and liquid systems: The volumes of solid and liquid do not change considerably, therefore $\Delta V = 0$ (isochoric process)
$\Delta H = \Delta E + P\Delta V$
Thus, $\Delta H = \Delta E$

Example: HNO_3 (aq) + NaOH (aq) → $NaNO_3$(aq) + H_2O (l)

b. For gaseous system:
The expression for gaseous system is as follows.

$$\Delta H = \Delta E + \Delta nRT$$

Or $q_p = q_v + \Delta nRT$

Δn = Number of moles of gases products – number of moles of gases reactants.

When number of moles of reactants is equal to number of moles of products in a gaseous system, $\Delta n = 0$ and the equation becomes $\Delta H = \Delta E$

Example: H_2(g) + Cl_2 (g) → 2HCl (g), $n_p - n_r = 2 - 2 = 0$

- ✓ If Δn is negative, then $\Delta H < \Delta E$.
  Example: 2NO(g) + O_2(g) → $2NO_2$(g)

- ✓ If Δn is positive, then $\Delta H > \Delta E$.
  Example: PCl_5(g) → PCl_3(g) + Cl_2(g)

Numerical problems based on enthalpy:

The heat of formation of methane at constant pressure at 298 K is -74.85 kJ. What will be the heat of formation at constant volume?

C (s) + $2H_2$ (g) → CH_4(g), ΔH (q_p) = -74.85 kJ = –74850 J
No. of moles of reactant = 2 (carbon is excluded as it is in solid form)
No. of moles of product = 1
$\Delta n = 1–2 = –1$
$\Delta E(q_v)$ =?
$\Delta H = \Delta E + \Delta nRT$
-74.85 kJ = $\Delta E - 1 \times 8.314 \times 298$
ΔE = -74850 + 2477.57 = -72372.43 J = - 72.373 kJ

ACTIVITY 3

1. How are ΔH and ΔE related in the following reaction?
   $3H_2(g) + N_2(g) \rightarrow 2NH_3$

2. The heat of combustion of benzoic acid at constant volume is found to be -3200.7 kJ.
   $C_6H_5COOH\ (s) + 6.5\ O_2\ (g) \rightarrow 6CO_2\ (g) + 3H_2O\ (l)$

3. Calculate the heat of reaction at 25°C and at constant pressure.

Spontaneous and non-spontaneous processes

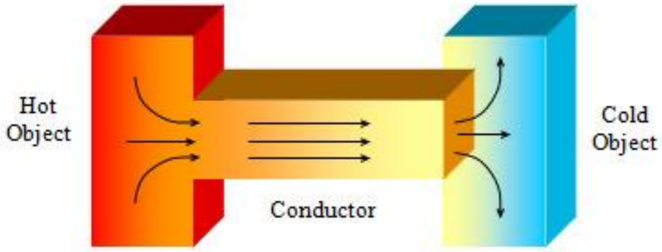
a) Spontaneous process

A spontaneous process can be defined as a process which takes place by itself without the help of any external agencies, under the given set of conditions.

Some of the spontaneous processes occur rapidly while others occur slowly. All those natural or irreversible processes are spontaneous process.

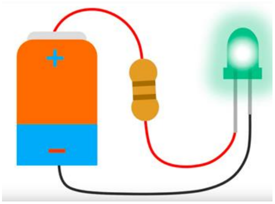
Examples of spontaneous processes

i. Spontaneous flow of heat from hotter end of a metal -rod to its colder end



ii. Spontaneous dissolution of common salt when dropped in water

iii. Flow of electricity from higher potential end to lower potential end



b) Non-spontaneous process

It is the process which does not have any natural tendency to occur by itself. Non-spontaneous processes are made to occur by supplying energy from external agency.

Example of non-spontaneous processes is electrolysis of molten lead bromide.
Other examples are like thermal decomposition of NH_3, $KClO_3$, etc.
These processes will continue only if the electricity is maintained.

Factors that determines the feasibility or spontaneity of a process

i. Enthalpy factor:

For the process to occur spontaneously, it must release the energy usually in the form of heat (ΔH is negative). So, all those exothermic processes occurring by release of energy are spontaneous.
However, there are some reactions which occur spontaneously by absorbing energy (heat)-i.e. endothermic in nature.

Example: evaporation of H_2O, C_2H_5OH, CH_3COCH_3

ii. Randomness factor:

This is another factor for determining the feasibility of the process. The process becomes more spontaneous if the degree of randomness or the disorderliness among the molecules is greater.

Example: diffusion of perfume molecules. The diffusion process is greater when molecules are more random.

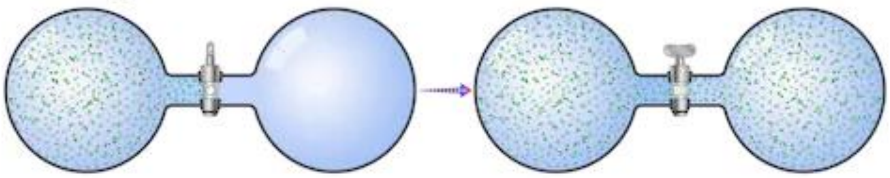
But neither of these two factors alone can decide the feasibility of the process.

iii. Driving force:

The overall tendency for a process to occur spontaneously by itself is called the driving force. Driving force is the main factor which determines the feasibility or spontaneity of a process. It is the summation of energy factor and the randomness factor.
Driving force = resultant of energy factor and randomness factor.

Entropy (S)

It is defined as the property of a system which measures the disorderliness or the randomness of the constituent particles of the system.



The entropy depends on the initial and final states of a system. Therefore, it is a state function.

Change in entropy (ΔS)

For any chemical process, ΔS = entropy of final state - entropy of initial state.

$$\Delta S = S_{final\ state} - S_{initial\ state}$$

For reversible process:

$\Delta S = \frac{q_{rev}}{T}$ at equilibrium. Here, q_{rev} is amount of heat exchanged at temperature T.

For irreversible process this equation is not applicable because the heat exchanged will be an indefinite and uncertain quantity.

Unit of ΔS: $JK^{-1}mol^{-1}$

The entropy of gas is greater than that of the liquid followed by solid.

$S_{vap} > S_{liquid} > S_{solid}$

For a spontaneous process, the entropy goes on increasing and becomes maximum at equilibrium. Beyond equilibrium the entropy does not increase. This means the entropy change (ΔS) at equilibrium is zero.

Examples of processes in which the entropy increases:

- Evaluation of water: H_2O (Liquid) $\xrightarrow{heat}$ H_2O (vapour)

- Melting of ice

- Decomposition of $CaCO_3$
  $CaCO_3(s) \rightarrow CaO\ (s) + CO_2\ (g)$

- Spreading of perfume molecules when the bottle is opened.

ACTIVITY 4

1. What happens to the entropy in the following process?
   i. $PCl_5 \rightarrow Cl_2 + PCl_3$
   ii. Boiling of eggs
   iii. $2CO\ (g) + O_2(g) \rightarrow 2CO_2\ (g)$
   iv. Diffusion of gas.

Limitations of first law of thermodynamics:

- The first law of thermodynamics does not put any restriction on the direction of flow of heat. It does not explain whether heat can flow from colder body to hotter body.
- It does not tell whether a gas can diffuse from low pressure to higher pressure or not.
- It does not explain why water cannot flow from lower level to higher level.
- It does not explain why perfume molecules that have diffused out cannot be collected back into the bottle.
- It does not explain the feasibility of the process in a particular direction.
- It does not explain why total heat cannot be converted into work.

Second law of thermodynamics:

The second law of thermodynamics helps us to predict whether a given process can occur spontaneously or not and the direction of a naturally occurring process under given conditions of temperature and pressure.

Second law of thermodynamics can be stated in various ways:

1st definition

All spontaneously occurring processes are thermodynamically irreversible.

Example: Heat spontaneously flows from hotter body to colder body but the reverse process is not possible.

2nd definition

A spontaneous process cannot be reversed without the help of any external agencies or in other words the process can be reversed with the help of external agencies.

Example: Heat can be made to flow from colder end to hotter end in the refrigerator.
Water can be made to go uphill with the help of an electric motor.

3rd definition

It is not possible to convert heat energy completely into work without leaving some effect elsewhere.

Example: Some amount of heat is lost by the car engine in overcoming the friction.

4th definition in terms of entropy

All spontaneous processes are accompanied by a net increase of entropy. For all spontaneous process $\Delta S_{total} = (\Delta S_{system} + \Delta S_{surroundings})$ is positive.

The entropy of the universe is increasing.

On combining the first and second laws it can be stated as:

The energy of the universe remains constant but the entropy of the universe is increasing continuously.

Summary

- Chemical Thermodynamics is the branch of chemistry which deals with various chemical and physical processes that involve energy changes.
- System is the specific portion of the matter under study and is separated from the rest of the universe.
- Open system is a system which transfers and exchanges both mass and the energy with its surrounding.
- Closed system is a system which transfers only mass but not energy with the surrounding.
- Isolated system is a system which exchanges neither mass nor energy with the surrounding.
- Intensive properties are properties which do not depend on the number of particles in the system. Examples: Temperature, density, viscosity, boiling point, freezing point, pressure, etc.
- Extensive properties are those properties which depend on the amount of substance (number of particles) present in the system.
- Isothermal process is the process in which the temperature of the system remains constant although heat enters or leaves the system.
- Adiabatic process is a process during which no heat enters or leaves the system.
- Isobaric process is the process during which the pressure of the system remains constant.
- Isochoric process: It is the process during which the volume of the system remains constant.
- Cyclic process is the process during which the system comes to its initial state through number of different processes.
- The internal energy is the sum of translational energy, rotational energy, vibrational energy, electronic energy and, nuclear energy in atoms and molecules.
- Heat (q) is exchanged between the system and surroundings due to the difference in temperature.

- In thermodynamics, work is the mode of transfer of energy between the system and the surrounding due to the difference in pressure.
- For isothermal expansion of a gas, $W = -P\Delta V$.
- Work done during isothermal irreversible process

$$w_{irre} = -P_2\,(V_2 - V_1)$$

- Work done during the isothermal and reversible expansion of an ideal gas

$$W = -2.303nRT \log \frac{V_2}{V_1} \quad \text{(at constant pressure)}$$

$$W = -2.303nRT \log \frac{P_1}{P_2} \quad \text{(at constant volume)}, R = 8.314\ JK^{-1}mol^{-1}$$

- First Law of thermodynamics, states that energy can neither be created nor be destroyed but can be converted from one form to equivalent amount of other form.
- Mathematical form of first law of thermodynamics

  $\Delta E = q - w$ (for work done by the system)

  $\Delta E = q + w$ (for work done on the system)
- Enthalpy is defined as the total heat content of a system at constant pressure. Mathematically: $H = E + PV$.
- For solid and liquid systems, $\Delta H = \Delta E$.
- The expression for gaseous system is $\Delta H = \Delta E + \Delta nRT$.
- A spontaneous process can be defined as a process which takes place by itself without the help of any external agencies, under the given set of conditions.
- Non-spontaneous process is the process which does not have any natural tendency to occur by itself. They are made to occur by supplying energy from external agency.
- Entropy is defined as the property of a system which measures the disorderliness or the randomness of the constituent particles of the system.
- The second law of thermodynamics in terms of entropy can be stated as- the energy of the universe remains constant but the entropy of the universe is increasing continuously.

Self-check for Learning

1. How are ΔE and ΔH related in the following reaction?

   $CO(g) + \frac{1}{2} O_2(g) \rightarrow CO_2(g)$
2. Which one of the following has higher entropy?

   1 mole of ice at 0^oC or 1 mole of water at 25^oC

   Solid KNO_3 or aqueous solution of KNO_3
3. Using the mathematical expression of first law of thermodynamics, write the expression for the adiabatic process and isochoric process.

1.5 Mass Spectroscopy

- Explain the principle of mass spectroscopy.
- Interpret mass spectrum of compounds.
- Write the applications of mass spectroscopy.
- Explain the instrumentation of mass spectrometer.

Introduction

Mass spectroscopy is an analytical technique, in which a sample of an organic compound is converted into gaseous positive ions, and then sorted according to their mass to charge ratio (m/z). The relative abundance of such ions is analysed in order to identify the composition of the compound and elucidate its structure.

Principle:

In this technique, the gaseous molecules of a substance are bombarded with the beam of energetic electron. During the bombardment an electron from the outermost orbit of the molecule is knocked off, as a result of which positively charged molecular ions are produced. The molecular ion further undergo fragmentation to produce positively charged ions called fragmented ions or daughter ions. The ions so produced are sorted and analysed based on their mass to charge ratio (m/z). For most of the ions, the charge is one and thus, m/z ratio is simply the molecular mass of the ion. The pattern of fragmentation and the m/z ratio of ammonia is shown below.

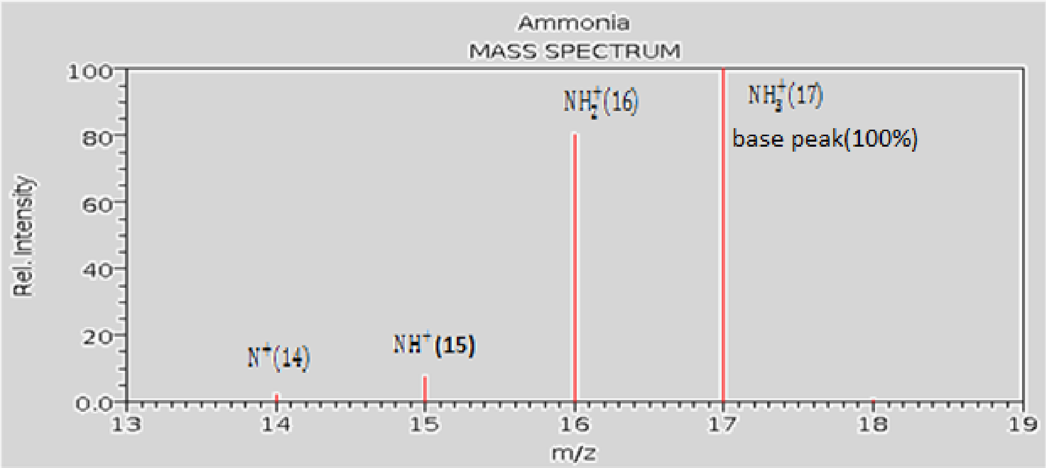
$$NH_3 + e^- \longrightarrow [NH_3]^+ \xrightarrow{-H} [NH_2]^+ \xrightarrow{-H} [NH]^+ \xrightarrow{-H} [N]^+$$

(e^-: bombarding electron; $[NH_3]^+$: molecular ion, m/z = 17; $[NH_2]^+$: m/z = 16; $[NH]^+$: m/z = 15; $[N]^+$: m/z = 14)

The molecular ion and other fragmented ions are separated by passing them through electric and magnetic field. A signal corresponding to m/z value of each of the ion is obtained. The relative intensities of the signals in the mass spectrum, indicates the relative abundance (number of ions) of the ions produced during bombardment.

Mass spectrum of a compound is the plot of relative abundance (intensity) and m/z ratio of different ions. A signal with the highest intensity is the *base peak* and assigned 100% abundance. The intensities of other peaks are relative to the intensity of the base peak. A particular type of compound has a unique base peak in its mass spectrum which is useful in identifying the compound. The mass spectrum of ammonia molecule is given below.

Ion	N^+ Third fragment	NH^+ Second fragment	NH_2^+ First fragment	NH_3^+ molecular ion or parent ion (M^+ peak)	^{15}N isotope in NH_3 (M^+ +1) peak
m/z ratio	14	15	16	17	18
Relative Intensity	2.2	7.5	80	100 (Base peak)	0.4



Neutral particles (whether neutral molecules or the radicals) produced during the bombardment, are not detected in the mass spectrum.

Interpretation of mass spectrum:

The peak with the highest m/z ratio is the peak of the molecular ion and found usually towards the extreme right of the spectrum. Such molecular ion peak (parent peak) is usually with the higher intensity and is taken as the base peak (100%). For example, in the case of NH_3, the molecular ion $NH_3{}^+$ has the peak with highest intensity and is taken as the base peak. However, the parent peak is not always the base peak in some of the compounds whose molecular ions are unstable and tend to undergo further fragmentation.

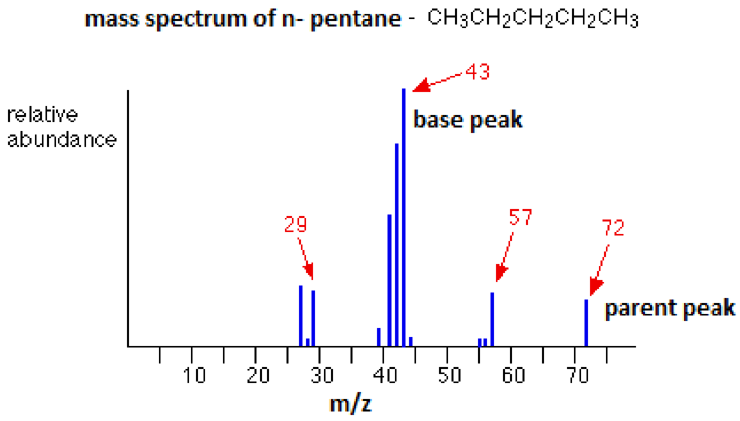
The molecular mass of the molecular ion as analysed by the mass spectroscopy gives the molecular mass of the compound.

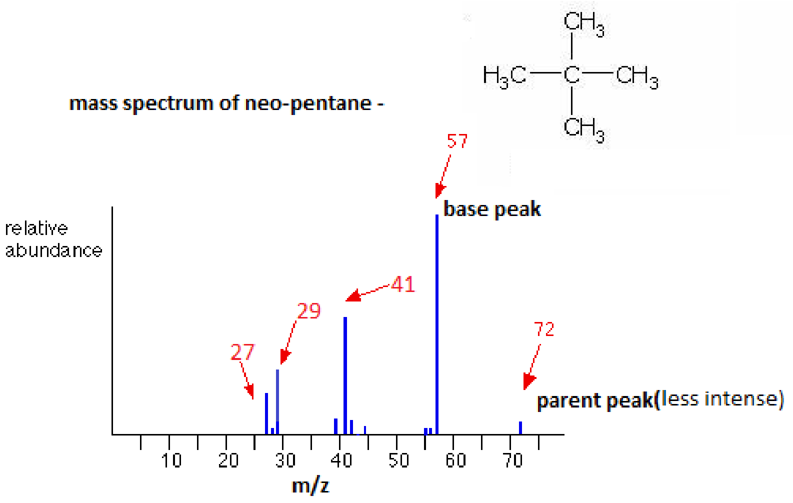
The mass spectrum of a particular compound is unique and no two compounds will have the same spectrum. The mass spectrum of a compound depends on its mode of fragmentation. It is useful in:

- determining the molecular mass of the compound from the m/z ratio of molecular ion.
- identifying the type of compound from its base peak.
- elucidating the structure of the compound from its pattern (mode) of fragmentation.

Some of the features of parent peak.

- The molecular ion peak (parent peak) in aromatic compounds is comparatively much intense due to delocalized pi- electron system.
- Unsaturated compounds (with double or triple bonds) give more intense peak than the saturated or the cyclic compounds.
- The intensity of the peak given by the saturated compounds is more than the corresponding branched chain with same number of carbon atoms. For example, the intensity of molecular ion of n- pentane is more intense than that of neopentane.





ACTIVITY 1

1. Observe the m/z values of neo-pentane and write its fragmentation mode.
2. Write the fragmentation mode of n- pentane.

For straight chain alkane, fragment peaks are formed 14 units apart and the base peak is due to $C_3H_7^+$ ion (43).

For example, a compound forms peaks at m/z values of 100, 85, 71, 57 and 43 (100%). The molecular formula of the compound and its fragmentation pattern can be deduced as follows.

The successive peaks are at 14 units apart, so it is a straight chain hydrocarbon.

The highest m/z value is 100 which is the molecular mass of the parent ion and corresponds to the molecular mass of the sample. The hydrocarbon (sample) with molecular mass 100 is that of a heptane - $CH_3CH_2CH_2CH_2CH_2CH_2CH_3$ - (C_7H_{16})

Fragmentation pattern:

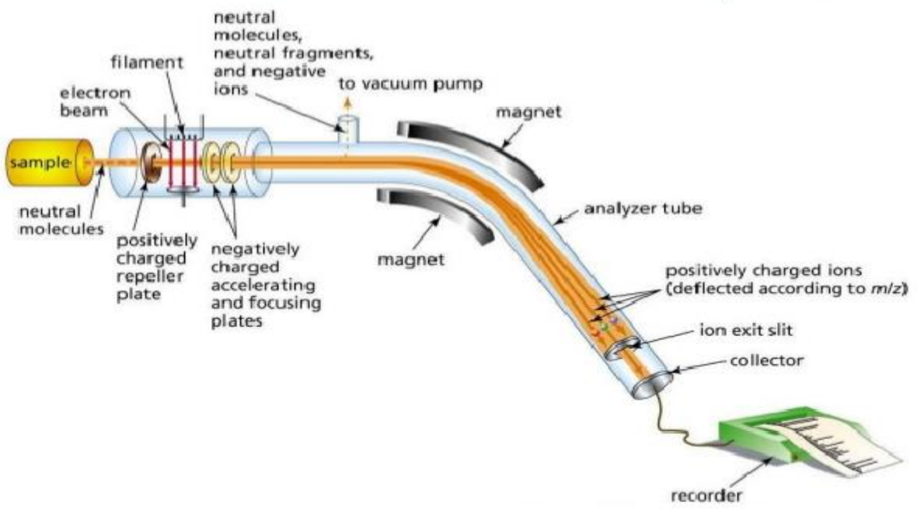
$C_7H_{16} + e^- \longrightarrow C_7H_{16}^+$ (100)
(heptane) (molecular ion)

- $C_7H_{16}^+$ (100) →
  - $C_6H_{13}^+$ (by loss of .CH_3) (85)
  - $C_5H_{11}^+$ (71)
  - $C_4H_9^+$ (57)
  - $C_3H_7^+$ (**base peak**) (43)

ACTIVITY 2

1. From the fragmentation mode of the above hydrocarbon, draw the mass spectrum.

Instrumentation: Mass spectrometer consists of the following parts.



a) Ion source

The first and the important step in mass spectroscopy is the production of ions. The ions are produced by bombarding the gaseous sample with electrons produced from an electrically heated tungsten filament.

The vapour of the sample is passed through a slit into the ion chamber. Here it is bombarded by a stream of electrons produced from tungsten filament. The bombarding electrons have energy of about 70 eV. During the bombardment, the molecule loses an electron to form parent ion.

$$A(\text{molecule}) + e^- \rightarrow A^+ (\text{molecular ion}) + 2\,e^-$$

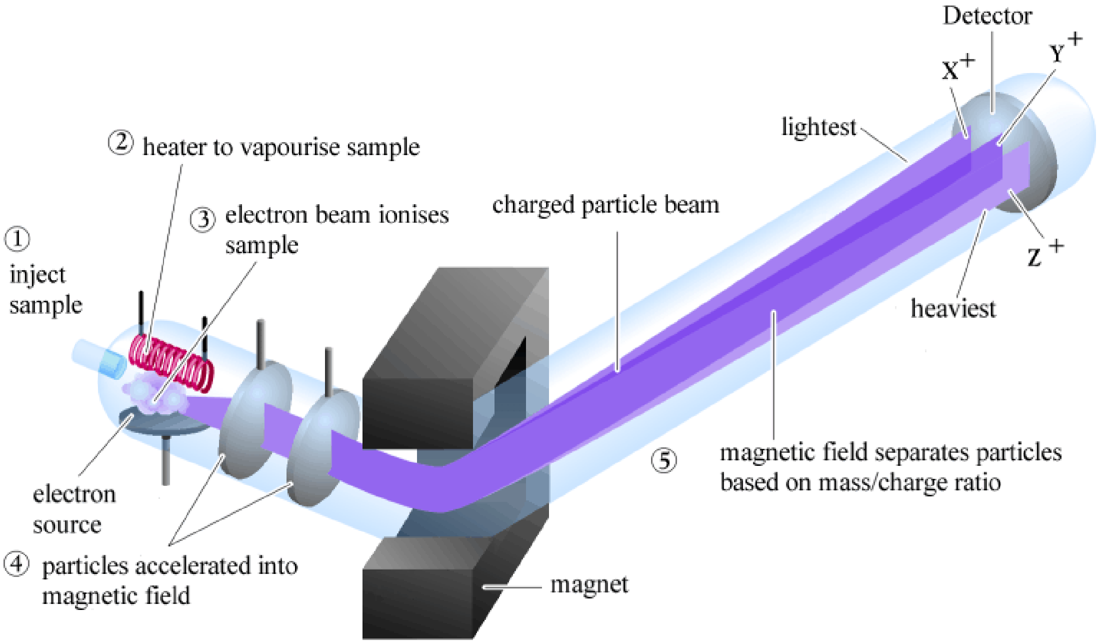
When the energy of the bombarding electron is around 70 eV, fragmentation of neutral molecules takes place and daughter ions are produced.

b) Mass analyser

The positively charged ions (parent and fragment ions) produced in the ion chamber, are accelerated by applying an acceleration potential. These ions then enter the mass analyser. In the mass analyser, fragment ions are differentiated on the basis of their m/z ratio. The fast moving positively charged ions are deflected by a magnetic field according to their m/z ratio. Those ions with lower m/z ratio (mass) are deflected more than those with higher masses. The positions of the deflected ions are recorded as they strike the detector.

c) Ion detector

The ions which are separated by the analyser, are detected and measured electrically or photographically. The spectrum is scanned by going up the scale. The ion currents are amplified by using direct current amplifier. The spectrum is recorded by using a fast scanning oscillograph.



Limitation

The resolving power of this instrument is limited by the spread of translational energy of the ion leaving the source. It is overcome by passing the ion through electric field prior to the magnetic field.

Modification

In a single focussing mass spectrometer, a single magnetic analyser is used to differentiate the ions based on their m/z values. Addition of an electrostatic analyser provides a double focussing mass spectrometer which can achieve a higher mass resolution than a single focussing mass spectrometer. The electric field effects will cause focusing of the ions by placing a slit between electrostatic and magnetic analysers.

Steps of analysis of compound by mass spectroscopy:

Ionization ⟶ Acceleration ⟶ Deflection ⟶ Detection

Summary

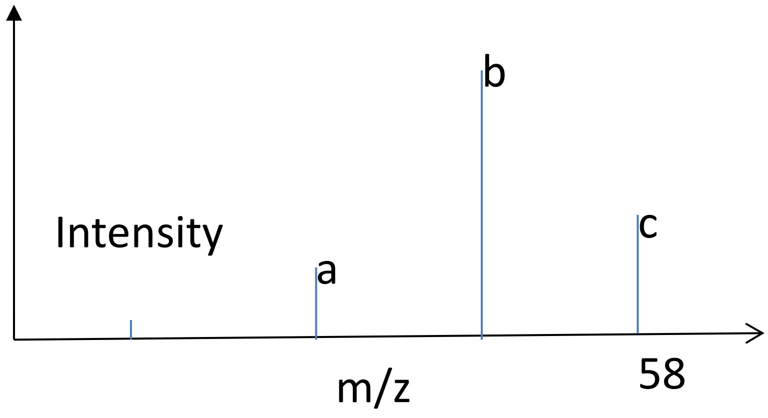
- Mass spectroscopy involves conversion of a sample of an organic compound into gaseous positive ions, and then sorting them according to their mass to charge ratio (m/z).
- The ions produced in the first step are molecular ions which further undergo fragmentation to produce daughter ions.
- Mass spectrum of a compound is the plot of relative abundance (intensity) and m/z ratio of different ions.
- Base peak is the peak with highest intensity.

- The peak with highest m/z value is the parent peak.
- Steps of analysis of compound by mass spectroscopy:

  Ionization ⟶ Acceleration ⟶ Deflection ⟶ Detection

Self-check for Learning

1. Write the formula of the fragments obtained from isobutane. The m/z values for the fragments are 43, 28 and 27.
2. What is mass spectroscopy?
3. An organic compound, alkane shows the mass spectrum as shown below:



   i. Identify the base peak from the spectrum.
   ii. Identify the parent peak.
   iii. What is the molecular mass of the compound?
   iv. Name the compound.

2. PHYSICS

2.1 Newtonian Gravitation and Kepler's Laws

- Explain the force of attraction between the two masses (Earth and Moon).
- Derive expression for acceleration of the moon with which it accelerates towards Earth.
- State Kepler's laws of planetary motion.
- Define the terms related to the laws.

Introduction

In this lesson you will learn about the significant force that keeps the Sun, Moon and planets in their respective positions and the Kepler's laws of planetary motion. This significant force is called the "Gravitational force" or simply gravity. One of the spectacular works in the history of science is the discovery of Newtonian Gravitation, which uncovers the Laws of Nature. It governs many of the underlying physical phenomena.

Newtonian Gravitation

Newton proposed that matter itself is a source of force which influences the dynamics of the matter. Any matter that has mass gives rise to the gravitational force of attraction.
Does the force of attraction exist between two people, or between the objects lying near you?
According to Newton, the gravitational force of attraction between any two spherical masses say M_1 and M_2 which is separated by the distance R is given by

$$F = \frac{GM_1M_2}{R^2}$$

Here G is called universal gravitational constant and its value is 6.67 x 10^{-11} Nm^2Kg^{-2}.

- And what kind of force is the gravitational force?
- Is it attractive or repulsive in nature?
- What would have happened if there was no gravitational force in the space?

Because of the Earth's gravitational force, the moon continuously orbits around the Earth, similarly the Earth-Moon system is orbiting the Sun in an elliptical orbit due to Sun's gravitational force of attraction.
The influence of the gravitational force is beyond our solar system. It reaches far beyond holding together the several galaxies.
For the Earth-Moon system the force of attraction is given by

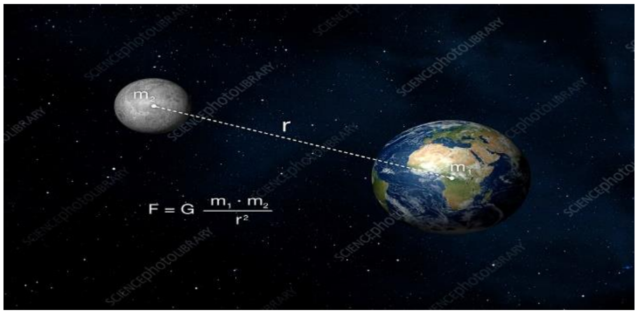
$$F = \frac{GM_EM_M}{R^2} - - - -1$$

where R is the distance between the centres of the Earth and the Moon.

Object close to the surface of the Earth is accelerated towards the Earth with the value of 9.8m/s^2. Therefore, the Moon, in its steady orbit around the Earth, is also accelerated towards the Earth, but with a different value of acceleration than the value of g.

Using equation (1), the value of acceleration, with which the Moon accelerates towards the Earth, can be calculated as follows:

$$F = M_M \left(\frac{GM_E}{R^2}\right)$$



Comparing the above equation with Newton's second law of motion, F = Ma, we have

$$F = M_M a_M, where a_M = \frac{GM_E}{R^2} ------ 2$$

a_M is acceleration imparted to the Moon, due to the Earth's gravitational force.

Also, at the Earth's surface the acceleration imparted on any object, due to Earth's gravitational force is given by

$$g = \frac{GM_E}{R_E^2} ------ 3$$ where R_E is the radius of the Earth.

Dividing equation (2) by (3) and finding the ratio of the acceleration (a_M) to acceleration due to gravity (g).

$$\frac{a_M}{g} = \frac{R_E^2}{R^2}$$

From the result you can conclude that the $\frac{a_M}{g}$ depends on the separation distance between the Earth and the Moon, but independent of the mass. This equation is valid for all the objects orbiting the Earth.

ACTIVITY 1

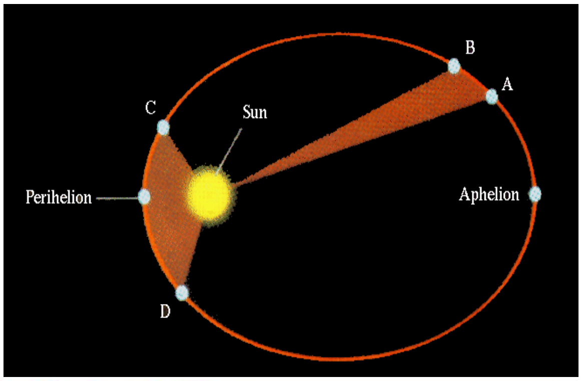
1. What do you think will happen if the gravitational force in our universe suddenly turns off? Write your predictions.

Kepler's Laws

Kepler's law basically deals with the planetary motion. Extensive observations of the motion of the planets were carried out by great astronomer Tycho Brahe to explain the complicated planetary motion. But it was his assistant, Johannes Kepler, who was able to satisfactorily explain the motion of the planets, by making use of observational data recorded by Tycho Brahe. Later these laws were known as Kepler's laws of Planetary Motion. Interestingly, Newton showed that his law of universal gravitation leads to Kepler's laws.

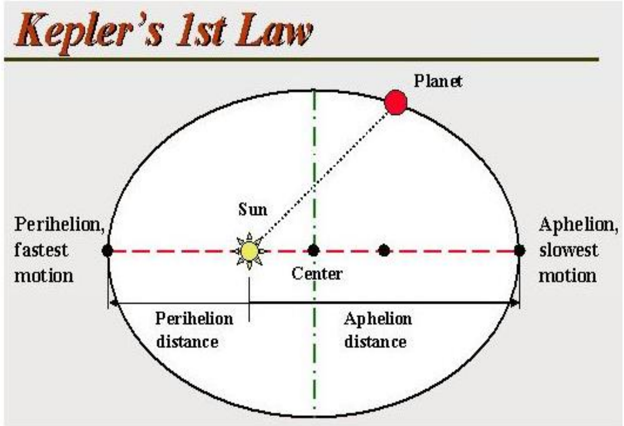
Kepler's First Law: Law of Orbits

According to Kepler's first law or the law of orbits, every planet revolves around the Sun in an elliptical orbit with the Sun situated at one of the foci of ellipse. This law states that all planets move in elliptical orbits, with Sun at one focus.



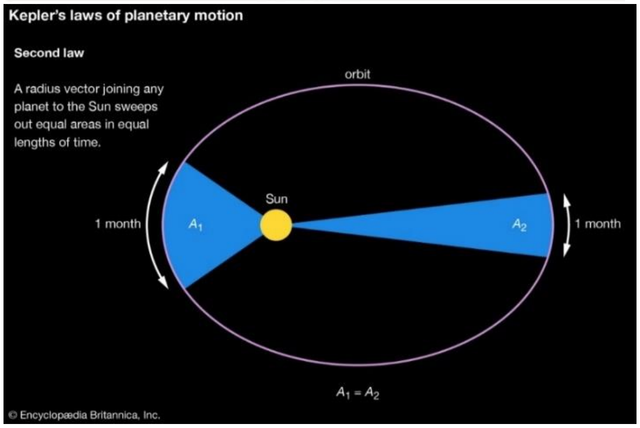
Terms Related to the First Law

- The distance of the planet in its orbit from the sun is called heliocentric distance.
- The point at which the planet is closest to Sun in its orbit is known as perihelion. At this point the planet moves the fastest.
- The point at which the planet is farthest distance from the Sun is known as aphelion. At this point the planet moves the slowest.



Kepler's Second Law: Law of Areas

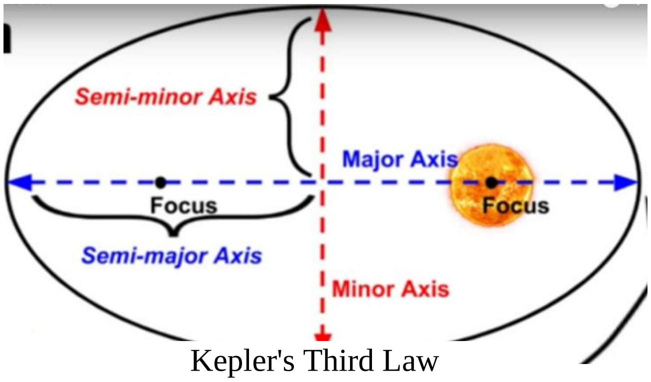
According to the Kepler's second law or the law of areas, the areal velocity of the planet orbiting the sun is constant. In other words, the line joining the planet to the Sun sweeps equal areas in equal intervals of time.



Kepler's Third Law: Law of Periods

According to Kepler's third law or the law of periods, the square of the time period (T) of revolution of a planet orbiting the Sun is directly proportional to the cube of semi-major axis(R) of its elliptical orbit.

$$T^2 \propto R^3$$



Kepler's Third Law

Summary

- The gravitational force between two masses is always attractive in nature.
- The point at which the planet is closest to the Sun in its orbit is known as perihelion.
- The point at which the planet is furthest from the Sun in its orbit is known as aphelion.
- The influence of the gravitational force is far beyond the size of our solar system and reaches across intergalactic space.
- Kepler's law is also known as law of orbits.
- First law is about the paths or shapes of the planetary orbits.
- Kepler's second law is the law of areas.
- Kepler's third law is the law of periods that relates the time period of revolution of the planets to semi-major axis of its orbit.

Self-check for Learning

1. Define Newtonian gravitation and Kepler's laws.
2. A planet is orbiting around the Sun in an elliptical orbit. At which point, perihelion or aphelion, it has
   (a) maximum kinetic energy and minimum potential energy and
   (b) minimum kinetic energy and maximum potential energy.
3. As the radius of the satellite orbit increases, its time period
   A. decreases.
   B. increases.
   C. remains constant.
   D. first increase, becomes maximum for satellite, and then decreases
4. When the planet P is nearest from the Sun S, then the planet is said to be in
   A. orbit. C. perihelion
   B. aphelion D. radioactive zone

2.2 Gravitation Potential and Escape Velocity

- Define gravitational potential and escape velocity.
- Derive the relation for escape velocity.
- Explain orbital velocity.
- Explain the satellite.
- Define orbit.
- State types of satellite.
- Give some real-life applications of escape velocity.

Introduction

What is gravitational potential (V)?

What is escape velocity (V_e)?

A spacecraft leaving the surface of Earth needs to go 7 miles per second, or nearly 25,000 miles per hour, to enter orbit. How do you think launching a spacecraft in a particular path is possible? How does a spacecraft stay so long in the same orbit? As a physics student you need to answer all these questions. Therefore, let us look at some aspects to find out how all these are possible.

Gravitational Potential

Gravitational potential of a body at a point in gravitational field of another body is equal to the amount of work done in bringing a body having unit mass from infinity to that particular point without acceleration.

Gravitational potential = W/m_o

here W is the amount of work done in bringing a body of mass m_o *from* infinity to that point.
Let us consider small amount of work (*dW)* done in moving a body of unit mass through a distance *dx.*We have

$$dW = F.\,dx \text{ --------------(1)}$$

From Newton's law of gravitation,

$$F = \frac{GM_E \times 1}{x^2}$$

$$F = \frac{GM_E}{x^2} \text{-------------(2)}$$

here *F* is force experienced by a body of unit mass kept at a distance *x* from the Earth of mass M_E. *G* is the gravitational constant.
Substituting equation (2) in (1), we get

$$dW = \frac{GM_E}{x^2}dx$$

Integrating from infinity to a given point (say) r, we get

$$W = \int_{\infty}^{r} F.dx = \int_{\infty}^{r} \frac{GM_e}{x^2} dx$$

$$W = GM_E \int_{\infty}^{r} \frac{1}{x^2} dx$$

$$W = GM_E \left| \frac{x^{-2+1}}{-2+1} \right|_{\infty}^{r}$$

$$W = GM_E \left| \frac{x^{-1}}{-1} \right|_{\infty}^{r}$$

$$W = GM_E \times - \left| \frac{1}{x} \right|_{\infty}^{r}$$

$$W = -GM_E \times \left[\frac{1}{r} - \frac{1}{\infty} \right]$$

$$W = -GM_E \times \left[\frac{1}{r} - 0 \right] \because \frac{1}{\infty} \approx 0$$

$$W = -GM_E \times \left[\frac{1}{r} \right]$$

$$W = \frac{-GM_E}{r}$$

This work done W is the measure of the gravitational potential at a given point and is given by

$$V = W = -GM_E/r.$$

Since the gravitational potential energy is given by

$$U = \frac{-GM_E m}{r}$$

Therefore, $U = V \times m$

That is Gravitational potential energy = Gravitational potential × mass of the body.

Escape Velocity

The idea is like rolling a ball up a slope. If you roll it fast enough it will get to the top. The physics behind this is simple - the ball needs sufficient kinetic energy (KE) at the bottom to produce enough potential energy (PE) to get to the top of the hill. For this simple example you would equate

KE = PE

$$\frac{1}{2}mv^2 = mgh$$

Cancelling the mass (m) and re-arranging, we get

$$v^2 = 2gh$$

$$v = \sqrt{2gh}$$

For escape velocity from the moon/planets etc, the gravitational potential energy formula is not mgh. It is PE = $-GMm/r^2$ where M is mass of planet, m is mass of object, G is universal Gravitational constant and r is distance from centre of planet (not the surface).
At the surface the object should have enough KE so that the total energy is zero (when it has escaped the planet).

Derivation of Escape Velocity

Escape velocity is the velocity of an object required to overcome the gravitational pull of the planet to escape into space. It is dependent on the mass and radius of the planet you are trying to escape from and Newton's gravitational constant. A larger planet has more gravity and requires a much greater escape velocity than a smaller planet with less gravity.
Now to derive escape velocity for a particular planet we just have to use energy equation. The concept is, the kinetic energy of the body at the surface of the planet should be sufficient to overcome the gravitational pull from the planet which means kinetic energy should be equal to the negative potential energy of the body at the surface of the planet.
From definition of potential energy we can calculate that for a planet of mass M and radius R, the potential at its surface is
$-(GM/R)$, where 'G' is the universal gravitational constant.
So potential energy of a body of mass m is equal to $-(GMm/R)$.
As we have calculated the work done in gravitational potential, it is at the cost of kinetic energy given to the body at the surface of the Earth. If we take distance $x = R_E$ (radius of earth) and V_e escape velocity, kinetic energy of the body = $\frac{1}{2}mv_e^2$.

According to the principle of conservation of energy, total energy at the surface of the Earth must also be zero. So,

$$PE + KE = 0$$

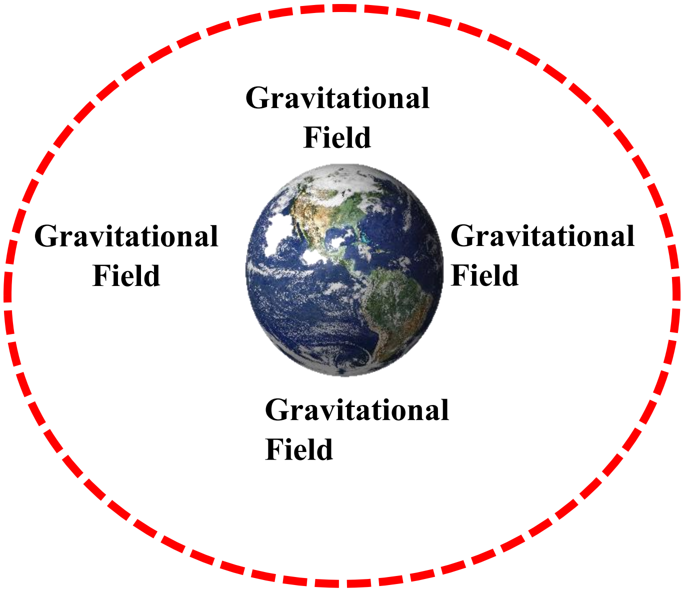
$$KE = PE$$

$$\frac{1}{2}mv_e^2 = \frac{GM_Em}{R_E}$$

$$v_e^2 = \frac{2GM_E}{R_E}$$

$$v_e = \sqrt{\frac{2GM_E}{R_E}}$$

Therefore, the minimum velocity with which a body should be projected vertically upwards from the surface of Earth, such that it is able to cross the gravitational field of the earth and never return on its own to the surface of Earth is called escape velocity (or escape speed).



What will happen to the satellites if they do not have enough velocity to escape the gravitational field?

The satellites fall back to the Earth due to gravitational force.

Escape velocity

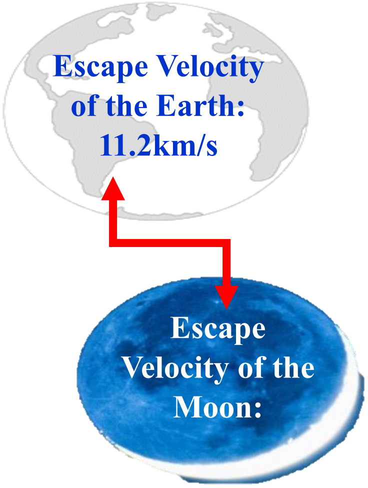
- does not depend on the direction in which the body is projected from the planet.
- would be achieved easily if an object is projected in the direction of the rotation of the earth.
- is same for all the masses of the object.

Example: *If you want to drive 100km to reach a destination in 1 hour, no matter how small or a big car you drive, you would still need to drive at the speed of 100km/h to reach the destination.*

Let us calculate the escape velocity of the moon.

$$v_e = \sqrt{\frac{2GM_E}{R_E}} \quad ---General\ formula\ to\ find\ escape\ velocity$$

$$v_m = \sqrt{\frac{2GM_m}{R_m}} \quad ----Escape velocity for the moon$$



Mass of the moon (M_m) = 7.36 x 10^{22} kg

Radius of the moon (R_m) = 1.74 x 10^{6} m

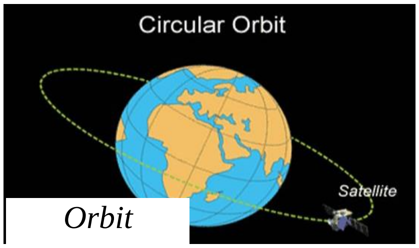
Gravitational constant (G) = 6.67 x 10^{-11} Nm^2/kg^2

$$v_m = \sqrt{\frac{2 \times 6.67 \times 10^{-11} \times 7.36 \times 10^{22}}{1.74 \times 10^{6}}}$$

$$v_m = 2.38 \times 10^{3} km/s$$

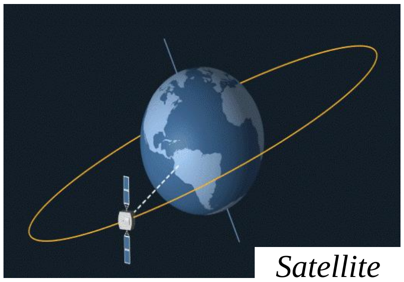
Definition

- An orbit is a curved path followed by any object around another object under the influence of gravity.



Orbit

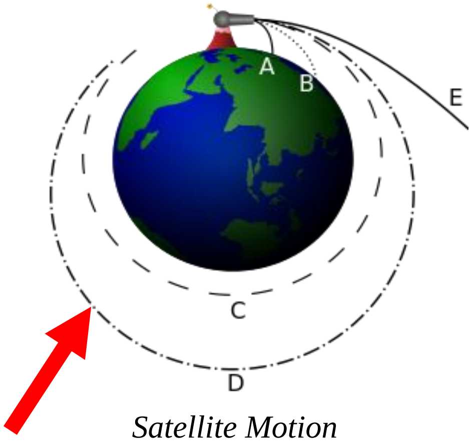
- A body which is revolving continuously in an orbit around a comparatively much larger body is called satellite.



Satellite

Satellite Motion

The motion of the satellite is almost projectile.
For the satellite to be in a particular orbit, first the satellite has to be launched with specific velocity called escape velocity and once it is in the desired orbit, it rotates with velocity called orbital velocity.
Newton was the first person to state that projectile launched with sufficient velocity would actually orbit the Earth.



Satellite Motion

Satellite needs specific velocity so that they do not fall back on the Earth due to gravity.
The specific minimum velocity required to put the satellite into a given orbit around the Earth is called *orbital velocity*.

$$v = R_E\sqrt{\frac{g}{R_E+h}}$$

This depends on the radius of the orbit and the height of the satellite from the Earth.

Orbital velocity helps the satellite to remain in motion and balance the force as well.
The centripetal force is provided by the gravitational attraction of the Earth.

$$F = \frac{GMm}{r^2} --- Gravitational force$$

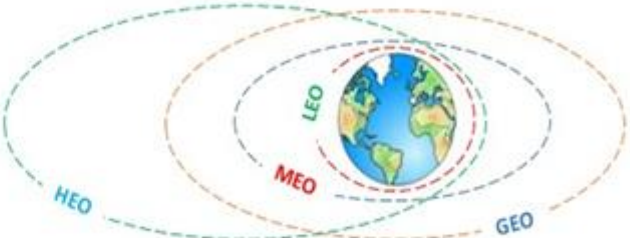
$$F = \frac{mv^2}{r^2} --- Centripetal force$$

The time taken by the satellite to complete one rotation around the Earth is called *orbital period*.

Types of Satellite Orbits

There are basically five types of orbits

1. **Low earth orbit (LEO)**
2. **Medium earth orbit (MEO)**
3. **Geo-stationary orbit (GEO)**
4. **Sun-synchronous orbit**
5. **Highly elliptical orbit (HEO)**



Types of Satellite Orbits

Orbital decay

- The orbital decay is a process that leads to gradual decrease of the distance between the two orbiting bodies.
- The orbital decay can be caused by the mechanical and gravitational effects.
- The orbits closer to the earth decay faster than orbits away from earth due to the large atmospheric drag.
- The satellites in the higher orbits are hardly affected due to its larger distance.

Choice of the Orbit

- The orbit that is chosen for the satellite depends upon its application, function and the area it serves.
- Low earth orbits are used for collecting high resolution images of the Earth by remote sensing satellites.
- Geostationary orbits are used for broadcasting television and communication.
- The most widely used orbits are the geostationary orbit and the low earth orbit.

Power of the Satellite

- Every satellite needs power to function, and Sun is the main source of power.
- Satellites have solar panels to convert sunlight into electrical energy.
- Satellite has battery to back up during eclipse.

ACTIVITY 1

1. Define gravitational potential and differentiate it with potential energy.
2. Calculate the escape velocity of a satellite launched from the Mars surface if the radius of the Mars is 3389.5 km and mass of the Mars is 6.39 x 10^{23} kg. [Use v_e to calculate where M_E and R_E are given]
3. Differentiate between velocity of an object and escape velocity.

Summary

- Gravitational potential energy (*U*) is a property of the system of two particles rather than that of the particle alone.
- If there are many particles, calculate the gravitational potential energy of each pair separately and find the algebraic sum of all the pairs.
- If we increase the distance(*r*), the value of gravitational potential energy (*U*) increases as due to negative sign.
- When the projectile reaches infinite distance, the total energy becomes zero.
- Escape velocity is independent of the mass of the body.
- Escape velocity depends on mass and radius of the body from where it is projected.
- Orbit is a regular, repeating path that an object in space takes around another one.
- There are different types of orbits in the solar system. Some are circular and some are elliptical.
- The satellite in the orbit is balanced by the gravitational force and the velocity of the satellite.
- A satellite orbit depends on the task for which it is designated.
- Most satellites are launched in the same direction as the rotation of earth.

Self-check for Learning

1. Define escape velocity, satellite, and orbital velocity.
2. Why is it difficult to plan intra-planet missions?
3. Calculate the escape velocity of a satellite launched from the earth's surface if the radius of the earth is 6.4×10^6 m and mass of the earth is 5.98×10^{24} kg. [Use v_e to calculate where M_E and R_E are given]
4. Is it better to launch a ship into orbit from near or away from the equator?

2.3 Semiconductors

- Define semiconductors.
- Mention at least two examples of semiconductors.
- Define energy band, valence band and conduction band.
- Distinguish intrinsic and extrinsic semiconductors with one example each.
- Explain P-type and N-type semiconductor using energy band diagram.
- Mention at least two applications of semiconductors in our daily life.

Introduction

In the last few decades, electronics have taken over major part of our life. We are surrounded by electronics at home, school, office, and everywhere. Have you ever wondered what these electronics are made up of? Most of their essential components (like diodes, transistors and integrated circuits) are made up of semiconductor material. We find semiconductor in virtually all electronic equipment. However, we need to first understand the concept of energy bands, before we learn about the semiconductors.

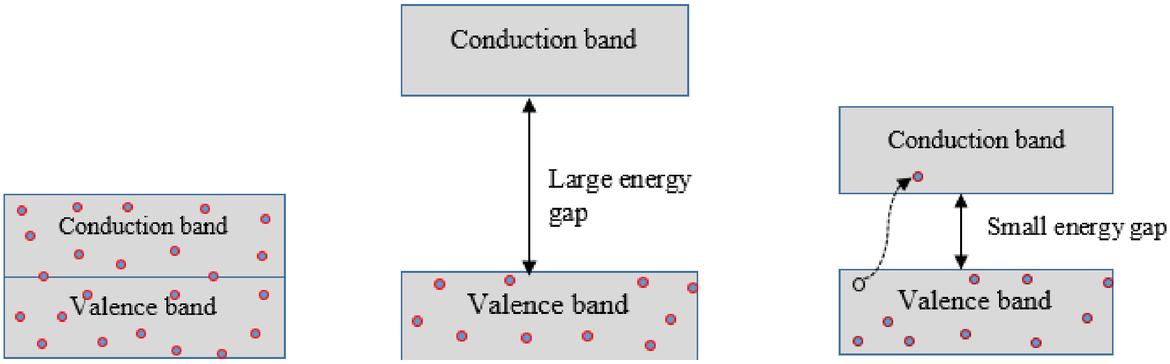
Energy band in solids

In a single free atom, electrons have well defined energy levels (also called electron shells, the fixed distances from the nucleus of an atom where electrons may be found). But in a crystal, the atoms do not have well defined energy levels. It is because, in a crystal, there are many atoms squeezed in a small space. As a result, their energy levels interact and split up into numerous, close and almost continuous energy levels called energy band.

Energy bands are defined as the group of closely spaced energy levels for the electrons in a particular orbit. The energy band formed by a series of energy levels containing valence electrons is called valence band. It is the lower energy band, which is completely filled with valence electrons. Just above the valence band, there is unfilled energy band called conduction band. It is a higher energy band which is completely empty. The gap between these two energy bands, that is, the valence band and the conduction band, is called energy gap (Eg) or band gap or forbidden gap. This is the space where no electrons are allowed to occupy. The energy difference between the valence and the conduction band is equal to width of the energy gap. To achieve a conductivity, electrons from the valence band have to move into the conduction band.

Energy levels are a little like the steps of a staircase. You can stand on one step or another but not in between the steps. The same goes for electrons. They can occupy one energy level or another but not the space between energy levels.

Thus, materials are classified into three categories on the basis of their electrical conductivity. If a material conducts electricity, it is a conductor and if it does not, it is an insulator. The third category of materials, which is neither a good conductor nor a good insulator is known as semiconductors. The energy band structure of a solid determines whether it is a conductor, an insulator or a semiconductor. The diagram below shows the energy bands in conductors, insulators and semiconductors.



Conductor **Insulator** **Semiconductor**

In conductor, there is no energy gap. The valence band and the conduction band overlap. The electrons from valence band can easily enter into conduction band due to this overlapping of bands. Therefore, very low potential difference can cause continuous flow of current.

In an insulator, the energy gap is very large and in general is more than 3 eV. So, no electron is available for conduction. Large amount of energy is needed to move electrons from valence band to conduction band.

In case of a semiconductor, the energy gap is very small. For silicon (Si), it is about 1.1 eV and and for germanium (Ge), it is about 0.7 eV. At 0K, the conduction band is empty and the valence band is completely filled. When a small amount of energy is supplied, the electrons can easily jump the energy gap and enter the conduction band.

ACTIVITY 1

1. The value of energy gap of certain materials P, Q, R, S are as follows:

Material	Energy Gap (eV)
P	3.6
Q	0.9
R	1.2
S	0.0

Sort out the materials into conductor, insulator and semiconductor.

What are Semiconductors?

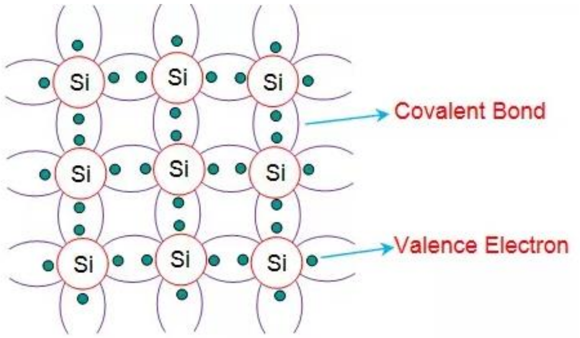
Semiconductors are materials whose ability to conduct electricity lies between that of conductors and insulators. Semiconductors exist in their single-element form as well as in compound form. Examples of single-element semiconductors are antimony (Sb), arsenic (As), astatine (At), boron (B), polonium (Po), tellurium (Te), silicon (Si), and germanium (Ge). Examples of the compound semiconductors are gallium arsenide, indium phosphide, gallium nitride, silicon carbide, and silicon germanium.

Types of semiconductors

1. Intrinsic Semiconductor

A semiconductor made up of only one type of element is called intrinsic semiconductor. It is also known as pure semiconductor as it contains no impurity element. Germanium and Silicon are the most common type of intrinsic semiconductor elements.

Intrinsic semiconductors like Si and Ge have four valence electrons and are all bonded to other atoms forming covalent bond. Two-dimensional representation of silicon structure is shown below.



If the valence electron is to move into the conduction band, it has to first set free by breaking covalent bond. At low temperature, no covalent bonds are broken in the crystal structures of silicon. The electrons are at their lowest energy level. The crystal acts as an insulator because no electron flows.

If the temperature of the semiconductor is increased, electrons are set free by breaking covalent bonds due to thermal energy. These thermally excited electrons are now able to cross the energy gap thereby reaching to conduction band. As the electron comes out from the valence band, it leaves a vacancy with an effective charge of +e. This vacancy is called hole (a vacant spot where an electron was), which apparently acts as a free charged particle (+e). When an external electric field is applied, the free electrons and holes move in an opposite direction and constitutes a current flowing through the crystal lattice.

In intrinsic semiconductors, the number of conduction electron is equal to the number of holes in the valence band.

ACTIVITY 2

1. A certain material that does not conduct electricity at Gasa is certainly observed to conduct electricity at Gelephu. What must be the reason? What material could it be?

2. Extrinsic semiconductor

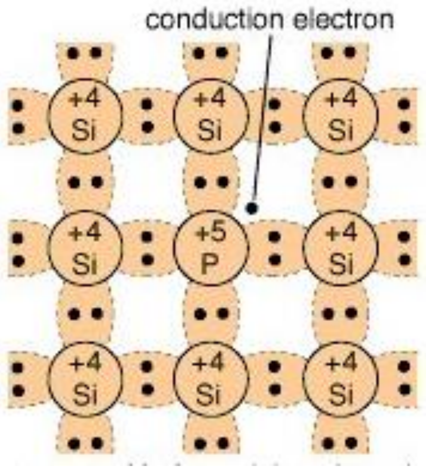
The electrical conductivity of pure (intrinsic) semiconductors can be improved by adding an impurity (normally trivalent or pentavalent atoms) which increases the number of free electrons and holes in the atom. The semiconductor obtained after adding impurity are called extrinsic semiconductor (impure semiconductors). The process of adding an impurity to a pure semiconductor is called doping and the impurity added is called dopant.

Two different impurities are added to the pure semiconductor atoms. The types of extrinsic semiconductors formed after the addition of the impurity are n-type Semiconductor and p-type semiconductor.

N-type semiconductor

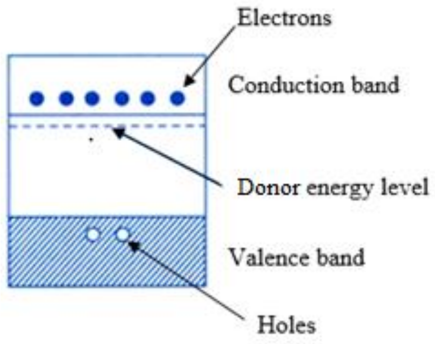
This type of semiconductors is formed by addition of pentavalent impurity atoms (have 5 valence electrons) such as antimony (As), Bismuth (Sb), and phosphorus (P) to a pure intrinsic semiconductor like Si and Ge.

When silicon atoms (have 4 valence electrons) are doped with phosphorus atoms (have 5 valence electrons) in a small amount, four covalent bonds are formed with the four valenceelectrons of silicon, and one electron is left free as a mobile charge carrier, whichimproves the conduction ability to some extent. This type of extrinsic semiconductors is called n-type semiconductors.



In n-type semiconductor material, conduction of electricity is mainly due to electrons and are called majority charge carrier while holes are called minority charge carriers. The addition of pentavalent impurities contributes free electrons which increases the conductivity of the intrinsic semiconductor. Such impurity is called donor atom.

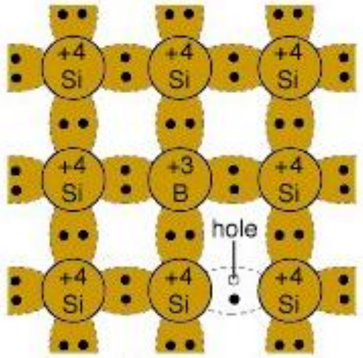
The energy level of the donor is located close to the conduction band, that is, the energy gap is small. The electrons at this energy level are easily excited to the conduction band and contribute to the conductivity. A large number of free electrons are available in the conduction band because of the addition of the pentavalent impurity.



P-type semiconductor

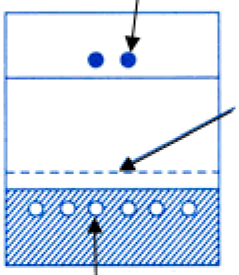
This type of extrinsic semiconductors is formed by addition of trivalent impurity atoms (have 3 valence electrons) like aluminium (Al) and boron (B) to intrinsic semiconductor. They have holes as majority charge carriers.

When an intrinsic semiconductor like silicon is doped with trivalent impurity such as boron (which has only three valence electrons), it leaves one of the bonds with only one electron, creating a ‘hole’ in the bonding structure as shown in the diagram below.



We now have a material with an overall deficiency of electrons, making a positive (p-type) material. Here, boron atom is called acceptor atom because it readily accepts electrons from a neighbouring bond, i.e., from valence band of Si. In this case, holes outnumbered the electrons, so holes are called majority charge carrier while electrons are called minority charge carriers. The energy level of the acceptor is close to the valence band. Since there are no electrons here, electrons in the valence band are excited. As a result, holes are formed in the valence band, which contributes to the conductivity.

In extrinsic semiconductors, because of external impurities, the number of electrons in the conduction band is not equal to the number of holes in the valence band.



Practical applications of semiconductors

Semiconductors are widely used in many electric appliances. Some common uses of semiconductors are as follows:

1. The temperature sensors used in air conditioners are made of semiconductors.
2. Rice cookers cook rice perfectly because semiconductors control the temperature precisely.
3. CPUs that operate personal computers are also made with semiconductors.
4. Many digital consumer products such as mobile phones / smartphones, digital cameras, televisions, washing machines, refrigerators and LED bulbs also use semiconductors.
5. Plays a central role in the operation of bank ATMs.

Summary

- Semiconductors are those materials whose electrical conductivity lies between that of conductors and insulators.
- Semiconductors can be compounds such as gallium arsenide or single-element, or elements such as germanium or silicon.
- Semiconductors act like an insulator at Zero Kelvin. On increasing the temperature, it works as a conductor.
- The resistance of semiconductor materials decreases with the increase in temperature and vice-versa.
- The pure semiconductors are called as intrinsic semiconductors and compound semiconductors are called as extrinsic semiconductors.
- Extrinsic semiconductors are obtained by adding either trivalent or pentavalent impurities.
- Extrinsic semiconductors are further classified as n-type and p-type semiconductors depending on the type of impurity (dopant).

- N-type semiconductors are formed by doping with pentavalent impurity. Every pentavalent impurity atom donates one electron in the crystal, therefore it is called a donor atom
- P-type semiconductors are formed by doping with trivalent impurity. Every trivalent impurity atom has a tendency to accept one electron, therefore it is called an acceptor atom.
- The energy band models can be used to explain conductor, insulator and semiconductor.
- The smaller energy gap or forbidden gap of semiconductor enables electrons to move from valence band to conduction band when it absorbs energy.
- Semiconductors are widely used in many electrical appliances making our life comfortable.

Self-check for Learning

1. What type of semiconductor do you get if you dope silicon crystal with boron?
2. Sort out the characteristics of n-type and p-type semiconductors.
   i. Excess of electrons
   ii. Deficiency of an electron
   iii. Majority charge carrier is hole
   iv. Majority charge carrier is electron
   v. Dopant donates electrons
   vi. Dopant accepts electrons
3. Distinguish between intrinsic and extrinsic semiconductors.
4. How would you imagine your life without semiconductors?

2.4 Communication System

- Define communication and communication system.
- Name three elements of communication system.
- Define terminologies used in communication system.
- Explain the working of communication system.
- Explain bandwidth of signal and channel.
- Describe the propagation of electromagnetic waves.

Introduction

Why do you think that you are able to see what is broadcasted in television though you live in different places? This is due to communications system. Can you think of the type of communication system that existed in Bhutan in early 1950s during the time of our second *Druk Gyalpo*? In those days, people used to communicate on foot. But today we use internet, mobile technology, radio and television. The modern communication is made possible by the application of electromagnetic waves.

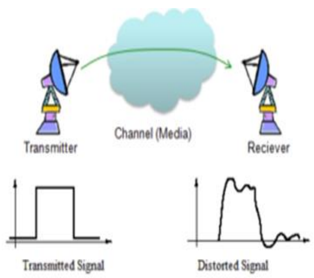
Communication system

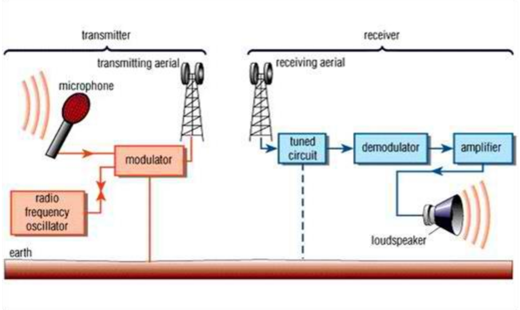
What is communication?

A communication is a mechanism of sending, processing and receiving data or information by electrical means.

What is communication system?

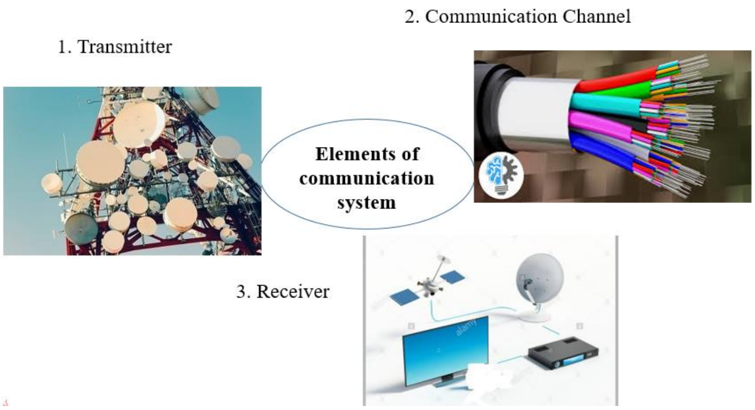
A communication system is an arrangement used for transmission of information from one place to another.





A communication system has three essential elements:

1. **Transmitter:** It is the device which converts the message, or signal, into a form suitable for transmission and then transmits the message signal through a suitable communication channel.
2. **Communication channel:** It is the pathway or the medium required for communicating data from transmitter to receiver. It uses two types of media:
   (a) cable (twisted-pair wire, cable, and fibre-optic cable).
   (b) broadcast (microwave, satellite, radio and infrared).
3. **Receiver:** It is a device that picks up the transmitted signal at the communication channel output and retrieves the message signal in suitable form.



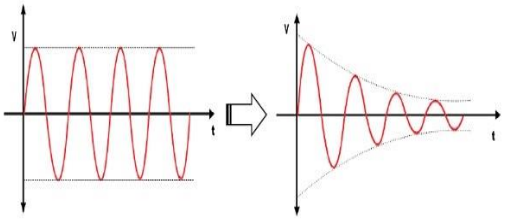
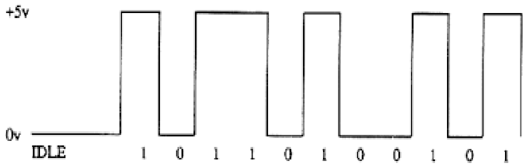
Elements of communication system

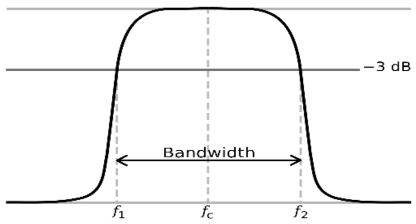
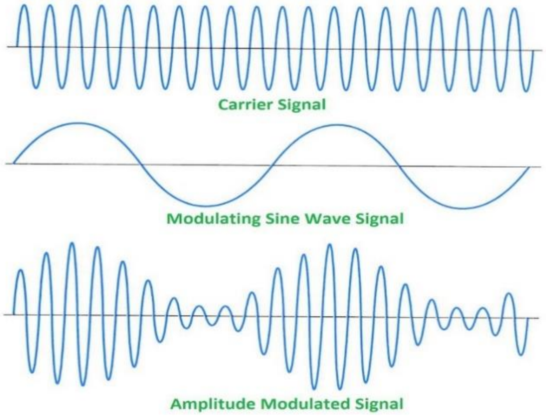
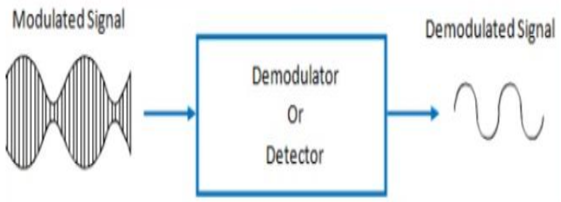
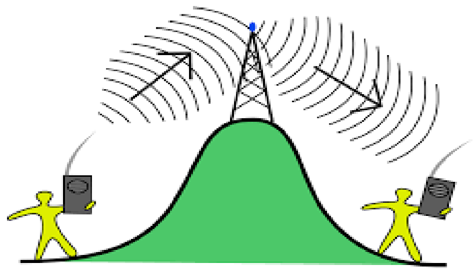
Mode of communication system

There are two basic modes of communication:

Mode of communication system	
1. Point to point mode	**2. Broadcast mode**
Communication takes place between single pair of transmitter and receiver.	Communication takes place between single transmitter and multiple receivers.
Example- Communication through mobile phones where one mobile phone is connected to just one other at a time.	Example- Communication through television and radio where there are many receivers available at one time.

Basic terminologies used in electronic communication system

Terminology	Definition	Examples
1. Transducer	A device used to convert one form of energy into another form.	1. Microphone (converts sound energy to electrical energy) 2. Loudspeaker (converts electrical energy to sound energy)
2. Attenuation	The loss of signal during the propagation through communication channel (reduction in signal strength occurs during the transmission of signal from one place to another).	(The diagram shows the strength of the signal being reduced). 
3. Signal	Electrical impulse that is used to convey information.	1. Analogue signal It changes its frequency and amplitude continuously (represented by sine wave). 2. Digital signal There is no continuous change in its frequency or amplitude (represented by square wave). 

4. Bandwidth	The portion of the electromagnetic spectrum occupied by a signal.	
5. Modulation	The process of imposition of low frequency message signal on a high frequency wave called carrier wave.	
6. Demodulation	The process of extracting signal from the modulated wave.	
7. Repeater	System which receives a weak signal, amplifies it and retransmits it to the next communication channel. Therefore, it is combination of receiver and transmitter.	

Advantages of digital signals in modern communication

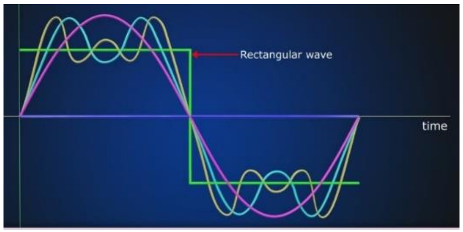
- Has more resistance to undesirable disturbances like noise.
- Draws negligible power.
- Provides common format for encoding.
- Flexibility in configuring digital communication system

The process of converting analogue signal to digital is called sampling. The reverse of sampling is called reconstruction.
To reconstruct, the sampled signal must have frequency equal or greater than 2 bandwidths.

Working of communication system

The transmitter receives the message signal from the information source, converts it into suitable form of signal and transmits the messages through communication channel. If the messages are in voice form, transducer converts it into electrical signal for transmission. The communication channel will carry the messages to the receiver. When messages travel long distance, the signals become weak. In such case, repeater is placed in communication channel and the repeater helps to amplify the signal and retransmit. The receiver picks up the signal and retrieves the message signals. Once the messages are received, the demodulation has to be done to get the exact original message.
Transmission of signal requires certain specifications. We need to specify the signals in terms of frequency. For instance, you might have heard that the frequency of BBS radio at Zhemgang is 93 MHz, while at Sarpang is 88.1 MHz. It means, there is range of frequencies for BBS radio signal. This range of frequencies is called bandwidth.

1. Bandwidth signal: Range of frequencies between upper and lower frequency generated by the signal.



For example, the audible bandwidth of human ears ranges from 20 Hz to 20,000 Hz.

2. Bandwidth of transmission medium: Transmission medium allows signals having certain bandwidth to pass through it.

For example, bandwidth of optical fibre is 1- 1000 THz.

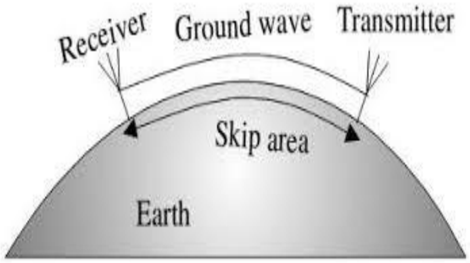
ACTIVITY 1

1. Which type of signal would you prefer analogue or digital? Give at least two reasons.
2. A basic communication system consists of (a) transmitter (b) information source (c) user of information (d) channel (e) receiver.
   Choose the correct sequence in which these are arranged in a basic communication system. Write the function of each component.

Propagation of Electromagnetic waves

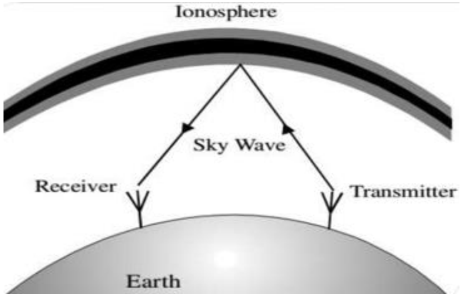
1. Ground Wave propagation

- It is the propagation of radio waves using the surface of the Earth.
- To efficiently radiate the signal, the size of antenna of transmitter should be ¼ of the wavelength of the signal.
- It is used to provide local radio communications coverage, especially by radio broadcast station that is required to cover a particular locality.



2. Sky Wave propagation

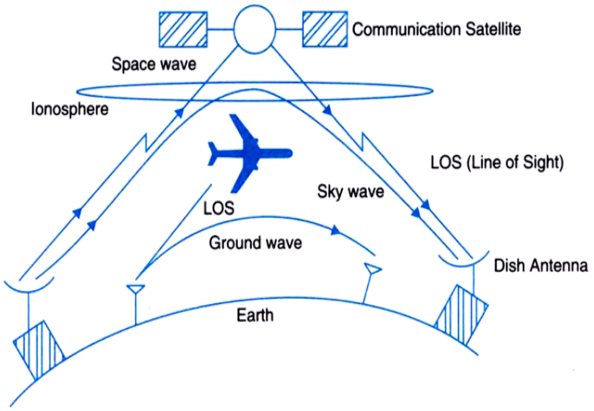
- The radio waves transmitted from the antenna of transmitter is reflected by the ionosphere and sent to the receiver.
- The ionosphere layers are found from a height of 65km to 400 km above the Earth's surface.
- Sky wave propagation is used for communication over long distance.



The maximum frequency of the radio waves that can be reflected by the atmosphere (ionosphere) is known as critical frequency. Beyond critical frequency, the waves get penetrated through the ionosphere.

3. Space Wave propagation

- Space waves travel in straight line and are used in satellite communication.
- In satellite communication, the beam of modulated signal is being sent from the ground station to satellite.
- The process of transmitting suitable signal from the Earth station is called uplink.
- The satellite receives the signal, amplifies it and sends back to the earth. This process is called down link.
- Line of sight communication is limited by the line of sight distance and the curvature of Earth.



Comparison among three types of waves

Ground Waves	Sky waves	Space Waves
Used for a low-frequency range transmission.	Used for a frequency range of 3 – 30 MHz.	Used for a very high-frequency range transmission
Make use of Earth's surface for propagation.	Ionosphere acts as reflecting surface for the waves.	Use of artificial satellite for propagation of waves.
Used for transmitting radio signals within a community.	Used for transmitting radio signals over large area.	Used for transmitting TV and radio signals.

ACTIVITY 2

1. Is it necessary for a transmitting antenna to be at the same height as that of the receiving antenna for line-of-sight communication? Justify.
2. Why are more number of transmission towers of equal transmitting strength required for mobile phone communication in Bhutan compared to India?

Summary

- Electromagnetic waves are the integral part of modern communication system.
- Transmitter, channel and receiver are three main elements of communication system.
- Digital and analogue are the two types of signals used in communication, but we prefer digital signal over analogue signal.
- Bandwidth is range of frequencies associated with signal and channel.
- Three types of propagation of electromagnetic waves are ground waves, sky waves and space waves.
- Radio wave is used in television transmission and radio communication.

Self-check for Learning

1. Explore some applications of microwaves and infrared waves.
2. What will be the situation of life without modern communication system?
3. Write down some negative impacts of modern communication.

2.5 Superposition of Waves

- State the principle of superposition of waves.
- Define interference of waves and state two types of interference.
- Define diffraction with examples.
- Define polarization of light and list its uses.

Introduction

Light is a form of energy. It can travel in the form of waves or can exhibit particle nature.
It is said to have particle nature because light can remove electrons from the metals.
If we consider the wave nature of light, we can explain phenomenon like reflection, refraction, interference, diffraction, and polarization and many more.
In this lesson, you will be looking at some common properties of waves such as interference, diffraction and polarization of waves.

Terms Related to Waves

a. **Path Difference (x):** The difference in distance travelled by two waves to a given point is called path difference.
b. **Wavelength (λ):** It is the distance between two consecutive crest or trough.
c. **Phase difference (ϕ):** The relative position in the crests and troughs of the two waves at a particular point in space at a particular instant of time is called phase difference.

Superposition of Waves

Principle of superposition of waves

When a number of waves get superimposed, the resultant displacement is equal to the vector sum of displacement of all waves.
Mathematically;

$$y = y_1 + y_2 + y_3 + \ldots + y_n$$

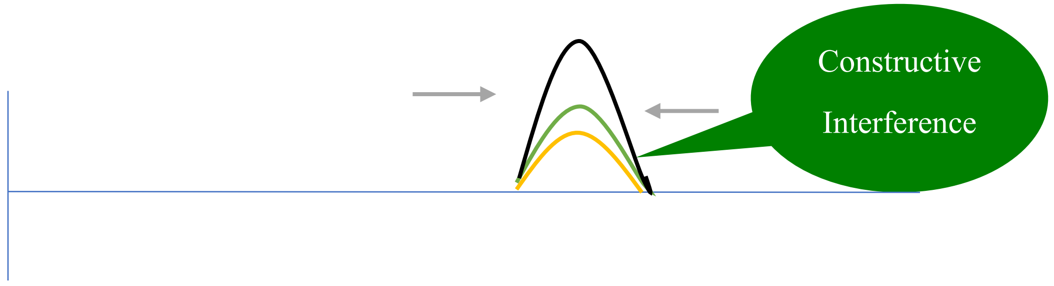
Where y_1, y_2, y_3 are displacement of individual waves and y is the displacement of resultant wave. This phenomenon is called INTERFERENCE.
The redistribution of light energy due to superposition of light waves from two coherent sources of light is called *interference of light*.

When number of waves propagate together either in same direction or opposite direction, for example, let's say 3 to 4 waves are travelling together, they tend to overlap on each other and produce the resultant wave. This is called superposition of waves.

Examples of Interference

- Disturbance in TV signals.
- Irritating sound of a loud speaker when mobile phone rings nearby.
- You hear number of voices on a radio, when you tune in to some frequency.

Constructive Interference:



Two waves (green and yellow in colour) interfere or overlap. They overlap in phase. The resultant wave (black in colour) has bigger amplitude than individual waves.

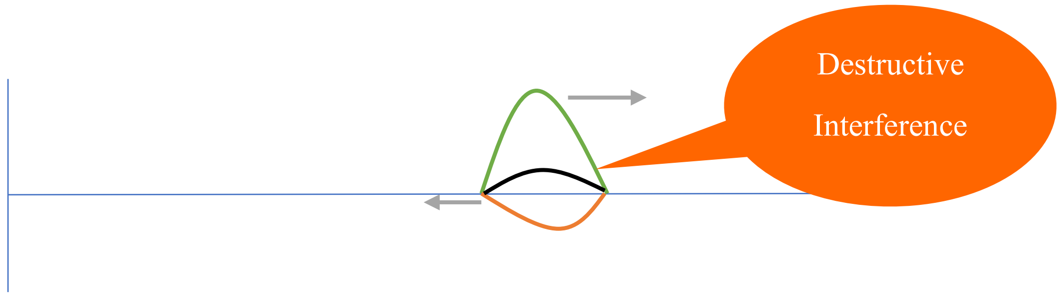
Phase difference: $\phi = 2n\pi$

Path difference: $x = n\,\lambda$

Examples in daily life:

1. Use of many lights in a room
2. Use of 2 loudspeakers in a music room
3. Two headlights of a vehicle

Destructive Interference:



Two waves (green and orange in colour) interfere or overlap. They are out of phase. The resultant wave (black in colour) has smaller amplitude compared to the amplitudes of individual waves.

Examples in daily life:

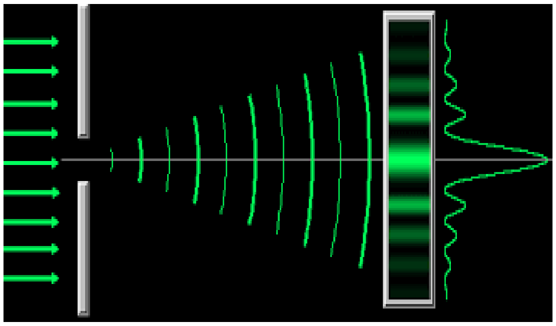
1. Different coloured light illuminating a room.
2. Noice in a football stadium.

Phase difference: $\phi = (2n + 1)\,\pi$

Path difference: $x = [(2n + 1)/2]\,\lambda$

Diffraction of light

The phenomenon of bending or spreading of light rays when it falls on an aperture or an obstacle is called *diffraction.* If we try to form a ray of light through a narrow slit (a very small hole comparable to wavelength of the light) or through many slits, diffraction will always defeat our effort because it always causes the light to spread. Narrower the slits we make, more the light spreads.

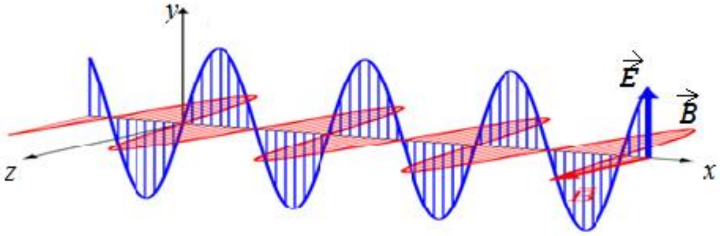


Diffraction of Light

Common example of diffraction is when you look at a clear blue sky and see tiny specks and hair-like structures floating in your view. These floaters, as they are called, are produced when light passes the edges of tiny deposits in the vitreous humor, the transparent material filling most of the eyeball. What you are seeing when a floater is in your field of vision is the diffraction pattern produced on the retina by one of these deposits. If you see through a pinhole in a piece of cardboard so as to make the light entering your eye approximately a plane wave, you can distinguish individual maxima and minima in the patterns.

Polarization of light

A light wave is an electromagnetic wave. It is a transverse wave having both *electric* and *magnetic* components. These electric and magnetic fields vibrate perpendicular to each other and also perpendicular to the propagation of light waves. It occurs in all the direction. This is called unpolarized light. The light from incandescent bulb, lamp, sunlight etc. are examples of unpolarised light.

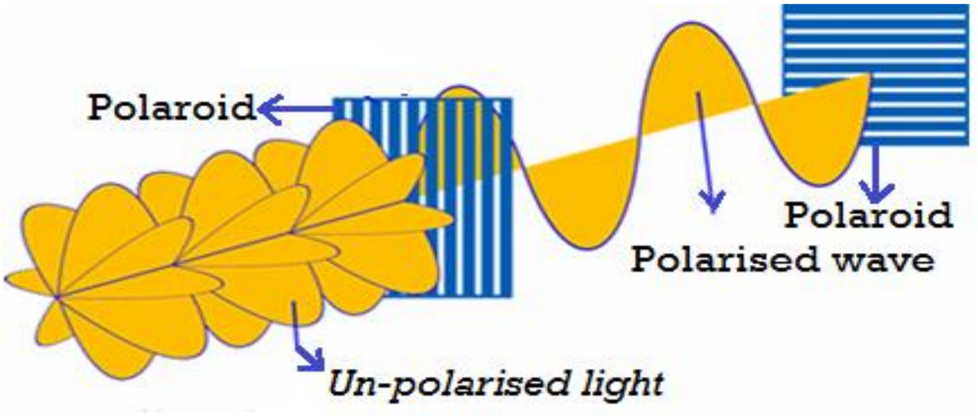


Electromagnetic Wave

In an electromagnetic wave, the electric field oscillates along the y-axis, and the magnetic field oscillates along the z-axis. At the same time the electromagnetic wave propagates along the x-axis. Since the electromagnetic wave is a transverse wave it can be polarized.
Linearly polarised light can be produced from unpolarised light with the aid of certain materials called polaroids.

In the diagram below, the light wave from the left is incident on the polaroid. The unpolarised light wave is filtered by the screen and only the light wave propagating in vertical direction passes through the polaroid. The light wave which is propagating in horizontal direction is obstructed by the polaroid.

The polarised wave between the two polaroids is propagating vertically. Now when this wave is incident on the polaroid with slits/opening placed horizontally, this wave is again obstructed. So, we can say that the polarization depends on the orientation of the slits in polaroids.



Polarization of Light

The process of making light waves to travel only in one direction is called *polarization.*

Concept of polarization is used in following examples with the help of polaroid:

- Communication
- Sunglasses
- Car windshield
- 3D movies

ACTIVITY 1

1. Why do the oil films on the surface of water appear to be coloured?
2. Diffraction is common in sound waves but not common in light waves. Why?

Summary

- According to the principle of linear superposition, the waves reinforce each other and constructive interference occurs. The resulting total wave has an amplitude that is equal to the sum of the amplitudes of the individual waves, and in the case of light waves, the brightness is greater than that due to either wave alone. The point will be bright. This is the maxima.
- According to the principle of linear superposition, when the waves cancel each other's effects, destructive interference results. This means spot will be dark. This is the minima.

- If constructive or destructive interference is to continue occurring at a point, the sources of the waves must be coherent sources.
- Coherent sources of light are:
    i. two sources of light should be obtained from a single source
    ii. the two sources of light should be monochromatic and
    iii. path difference between the light from two sources should be very small.
- Path difference is defined as the difference in the path length or distance travelled by the two waves to a given point on the interference pattern.
- A light wave is an electromagnetic wave which is unpolarised.
- The process of making light waves to travel only in one direction is called *polarization.*

Self-check for Learning

1. Define superposition principle.
2. Give the conditions for constructive and destructive interference.
3. How can light be polarised?
4. If two waves overlap resulting a bigger wave, calculate the path and phase difference for n = 0,1,2, and wavelength 650 nm.
5. Light waves can be polarized while sound waves cannot. Why?
6. What evidence is there to show that sound is not electromagnetic in nature?

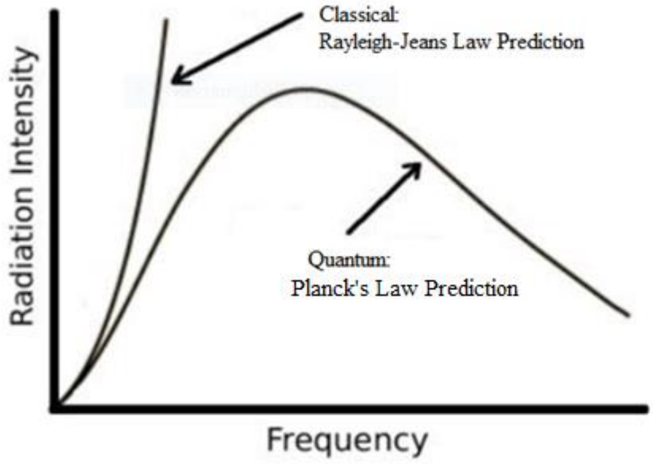
2.6 Photon Model of Electromagnetic Radiation

- Explain the concept of photon.
- Explain the photon model of light.
- Describe experimental setup for photoelectric effect.
- Explain the factors affecting the photoelectric effect.
- Mention few applications of photoelectric effect.

Introduction

In 1900, light was known only as waves. At that time, a British physicist named Lord Rayleigh knew that the colour of hot object depended on temperature. Rayleigh and his friend Jeans considered an object called black body, something that absorbed all radiant energy falling on it, reached some equilibrium temperature and then emitted that energy as quickly as it absorbs. They wanted to find out where the light came from and then doing so, he came up with a law called Rayleigh-Jeans law.

The Rayleigh–Jeans formula gave results in agreement with the experimental observations at low frequencies; however, it failed miserably at high frequencies. According to this law, for an ideal black body at a constant temperature, energy emitted is proportional to frequency squared, which means the energy it emits increased as the frequency increased exponentially. Here lies the problem, because UV light has frequency higher than visible light, and the black body is supposed to give infinite UV light, destroying everything and disintegrating Earth in an instant. This means that if you sit near the fire, the infinite UV rays will destroy you. Thus, violating law of conservation of energy and causing a huge issue which was known as the Rayleigh–Jeans ultraviolet catastrophe. This problem had caused people to question the basic concepts of classical physics as there was a serious discrepancy between the results of classical theory and the experiment, especially for large frequencies.



Blackbody Radiation Vs Frequency

The solution came somewhat accidentally, from a man called Max Planck (a German theoretical physicist whose discovery of energy quanta won him the Nobel Prize in Physics in 1918). Planck was hired by a utility company to try and find a nice bulb, one that would emit maximum amount of energy which would be in visible spectrum rather than heat or UV. Planck found the difference between the classical Rayleigh-Jeans estimation of intensity emitted and his actual result recorded. Planck proposed that energy emitted is in the form of a particle, packets or quanta which later came to be known as photon. And his mathematical calculations matched the experimental findings. The theory and experiment reconciled only after assuming the existence of energy quanta. However, at that time, Planck himself was not very much convinced with his findings and expected that his theory may get refined with time.

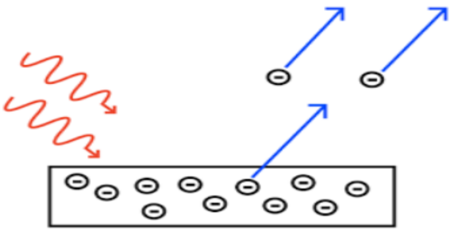
The real quantum revolution began five years later when Albert Einstein used Planck's Quantum theory to explain photoelectric effect. On the other hand, the American experimental physicist Robert Millikan could not accept Einstein's theory of photoelectric effect. He spent ten years trying to disprove Einstein, but only ended up instead proving repeatedly that his discovery of photoelectric effect was correct. Millikan still received a Nobel Prize for his results.

Despite the popularity of Einstein's theories of relativity and his musings on black holes, Einstein's Nobel Prize in physics was actually awarded for his discovery of the photoelectric effect. This discovery revolutionized our understanding of the world around us.

Now there are two models of light that are helpful in describing various experiments. The wave model of light can explain the phenomena of interference and diffraction but fails to explain the photoelectric effect. This difficulty is overcome by the photon model of light.

Photoelectric Effect

Photoelectric effect is defined as a phenomenon in which electrons are emitted from a metal surface when a photon (light that behave as particle) of sufficient energy falls on it. This process is referred to as photoemission and the electrons ejected in this way are called photoelectrons. The diagram below shows photoelectric effect in which photon hitting a metal surface causes electrons to be ejected from the metal surface.



The energy of the photon can be calculated using Planck's equation as

$$E_{photon} = hf$$

where h is Planck's constant (= 6.626 x 10^{-34} J s) and f is the frequency of the photon.

According to this equation, the energy of a photon is directly proportional to frequency of light. If such a photon strikes an electron inside a metallic conductor, it can knock the electrons out of the metal. Once ejected, the free electron has an energy $hf - \emptyset$, where

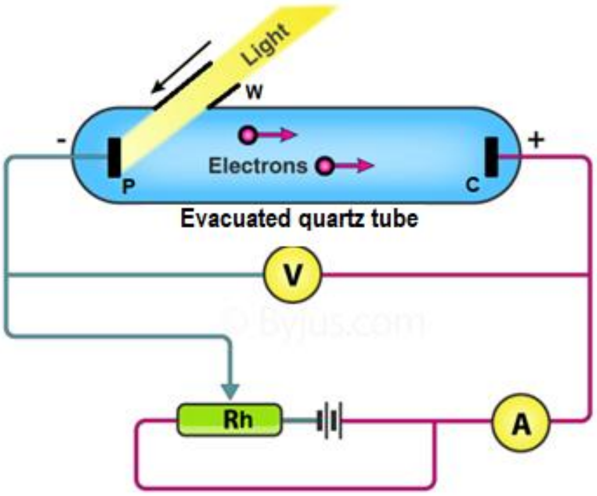
$\emptyset$ is the binding energy which formerly kept it inside the metal. It is also called as "work function" of the metal, which is the minimum amount of energy required to dislodge the electrons from metal surface.

ACTIVITY 1

1. Who discovered the photoelectric effect?
2. As the wavelength of a photon increases, what happens to the photon's energy?

Experimental study of photoelectric effect

The diagram below shows an experimental setup to study the photoelectric effect. The apparatus consists of an evacuated quartz (or glass tube) with a side quartz window W. Two metal plates P and C are enclosed in the tube. The plate P (cathode) is connected to the negative terminal of the battery and C (anode) is connected to the positive terminal of the battery. When light of suitable frequency is made to fall on the plate P through a quartz window, it emits photoelectrons which flow towards the plate C constituting current called photocurrent.



Experimental setup of photoelectric effect

Experimental investigations

What do you think will happen to photoelectric current, if you:

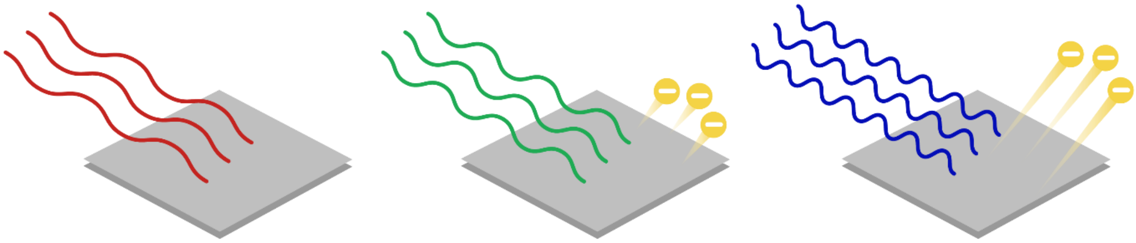
1. vary the frequency of the incident light?
2. vary the intensity of the incident light?
3. vary the potential difference?

These are the three factors that affect the photoelectricity. Let us now see, how each of these factors affect the photoelectricity.

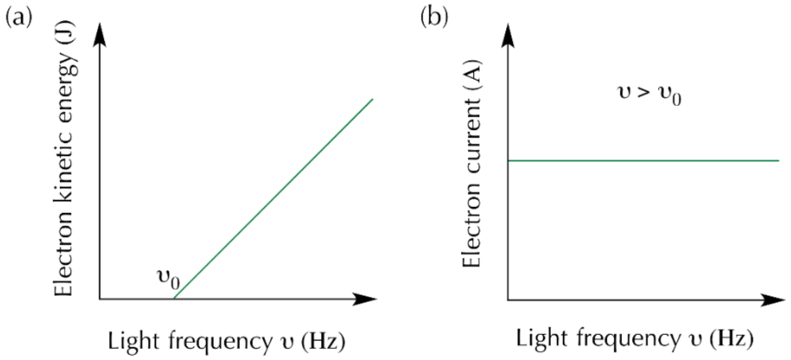
1. Effect of frequency of the incident light on photoelectric effect

To understand the effect of frequency of light on photoelectric effect, light of constant (fixed) intensity but variable frequency is made to fall on the plate P. The frequency of incident light slowly increased. It is found that there is no photoelectric current up to certain frequency. This minimum frequency of incident light for which photoelectrons are just emitted from the surface of the metal plate P (below which there is no photoelectricity) is called threshold frequency (v_0). The value of the threshold frequency depends on the material of the metal plate.

Now, carefully study the diagrams given below which illustrate the relationship between light frequency and the kinetic energy of ejected electrons.



We see that the frequency of red light (left) is less than the threshold frequency of the given metal $(v_{red} < v_0)$, so no electrons are ejected. The green (middle) and blue light (right) have frequency greater than the threshold frequency $(v > v_0)$, so both cause photoemission. The higher energy blue light ejects electrons with higher kinetic energy compared to the green light. The relationship between photoelectron's kinetic energy and light frequency is shown in graph (a) below.



Since the light amplitude was kept constant as the light frequency increased, the number of photons being absorbed by the metal remained constant. Thus, the rate at which electrons were ejected from the metal (or the electric current) remained constant as well. The relationship between electron current and light frequency is illustrated in graph (b) above.

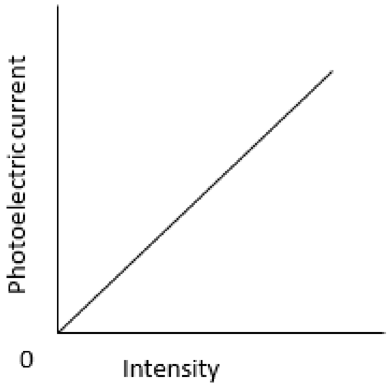
The amplitude of the light is proportional to the number of photons with a given frequency.

ACTIVITY 2

1. Sketch a graph for:
   (a) Electron current versus light amplitude.
   (b) Electron kinetic energy versus light amplitude.

2. Effect of intensity of incident light on photoelectric effect

In this case, light of constant frequency (greater than the threshold frequency) with variable intensities is made to fall on the metal plate P. Then, the intensity of incident light is slowly increased. It is observed that, as the intensity of the incident light increases, the photoelectric current also increases. This shows that photoelectric effect depends on the intensity of incident light. The variation of photoelectric current with the intensity of incident light is shown in the following graph.



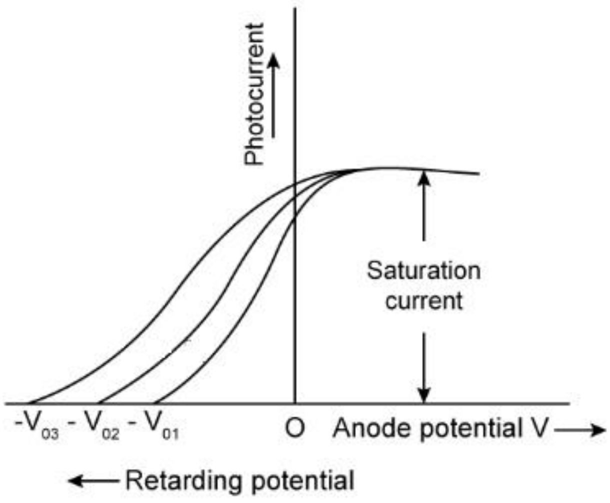
ACTIVITY 3

1. Think of one more way to increase the photoelectric current.

3. Effect of potential difference on photoelectric effect

In this case, light of constant intensity and having frequency greater than its threshold frequency is made to fall on the metal plate P. It is observed that when potential difference applied between the plates is increased gradually, the photoelectric current also increases up to a characteristic value. After that, there is no change in photoelectric current for any increase in the accelerating voltage. This maximum value of the current is called as saturation current.

The variation of photoelectric current with potential difference is shown in the graph below.



If the potential difference between the plates is decreased, the photoelectric current is also found to be decreasing. If the potential is reduced below zero and made more and more negative, a point is reached where the photoelectric current reduces to zero. This retarding potential for which photoelectric current is zero is called stopping potential (V_o). The value of stopping potential depends on the kinetic energy of the photoelectrons.

The kinetic energy of the photoelectron can be calculated using the formula

$$eV_o = \frac{1}{2} m v_{max}^2$$

where e is the charge on electron, V_o is the stopping potential, m is the mass of electron and v_{max} is the maximum velocity of the photoelectron.

ACTIVITY 4

1. Sketch a graph between photoelectric current and potential difference for the incident light of the same frequency and different intensities.

4. Applications of photoelectric effect

- The photoelectric effect has direct applications in the use of photocells and solar cells where energy is produced due to incident photons.

- Photoelectric effect is used to generate electricity in solar panels. These panels contain metal combinations that allow electricity generation from a wide range of wavelengths.
- Motion and Position Sensors: In this case, a photoelectric material is placed in front of a UV or IR LED. When an object is placed in between the Light-emitting diode (LED) and sensor, light is cut off and the electronic circuit registers a change in potential difference
- Lighting sensors such as the ones used in smart phones enable automatic adjustment of screen brightness according to the lighting. This is because the amount of current generated via the photoelectric effect is dependent on the intensity of light hitting the sensor.
- Digital cameras can detect and record light because they have photoelectric sensors that respond to different colours of light.
- X-Ray Photoelectron Spectroscopy: This technique uses x-rays to irradiate a surface and measure the kinetic energies of the emitted electrons. Important aspects of the chemistry of a surface can be obtained such as elemental composition, chemical composition, the empirical formula of compounds and chemical state.
- Photoelectric cells are used in burglar alarms.

Summary

- Based on the wave model of light, physicists predicted that increasing light amplitude would increase the kinetic energy of emitted photoelectrons, while increasing the frequency would increase measured current.
- Experiments have shown that increasing the light frequency increased the kinetic energy of the photoelectrons, and increasing the light amplitude increased the current.
- Based on these findings, Einstein proposed that light behaved like a stream of *photons* with an energy $E_{photon} = hf$.
- The work function, $\emptyset$, is the minimum amount of energy required to induce photoemission of electrons from a specific metal surface.
- The energy of the incident photon must be equal to the sum of the work function and the kinetic energy of a photoelectron $E_{photon} = KE_{electrons} + \emptyset$
- The photoelectric effect occurs when photoelectrons are ejected from a metal surface in response to monochromatic radiation incident on the surface. It has three characteristics: (1) it is instantaneous, (2) it occurs only when the radiation is above a cut-off frequency, and (3) kinetic energies of photoelectrons at the surface do not depend on the intensity of radiation. The photoelectric effect cannot be explained by classical theory.
- We can explain the photoelectric effect by assuming that radiation consists of photons (particles of light). Each photon carries a quantum of energy. The energy of a photon

depends only on its frequency, which is the frequency of the radiation. At the surface, the entire energy of a photon is transferred to one photoelectron.

- The maximum kinetic energy of a photoelectron at the metal surface is the difference between the energy of the incident photon and the work function of the metal. The work function is the binding energy of electrons to the metal surface. Each metal has its own characteristic work function.

Self-check for Learning

1. The work function of copper metal is 7.53×10^{-19}J. If the light of frequency 3.0×10^{16} Hz is made to fall on copper metal, will the photoelectric effect be observed?

2. What is the kinetic energy of the photoelectrons ejected from the copper metal by light of frequency of 3.0×10^{16} Hz?

2.7 Electron Diffraction

- State that electrons exhibit both particle and wave nature.
- State the applications of electron diffraction.
- Explain the formation of hydrogen spectrum.
- Explain different types of spectrum - continuous, emission and absorption spectra.
- Calculate the energy released or absorbed by an electron when it transits from one energy level to another level.

Introduction

The wave nature of light was established by Maxwell's equations of electromagnetism and Hertz experiment during the generation and detection of electromagnetic waves. The discovery of X-rays by Roentgen in 1895 and of electron by J. J. Thomson in 1897, were important milestones in the understanding of atomic structure. Cathode rays were discovered by William Crookes in 1870 who later in 1879 suggested that these rays consisted of fast-moving negatively charged particles.

When light passes through the edges or a slit, it bends. This phenomenon of bending of light is called diffraction.

According to wave optics light is a form of energy which travels through a medium in the form of transverse wave motion. The speed of light in a medium depends upon the nature of the medium. Thomas Young in 1801 proved that light behaves like waves.

In wave optics, we consider the wave nature of light. By definition, a wave is a disturbance that propagates in a medium. A light source sends out disturbances (or waves) in three-dimensional space.

In 1905 Albert Einstein explained photoelectric effect on the basis of Planck's quantum theory according to which light is considered to be made up of small packets (or particles) of energy known as quanta of energy or radiation.

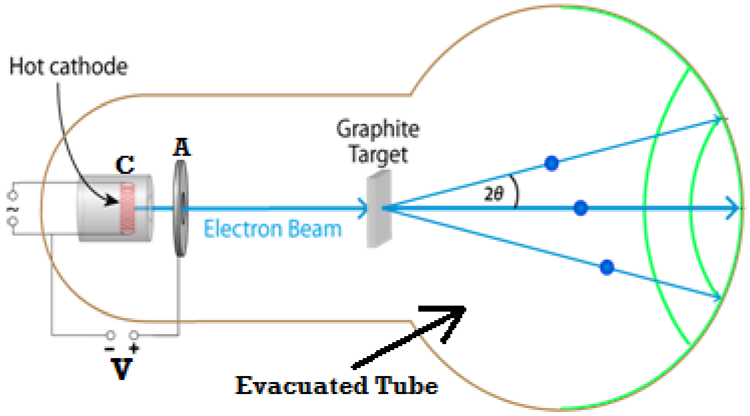
In optics, interference, diffraction and polarization of light show the wave nature of light while photoelectric effect and Compton effect show that light has a particle nature.

Therefore, we can conclude from the above discussion that the electrons behave as both particle and waves.

Electron Diffraction

Experimentally the wave nature of electron was demonstrated in 1927 by two American physicists, C.J. Davisson and L.H. Germer. The basis of their experiment was that since the wavelength of an electron is of the order of spacing of atoms of a crystal, a beam of electrons shows diffraction effects when incident on a crystal.

Phenomenon of Electron Diffraction –Davisson and Germer's Experiment



In the experimental set up above, used by Davisson and Germer the electrons from a hot tungsten cathode are accelerated by a potential difference V between the cathode (C) and anode (A). A narrow hole in the anode renders the electrons into a fine beam and allows them to strike the target.

The electrons are scattered in all directions by the atoms in the crystal and the intensity of the scattered beam in a given direction is found by the use of a detector. The graph is plotted between angle Φ (angle between the incident direction and the scattered direction of the electron beam) and intensity of the scattered beam.

In the experiment, the accelerating voltage was varied from 44 V to 68 V. It was noticed that a strong peak appeared in the intensity (I) of the scattered electron for an accelerating voltage of 54 V and at a scattering angle of 50°. The peak is observed in a particular direction due to the constructive interference of electrons scattered from different layers of the regularly spaced atoms of the crystal. From the electron diffraction measurements, the wavelength of matter waves was found to be 0.165 nm. The de Broglie wavelength λ associated with electrons can be calculated by using the relation $\lambda = \frac{h}{P}$ or wavelength can also be calculated by using formula

$$\lambda = \frac{h}{\sqrt{2meV}} = \frac{6.63\times10^{-34}}{\sqrt{2\times9.1\times10^{-31}\times1.6\times10^{-19}\times V}}$$

$$= \frac{1.227}{\sqrt{V}}\text{nm}$$

Now if the value of V is 54V, then we get,

$$= \frac{1.227}{\sqrt{54}}\text{nm}$$

=0.167 nm

The above value of wavelength indicates that there is excellent agreement between the theoretical and experimental values of de Broglie wavelength. This experiment, therefore, confirms the wave nature of electrons and the de Broglie relation.

Applications of Electron Diffraction

- It is used to study structure of crystal solids.
- It is used to estimate the size of nucleus.
- It is used in medicines (Crystalline drugs).
- It is also used in the study of biological specimens.

Electron diffraction is often used to study and determine the structure of crystalline solids. The size of nucleus can also be estimated using diffraction method.

A wave diffracted by a crystal behaves as if it were reflected off the planes of the crystal. In relation to diffraction pattern there are two different types of solid matter: single crystal and polycrystalline materials. Single crystals consist of atoms arranged in an orderly lattice. Some types of crystal lattice are simple cubic, face centre cubic (FCC), and body centre cubic (BCC). Single crystals are the more ordered of the two structures.

Electron diffraction has been recently used in the pharmaceutical industry to study the polymorphism in crystalline drug substances.
An electron microscope was used to investigate the structure of periodic biological specimens through their low angle electron diffraction patterns.

Example

1. Calculate the de Broglie wavelength of the electron moving with the speed of 3.0 x 10^3 km/s.

Solution: $We know the$ de Broglie $wavelength of electron is given by \lambda = \frac{h}{p} = \frac{h}{mv}$

since h = 6.63 x 10^{-34}Js, m_e = 9.1 x 10^{-31} kg, and v= 3.0 x 10^3 km/s

$$\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}\text{Js}}{(9.1\times10^{-31}\text{kg})(3\times10^{6}\text{m/s})}$$

$$= \left(\frac{6.63}{9.1 \times 3}\right) \times \left(\frac{10^{-34}}{10^{-31} \times 10^{6}}\right) m$$

$$= 0.2429 \times 10^{-9} m$$

$$= 2.429 \times 10^{-10} m$$

Three Types of Spectrum

When materials are heated, they emit electromagnetic radiation. This radiation may contain different components having a range of wavelengths.
These components may be visible or not visible. They may be continuous or emission or absorption line spectrum.
Let us see the spectrum in detail.
Continuous spectrum is produced when hot object gives off light of all colours.
Example: Sun
Emission line spectrum is produced when excited atoms of a hot dense object gives off only particular colour of light.

Example: some of the stars and galaxies.

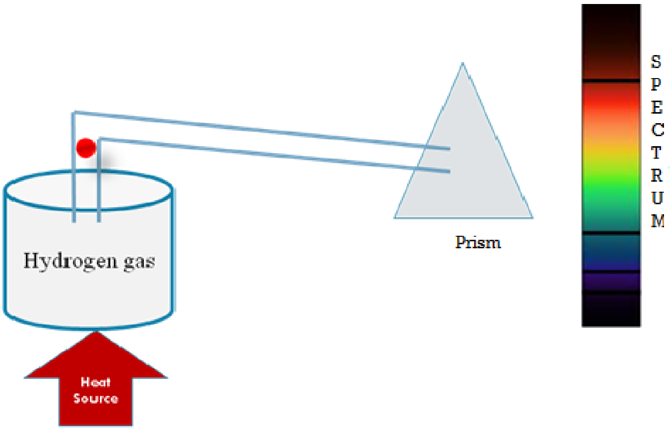
Absorption line spectrum is produced when the light from hot object passes through a cloud of gas. The atoms absorb particular colour of light, hence we see dark lines.

Example: Hydrogen

Hydrogen Spectra

Now let us see how hydrogen spectrum is produced.

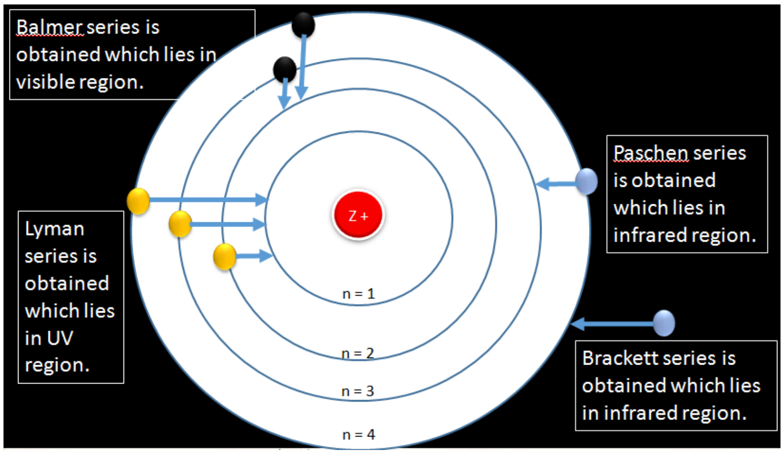
If hydrogen gas is enclosed in a sealed tube and heated to high temperature, and the emitted radiation is passed through a prism, we get the emission spectrum for hydrogen containing some sharply defined, discrete wavelengths.



For example, between two wavelengths of 656.3 nm and 486.1 nm that are found in the spectrum, there are no other wavelength.

This is because the hydrogen atoms do not emit any radiation between 656.3 nm and 486.1 nm.

The Balmer series lying in the visible region involves transition starting (for absorption) or ending (for emission) with the first state (n = 2) of hydrogen, while the Lyman series lying in the ultraviolet region involves transitions that start or end with the ground state (n = 1) of hydrogen. Similarly, the Paschen series, the Brackett series and the Pfund series involve transitions that start or end with n = 3, n = 4 and n = 5 energy level respectively and all lie in the infrared region.



Calculation of the energy of the photon when transition takes place from different energy levels

The energy levels of hydrogen agree with the Bohr's model, and the electron that transits in the hydrogen atom between quantised energy level with different quantum number n(from orbit of higher energy to an orbit of lower energy) emits a photon with quantum energy given by

$$E_{photon} = hf = E_i - E_f = \Delta E$$

where E_i is the energy of the electron in initial orbit and E_f is the energy of the electon in final orbit.

The wave length of the emitted radiation is given by the Einstein-Planck's relation

$$\Delta E = hf = \frac{hc}{\lambda}$$

For hydrogen or hydrogen-like atoms, the energy in a particular Bohr's orbit or energy level "n" is given by the relation

$$E_n = -\frac{13.6Z^2}{n^2} eV$$

where Z is the atomic number of hydrogen and *n* the energy level.

Where do I apply the hydrogen spectrum?

- Spectral line is used to study red-shift
- Spectral line is used in astronomy to check the presence of hydrogen.

Example

2. How much energy is released when an electron transits from orbit level 4 to 2 in hydrogen?

Solution: Given $n_i = 4$, $n_f = 2$, and we know for hydrogen Z = 1,

Using the formula

$$E_n = -\frac{13.6Z^2}{n^2} eV$$

$$\Delta E = (-E_f) - (-E_i)$$
$$= -E_f + E_i$$
$$= E_i - E_f$$
$$= \frac{13.6Z^2}{n_i^2} - \frac{13.6Z^2}{n_f^2}$$
$$= \frac{13.6(1)^2}{4^2} - \frac{13.6(1)^2}{2^2}$$
$$= -2.55 eV or - 4.08 \times 10^{-19} \text{joules}$$

ACTIVITY 1

1. Give examples where the light exhibits wave and particle nature.
2. Define emission line spectrum and absorption line spectrum.
3. Explore two more applications of electron diffraction?
4. Sometimes when viewed from the Earth, we see spectrum circling the Sun. Can you talk with your parents and write down the beliefs about existence of spectrum around the Sun?
5. If you observe the Sun's spectrum by high resolution spectrometer, what kind of spectrum do you think you will see?

Summary

- Bending of light through the corners and edges is known as diffraction.
- The de Broglie wavelength λ is associated with electrons.
- Electron diffraction determines the structure of crystalline solids and the size of nucleus.
- The phenomenon of emission of electrons from the surface of the metal is called electron emission.
- Continuous spectrum is produced when hot object gives off light of all colours.
- Balmer series lies in the visible region.
- Lyman series lies in the ultraviolet region.
- Paschen, Brackett, and Pfund series all lie in the infrared region.

Self-check for Learning

1. Calculate the wavelength of the radiation emitted when it makes a transition from the state n = 3 to state n = 2.
2. A bacterium of mass 2 x 10^{-15} kg is moving in the blood at a speed of 0.33 m/s. Find the de Broglie wavelength of the bacterium.
3. de Broglie wavelength of the proton and an electron is same. Which one has more total energy?

2.8 Quark Model and Radioactive Decay

- Explain particles and antiparticles.
- Classify particles.
- State properties of quarks.
- Explain conservation laws.
- Explain radioactive decay.

Introduction

Over the past century, discovery in physics has come thick and fast. Some has changed the way we understand the world. Understanding the structure of the atom had been huge focus of scientific research resulting in change that we have ever seen before.
You will learn about particles and antiparticles, classification of particles and their properties, conservation laws regulating particles and radioactive decay.

What is the smallest thing you can think of? May be, a pen or a dice or a grain of rice. Let us go for a smaller thing, a grain of salt. It's about 0.3 mm; where 100 cm=1m, 1000 mm=1m. And even smaller, bacteria, a few micrometer; where 1million micrometer=1m. A virus, around 20-300 nano meter; where 1billion nanometre(nm) = 1m. The diameter of DNA is about 2nm. The size of an atom is about 0.5-5 angstrom; where 10 billion angstrom =1m.

The study of elementary particles which form all the matter in the universe has a long history. Over the time, in-depth study of matter had revealed that considered smallest particle 'atom' is made up of different smaller sub-particles. Let us look into developmental history on atomic model briefly.
Around 460-370 BC, Greek philosopher Democritus formulated the very first 'atomic theory' stating: All matter is made up of tiny particles called atom which is indivisible and indestructible. There is empty space between atoms and atoms are always in motion. There are infinite number of atoms of varying shapes and size. Remember, the formulation of atomic theory by Democritus in that dull era, without proper equipment was something to be appreciated despite some hiccups in coming time unlike present era, where any scientific study is much at ease with aids of advanced technologies.

Particle Physics

Particle physics (also known as high energy physics) is the branch of physics that deals with the properties, the relationships and the interaction of the subatomic particles that makes up all the matter in the nature.
Over the long period of time, many scientists and philosophers have modified the atomic structure and discovered many subatomic particles till this current view of matter starting from molecules down to the quark and the electron (i.e. lepton). The various elementary particles that have been discovered can interact through one or more of the four fundamental forces.

Four fundamental forces in nature are:

1. **Gravitational Force**
   Gravitational force is the force of attraction between any two bodies by the virtue of their masses. It is a universal force. Every object experiences this force due to the other objects. For example, all objects experience a force of gravity due to mass of Earth. Gravity is responsible for the motion of the moon and the artificial satellites around the Earth and also for the motion of the Earth and other planets around the sun. And of course, it is responsible for motion of the body falling to the Earth. It plays a key role in a large-scale phenomenon of the universe such as the formation and revolution of stars, galaxies and galactic clusters.

2. **Electromagnetic force**
   Electromagnetic force is the force between the charged particles. The magnitude of force is given by Coulomb's law. Unlike charges attract and like charges repel each other. Charges in motion produce magnetic effect and the magnetic field gives rise to a force on moving charge. Same like gravitational force, electromagnetic force acts over large distance and it does not use any kind of medium. Electromagnetic force is so much stronger than the gravitational force, it dominates all phenomena at an atomic or molecular scale. Thus, it is mainly the electromagnetic force that regulates the structure of atom and molecule. It is responsible for the microscopic forces like tension, friction, normal force, spring force, etc. Gravity is always attractive whereas electromagnetic force can be either attractive or repulsive.

3. **Strong nuclear force**
   The strong nuclear force binds protons and neutrons in a nucleus. It is evident that without some attractive force, the nucleus will be unstable due to electrical repulsion between protons. This attractive force cannot be gravitational since the force of gravity is negligible compared to the electric force. Therefore, new basic force must be involved and that is the nuclear force. The strong nuclear force is strongest among all the fundamental forces. It is about 100 times of electromagnetic force strength. It is independent of the nature of charge and acts equally between the proton-proton, neutron-neutron and proton-neutron. Its range is extremely small about nuclear dimensions, 10-15 microns. It is responsible for the stability of nuclei.

4. **Weak nuclear force**
   Weak nuclear force appears only in certain nuclear processes such as beta decay of nucleus. In beta decay, the nucleus emits an electron and uncharged particles called neutrino. The weak nuclear force is not as weak as gravitational force but much weaker than a strong nuclear force and electromagnetic force. The range of weak nuclear force is extremely small of the order of 10-16 microns.

So, these are the four fundamental forces.

In olden days, the atom was thought to be the smallest unit of matter. Later with the discovery of the electrons, protons, and neutrons these particles were thought to be the smallest particles. However, it was found that even the neutrons and protons were made of even smaller particles called quarks.

Nucleus is made up of proton and neutron. If you look into those proton and neutrons, you will see that they are made up of quarks. Protons are made up of two up quarks and one down quark whereas neutrons are made up of one up quark and two down quarks. Finally, when we get into the level of quarks and electrons, we are at the level of fundamental particles, which does not have internal structure.

Particles and Antiparticles

Now let us talk about particles and antiparticles. There is something very interesting about anti particles. If you concentrate huge amount of energy in tiny space, new particles will come into existence. If you look closer, you will see these particles always come in pair. This is because particles always have their counterpart, antiparticles and these are always produced in exactly equal amount. In the collision between two protons, billions of particles and antiparticles are produced every second. Consider for example, an electron. It has a very small mass and negative charge. Its antiparticle, the positron, has exactly the same mass but positive charge. Apart from the opposite charges, both particles are identical and perfectly stable. It is the same for proton and anti-proton. Remember that large amount of energy will be released when particle and antiparticle collide with each other which is known as pair annihilation.

As discussed earlier, scientists have now come to know that all the matter in universe is composed of quarks and leptons. A quark is a type of elementary particle and a fundamental constituent of matter. It combines to form composite particles called hadrons. In the present standard model, there are six flavours of quarks that are found.

Quarks

The up quark has the charge of 2/3 and the down quark has the charge of -1/3. How are they different? They all have different masses as well as charge and another property called spin. The up and down quarks are most common and least massive. The proton is found to be made of two up quarks and one down quark. We know that charge of proton is +1. If we look into this in term of fractional charges given to quarks, one up quark will have charge of 2/3. So, two up quarks will have charge of +4/3. Adding it with the down quarks of charge -1/3 reduces the charge to 3/3 which is equal to 1. Neutron is found to consist of two down quarks and one up quark, which gives charge of 0. The discovery of up quark and down quark was followed in the coming years by the strange quark, charm quark, top quark and bottom quark.

Besides six quarks, there are six corresponding anti-quarks with same mass but opposite charge, baryon number and strangeness (anti-up, anti-down, anti-charm, anti-strange, anti-top and anti-bottom).

If you look at the properties of quarks, you can see that up, charm and top quarks have charge of +2/3 whereas down, strange and bottom quarks have charge of -1/3.

The combination of a quark and anti-quark produces a particle called meson [example of mesons are Pion(π^-, π^0, π^+) and kaon(K^-, K^0, K^+)] which is lighter than a proton but heavier than an electron.

For example, if down quark and anti-strange quark combine together, meson known as neutral kaon(K^0) is formed. Similarly, up quark and anti-down quark form positively charged pion (π^+).

Combination of three quarks form a particle called baryons which is heavier than proton. Protons and neutrons are classified as baryons.
Similar to quarks, leptons are also elementary particles. But unlike quarks they do not undergo strong interactions.
Strong nuclear force holds a proton and a neutron together in a nucleus.
What determines the stability of nucleus? In stable nucleus, the nuclear force is strong enough to hold nucleus together permanently. Most of the nuclei formed during a big bang nearly 14 billion years ago are still in existence today. But not all nuclei are stable. Unstable nuclei have too many protons or too many neutrons upsetting the strong nuclear force. Unstable nuclei try to balance themselves by giving excess proton or neutron. This is known as radioactive decay. Unstable nuclei are radioactive and emit radiation.
There are three types of decay: alpha decay, beta minus decay (β^-) and beta plus decay (β^+).
Alpha decay is the loss of the alpha particle. An alpha particle is made of two neutrons and two protons. They have a mass of 4 and charge of +2. When atom loses the alpha particle, its mass number decreases by 4 and atomic number decreases by two. The new element is formed two places lower in the periodic table.
When an isotope has too many neutrons, it decays by β minus (β^-). Neutron changes into a proton and an electron. The proton is retained by the atom whereas an electron is lost. The lost electron is of high energy and is called β particle. The loss of neutron is gain in proton, where mass number remains same but atomic number increases by one. The new element is formed one place higher in the periodic table.
When an isotope has too many protons, it decays by beta plus (β^+). A proton is converted into a neutron and β plus particle called positron. Positron has same mass as that of electron but opposite charge. The loss of positron is gain in neutron, where mass remains same but atomic number decreases by one.
This clearly points that neutrons and protons are not really elementary particles.

Properties of Quarks

All quarks and antiquarks carry a charge which is a fraction of the charge of an electron or proton that is ,1.6 x 10^{-19}C.
Baryon number is denoted by B. All quarks and antiquarks have baryon number associated with them and quark's baryon number is +1/3 and antiquark's baryon number are -1/3.
All quarks and antiquarks have strangeness zero except strange quark has strangeness of -1 and the anti-strange quark has a strangeness of +1. Strangeness is denoted by S.
Charm is denoted by the symbol C and all quarks and anti-quarks have charm of zero, except charm quark has charm of +1 and anti-charm quark has charm of -1.
Topness is denoted by the symbol T and all quarks and anti-quarks have topness of zero, except top quark has topness of +1 and anti-top quark has topness of -1.
Bottomness is denoted by the symbol B' and all quarks and anti-quarks have bottomness of zero, except bottom quark has bottomness of -1 and anti-bottom quark has bottomness of +1.

Conservation Laws

We already know the laws such as mass-energy, linear momentum and angular momentum which are always obeyed. We also have additional conservation laws which are important in elementary particles interactions, such as conservation of charge, baryon numbers, and strangeness.

- Conservation of charge: in all elementary particle interactions the charge must be conserved.
- Conservation of the baryon number: In all elementary particle interactions the baryon number is conserved.
- Conservation of strangeness: In all elementary particle interactions involving the strong force and electromagnetic force, strangeness must be conserved. But in weak interaction, strangeness may be conserved or may change by ± 1.

Leptons

Similar to quarks, leptons are also elementary particles. They do not undergo strong interaction. Leptons are of two types: charged leptons and neutral leptons. Charged leptons are electron-like leptons and neutral leptons are neutrinos. Leptons and protons do not have baryon number and strangeness. An electron and a neutrino have a lepton number of +1 while their respective anti-particles a positron and an antineutrino have a lepton number of -1. Lepton number must be conserved in all the interactions.
Example:
For reaction $n \rightarrow$ p+e^-

a) Charge is conserved
   Before: 0 (Charge of neutron is 0)
   After: (+1e) + (-1e) = (0) (Charge of proton + charge of electron)

b) Baryon number
Before: 3(+1/3) = +1 (Since neutron consists of 3 quarks)
After: 3 (+1/3) + 0 = +1 (Since proton consists of 3 quarks)

c) Strangeness is conserved
Before: (0)
After: (0) + (0) = (0)

d) Lepton number
Before: (0) (lepton number of neutron)
After: (0) + 1 = +1 (lepton number of protons + lepton number of electron)

Since the lepton number is not conserved, the interaction is not possible.

ACTIVITY 1

1. Apply the conservation laws to predict whether the interaction is possible or not.
$$n \rightarrow p + e^{-} + v_e$$
2. Write one property of a proton that is same as its antiparticle and another property that is different.
3. Explain the quark model in detail along with various types of quarks and anti-quarks along with their properties.
4. What values of electric charge are possible for a meson in a quark model?

Summary

- Particle physics is all about the properties, the relationship, and the interactions of the subatomic particles that make up all the matter in the universe.
- The four fundamental forces are gravitational force, electromagnetic force, strong force, and weak force.
- Cosmic rays contain high energy particles.
- Positively charged electrons were named as positrons.

Some of the particles and their antiparticles along with their charge and rest mass

Particle	Symbol	Charge (q)	Rest Mass (Mev-million electron volts)
Electron	e^{-}, β^{-}, e	-	0.510999

Positron	$e^+, \beta^+, \bar{e}$	+	0.510999
Proton	p	+	938.257
Antiproton	$\overline{p}$	-	938.257
Neutron	n	0	939.551
Antineutron	$\bar{n}$	0	939.551
Neutrino	$\nu(nu)$	0	0
Antineutrino	$\bar{\nu}(nu)$	0	0

Properties of Quarks

Quarks	Symbols	Relative Mass	Charge (q)	Baryon Number (B)	Strangeness (S)
up	u	1	$\frac{+2}{3}$	$\frac{+1}{3}$	0
down	d	2	$\frac{-1}{3}$	$\frac{+1}{3}$	0
strange	s	40	$\frac{-1}{3}$	$\frac{+1}{3}$	-1
charm	c	600	$\frac{+2}{3}$	$\frac{+1}{3}$	0
top	t	90000	$\frac{+2}{3}$	$\frac{+1}{3}$	0
bottom	b	2000	$\frac{-1}{3}$	$\frac{+1}{3}$	0

Self-check for Learning

1. What are elementary particles found in an atom?
2. What is the charm of the quarks?
3. Can leptons combine to form any other particles? Give example.
4. Applying conservation laws, show if the following reaction is possible or not.

$$n \rightarrow \text{p+e}^- + \bar{\nu}_e$$

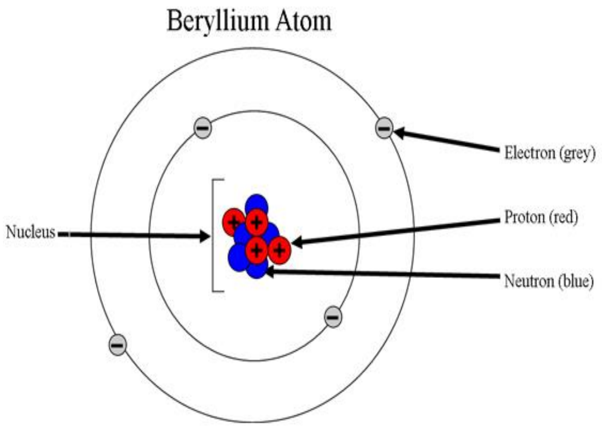
2.9 Nuclear Energy

- Define mass defect with its formula.
- Explain binding energy using binding energy curve.
- Calculate mass defect and binding energy.
- Explain the process of nuclear fission and fusion with an example each.
- State applications of nuclear fission and nuclear fusion.

Introduction

We learnt that an atom is the smallest part of any element that has all the properties of that element. In an atom the entire positive charge and mass are concentrated in a small space known as the nucleus. The nucleus is a tiny sphere within an atom and the size of the nucleus is very small as compared to the size of the atom. An example of beryllium atom is given at the side.

Nucleus: A tiny central core in which the positive charge and almost entire mass of the atom are concentrated is known as nucleus.



In this lesson, you will learn about mass defect, binding energy and binding energy per nucleon. We will also discuss about the nuclear fission and nuclear fusion along with its applications and destructions.

Nuclear Energy

Nuclear energy: The energy emitted by a nucleus as it becomes more stable is called nuclear energy.

The masses of atoms, nuclei, etc. are expressed in terms of atomic mass unit represented by amu or 'u'.

Proton and Neutron

The proton was discovered by Rutherford by bombardment of α-particles on nitrogen in accordance with the following equation:

$^{14}_{7}N$	+	$^{4}_{2}He$	→	$^{17}_{8}O$	+	$^{1}_{1}H$
(Nitrogen)		(α-particle)		(Oxygen)		(Proton)

The superscripts denote the mass number and subscripts denote the atomic number.

The neutron was discovered by Chadwick by the bombardment of α-particles on beryllium in accordance with the following equation.

$^{9}_{4}Be$	+	$^{4}_{2}He$	→	$^{12}_{6}C$	+	$^{1}_{0}n$
(Beryllium)		(α-particle)		(Carbon)		(Neutron)

[A neutron is neutral (zero charge) particle and its mass number is 1].

Neutron being neutral is used for artificial disintegration.

Composition of Nucleus

The nucleus is supposed to be composed of protons and neutrons. The number of protons in a nucleus is called atomic number (Z) while the number of nucleons (i.e., protons + neutrons) is called the mass number (A). In general mass number > atomic number (except for hydrogen nucleus when A = Z).

A nucleus is expressed as

$$^{A}_{Z}X$$

Mass Defect (Δm)

It is observed that the mass of a nucleus is always less than the mass of constituent nucleons (i.e., protons + neutrons). The difference in the mass of constituent nucleons (i.e., protons + neutrons) and the mass of a nucleus is known as mass defect, denoted by Δm.

The mass defect (Δm) is calculated by the given formula:

$$\Delta m = Z.\, m_p + (A - Z).\, m_n - M\ (\text{nucleus})$$

where m_p, m_n and M (nucleus) are the mass of proton, neutron and nucleus respectively.

The nucleons are bound together in a nucleus and the energy that has to be supplied in order to break apart the constituents into free nucleons is called binding energy and is denoted by B.E. Most of the time, B.E. is calculated in MeV.

From Einstein's law of inter-conversion of mass and energy, the binding energy and the mass defect are related as

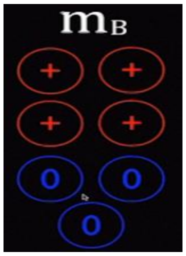
$$BE = \Delta m.c^2$$

where $c = 3 \times 10^8$ m/s is speed of light in vacuum.

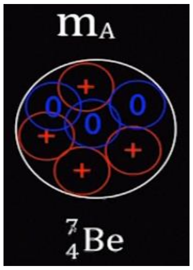
Generally, Δm is measured in unified atomic mass unit (u) and the energy equivalent to 1 u of mass is equal to 931 MeV. Therefore,

$$BE = \Delta m.c^2 = (931)\ \text{MeV}$$

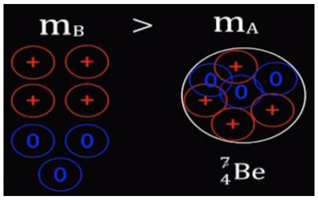
Let us discuss more with examples.
In this case, we have 4 protons and 3 neutrons and adding the individual masses, we get a mass of constituent nucleons, m_B.



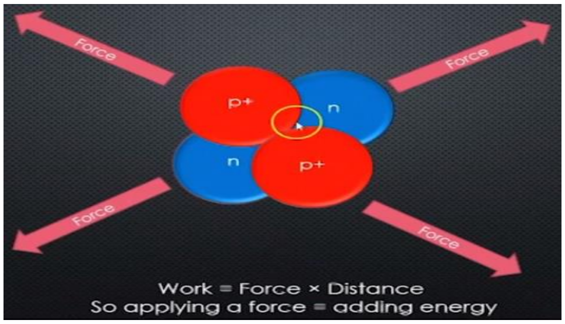
If we put them in a nucleus, we will have beryllium because of its atomic number 4.



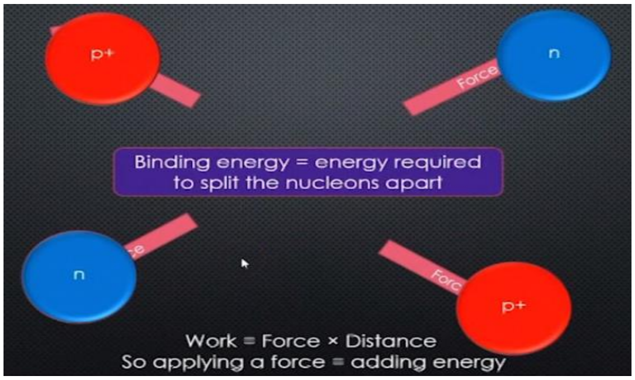
The mass of the nucleus is denoted by m_A where mass of constituent nucleons (m_B) is greater than mass of nucleus (m_A).



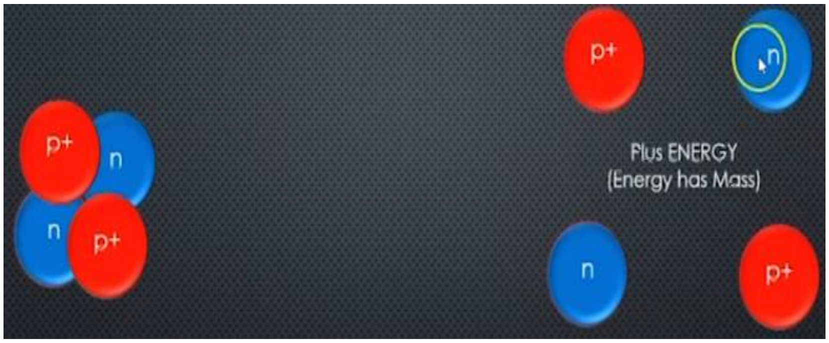
The difference between two masses is the mass defect (Δm) which we can convert into binding energy (BE).
Let us look into another example. Imagine a nucleus with 2 protons and 2 neutrons. It is Helium. And if you want to split this nucleus into constituent nucleons, we need to apply a force to each particle which is bonded together by strong nuclear force. Since work done is equal to the product of force and distance, adding a force means supplying energy.



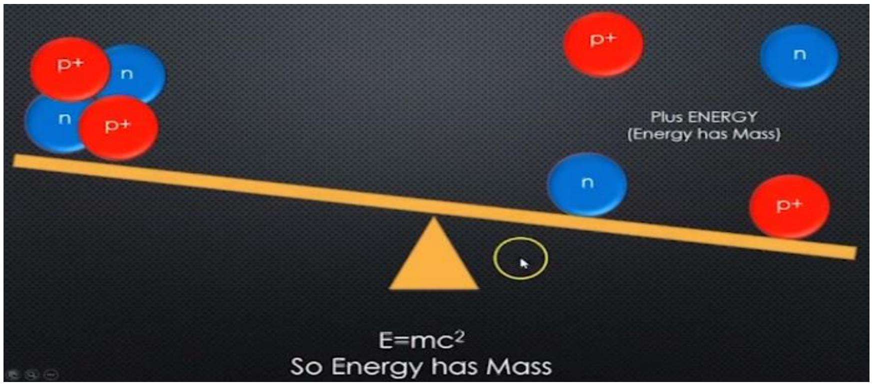
The energy is used to break the nucleus into constituent nucleons. Therefore, BE is the energy required to split the nucleus apart.



According to Einstein’s equation, $E=mc^2$ the supply in energy means supply in mass.



If we place these two on imaginary weighing machine, you can see that constituent nucleons are much heavier due to excess mass obtained through energy.



Thus, we can calculate mass defect (Δm) and BE.

Solved Example:

Determine the mass defect and average binding energy per nucleon for an iron – 56 nucleus.

$$^{56}_{26}\boldsymbol{Fe}$$

$m_p = 1.007825\ u$

$m_n = 1.008665\ u$

The given mass of iron ($^{56}_{26}Fe$) is 55.934939 u

Answer: Given:

A = 56

Z = 26

We have mass defect (Δm) given by

$$\Delta m = Z.\ m_p + (A - Z).\ m_n - M\ (\text{nucleus})$$
$$= 26\ (1.007825) + (56\text{-}26)\ (1.008665) - 55.934939$$
$$= 26.203450 + (30 \times 1.008665) - 55.934939$$
$$= 26.203450 + 30.259950 - 55.934939$$
$$= 56.463400 - 55.934939$$
$$\Delta m = 0.528461\ u$$

Using the equation, $E = \Delta m.c^2$, we can convert the mass defect (Δm) to BE. Here mass should be in kg.

We know that, $1\ u = 1.66 \times 10^{-27}$ kg

Where $\Delta m = 0.528461\ u \times \frac{(1.66 \times 10^{-27})kg}{1\ u} = 8.77 \times 10^{-28}$ kg

Using $E = \Delta m.c^2$

$= 8.77 \times 10^{-28}\ kg \times (3 \times 10^{8}\ m/s)^2$

$E = 7.89 \times 10^{-11}$ J

The BE is expressed in eV. We know $1\ eV = 1.6 \times 10^{-19}$ J

So $E = 7.89 \times 10^{-11}\ J \times \frac{1\ eV}{1.6 \times 10^{-19}\ J} = 493.125 \times 10^{6}$ eV

As discussed earlier, BE is expressed in MeV. We know 10^{6} eV = 1 MeV.

So we have E = 493.125 MeV.

BE per nucleon for an iron-56 nucleus is

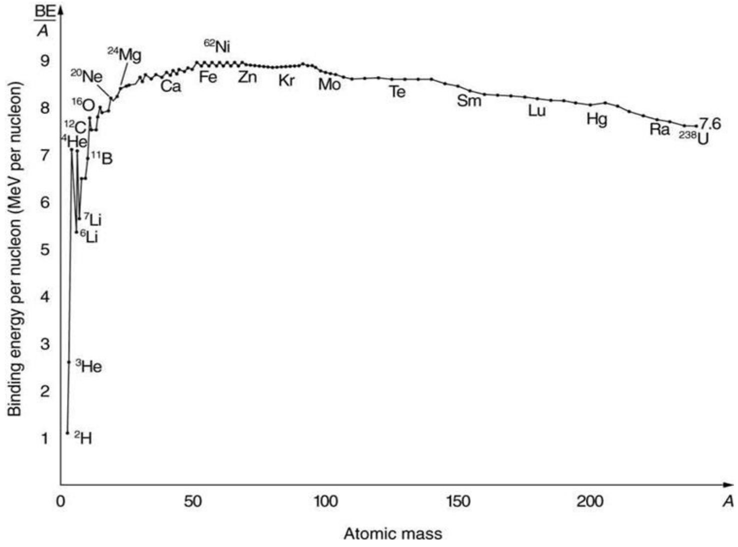
$E = \frac{493.125\ MeV}{56} = 8.806$ MeV

ACTIVITY 1

1. Calculate the disintegration energy Q of a uranium $^{235}_{92}U$nucleus. Mass of uranium nucleus is 235.04 u.

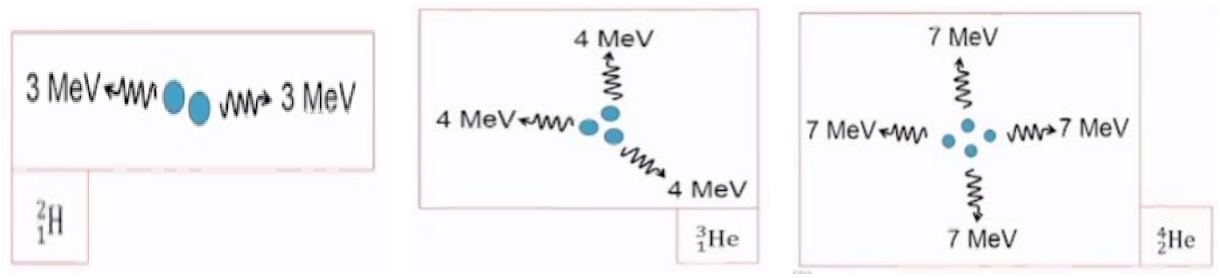
Binding energy per nucleon is very useful quantity in predicting the stability of a nucleus. Binding energy per nucleon versus mass number (A) curve is shown below. Binding energy per nucleon reaches maximum of about 8.7 MeV for A (mass number) between 50 -80. This is called the region of greatest stability.

Those nuclei whose mass number (A) lies above and below the stability region are considered as less stable which will undergo nuclear reaction.



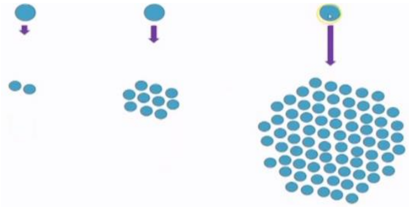
When a nucleus is formed, nucleons emit light. When light is being emitted, nucleon loses mass. This is because energy is equivalent to mass given by the Einstein's equation $E = \Delta m.c^2$.

When we have a small nucleus, each nucleon loses less energy and when we have a bigger nucleus, each nucleon loses more energy. For example, the bigger nucleus ${}^{4}_{2}He$ loses more energy (7 MeV) per nucleon compared to smaller nucleus ${}^{2}_{1}H$ (3 MeV) and ${}^{3}_{1}He$ (4 MeV) as shown in the diagrams below:



Using the binding energy per nucleon versus mass number (A) graph, let us discuss the concept. In the graph, on X-axis it shows the size of a nucleus and on Y-axis, it shows how much energy each nucleon loses. The graph shows an increase in its initial phases as we discussed.

Let us take 3 different nuclei and we are going to put 3 different nucleons nearby. These nuclei act like a magnet, but they do not pull with the magnetic force rather pulls with nuclear force. So the smaller the nucleus weaker the force and bigger the nucleus, greater the nuclear force.

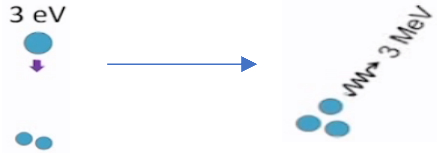


ACTIVITY 2

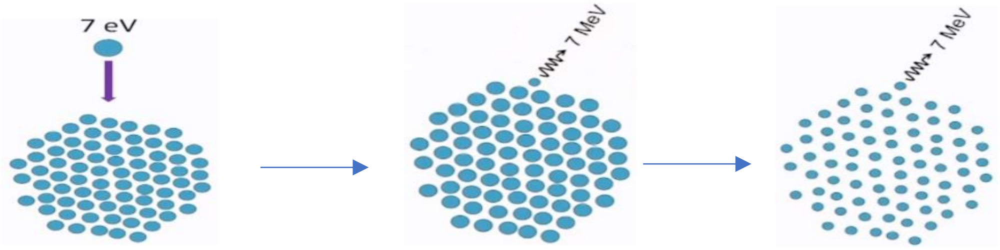
1. From the above figure, which of the 3 nucleons has least potential energy?

Let us assume that we have two nuclei of PE of 3eV and 7eV respectively.

When the nucleon meets the small nucleus, it loses less PE.



When the nucleon meets the bigger nucleus, it loses more PE, therefore loses more mass



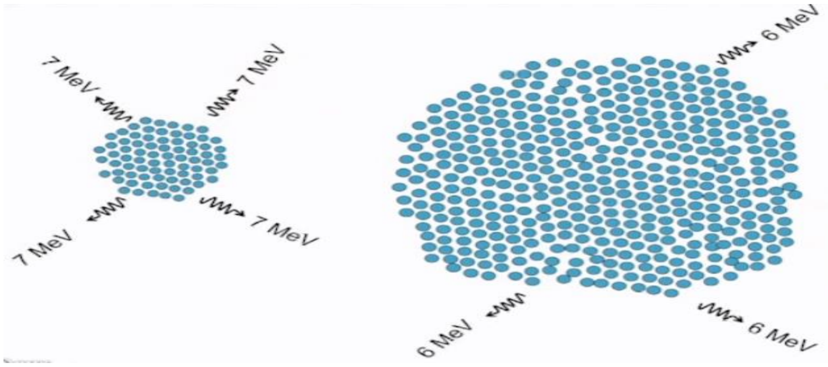
(loss in more mass)

But remember that the concept applies to those having mass number less than 50.

ACTIVITY 3

1. If we take a huge nucleus and put nucleons close by, does it act like huge magnet to nucleons with a giant force?

When we compare bigger nucleus and medium nucleus, the medium nucleus acts like a bigger magnet and each nucleon loses more energy compared to bigger nucleus. This is why, when we look at the binding energy curve, we can see initially atoms lose more and more energy and then suddenly drops.

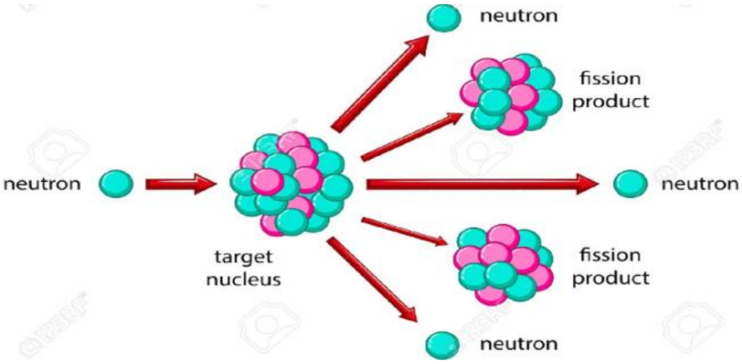


Similarly, in the binding energy per nucleon versus mass number (A) graph, part of the curve for A between 50 to 80 is called region of greatest stability. When the atomic mass increases, the energy released per nucleon keeps on increasing till it reaches the stability region. Beyond it, even when we increase the atomic mass, the energy released per nucleon decreases. That is why, when we look at the BE curve, we can see that initially atom loses more energy and then suddenly drops. So, the nucleus undergoes the nuclear reaction to obtain stability.

Earlier in this lesson, we have found that average BE per nucleon for an iron-56 nucleus is about 8.806 MeV. When we look at the BE curve, we can see that the iron ($^{56}_{26}Fe$) lies in the region of greatest stability which indicates that the nucleus of $^{56}_{26}Fe$ is stable.

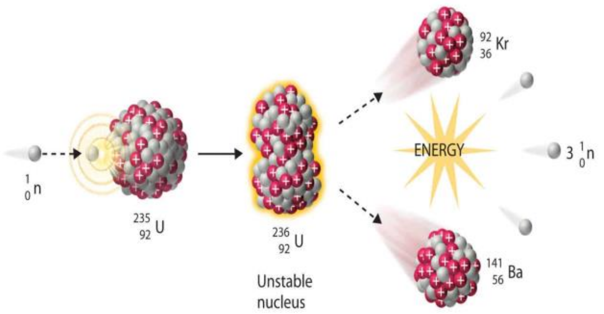
Nuclear Fission

It is the process of splitting a large nucleus to form two smaller, more stable nuclei.
In this process, atomic nucleus is hit by single neutron that is flying around. The impact causes the atomic nucleus to split into two new nuclei. Each of them takes part of electron with them so that two new atoms are formed. In case of some very large atoms, few neutrons are additionally released.



When uranium atoms are split in a nuclear plant, it usually involves release of 3 neutrons. This can affect the next fission processes in a chain reaction. Finally, the energy is released.

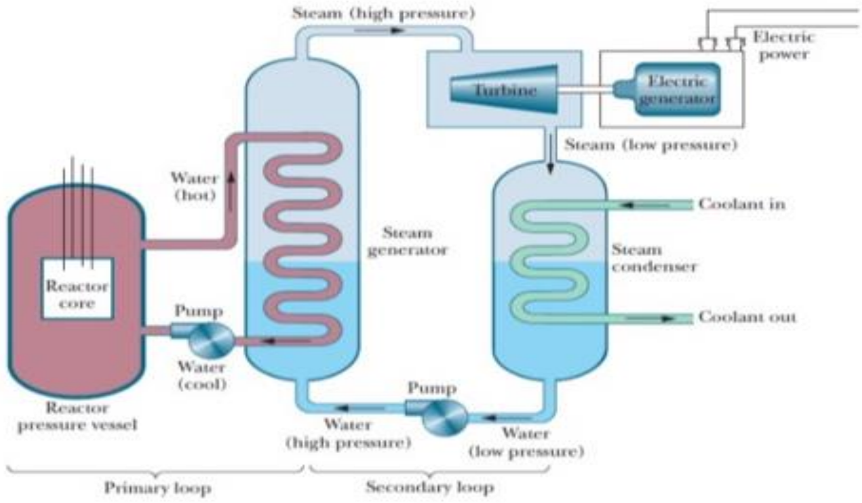
1kg of naturally occurring uranium has the energy of 12000L of mineral oil or almost 19000kg of hard coal. Where does this energy come from? Why is it so much more than the case of other energy carrier? Let us recall.



Beside the neutrons, the atomic nucleus only consists of the positively charged protons. Now like charges repel each other. But the proton in the atomic nucleus always remains together due to the strong interaction which is known as strong nuclear force. It acts like a strong rubber band that holds atomic nucleus with its protons together. When the impacting neutron forces the nucleus apart, it is exactly the energy that has been stored in the rubber band that is released.

Pros and cons of nuclear fission

The nuclear reactor forces the atoms of uranium to break apart. As they split, atoms release tiny particles called fission product. Fission products cause other uranium atoms to split, starting a chain reaction. The energy released from this chain reaction creates heat. The heat created by nuclear fission warms a cooling agent, usually water. The cooling agent produces steam that turn turbines. The turbines drive generators or engines that create electricity. Nuclear energy can provide clean, pollution free power with no greenhouse gas emission and also deforestation. However, nuclear reactors do produce radioactive wastes that are extremely toxic. Harmful radiation stays thousands of years causing affect to the living beings.

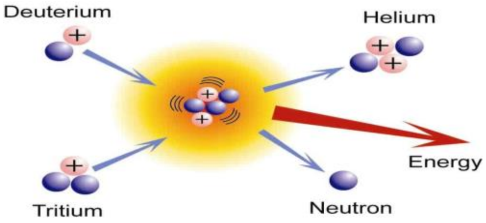


A simplified layout of a nuclear power station based on a pressurised-water reactor.

Nuclear fusion

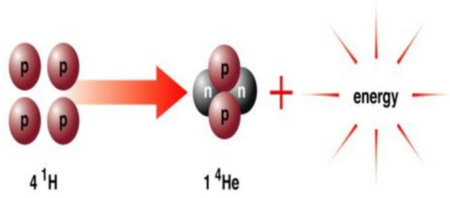
It is the process of joining together two light nuclei to form a larger, more stable nucleus.

Nuclear fusion works only with smaller atoms like hydrogen. The atomic nucleus of hydrogen consists of only one proton.



If you try to bring two protons together, they will repel each other due to like charges. This is referred as a coulomb's force. This force acts as if each proton had a fence around them trying to keep off other protons. Like fission needing a force to overcome the rubber band of strong interaction, fusion also needs force to keep the protons so closely together that the forces are pulled down. And once this happens, the protons come too close together and strong interaction comes into play. It also makes sure that two protons can make one new atomic nucleus.

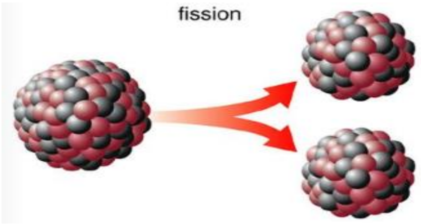
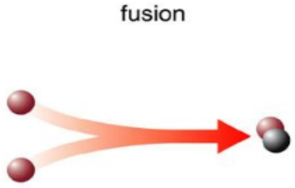
In case of nuclear fusion on the Sun, the four hydrogen atoms (four protons) combine to form a helium atom. In the process, large amount of energy is released. In this case, it just needs 1g of hydrogen isotopes to gain energy of 12000kg of hard coal.



ACTIVITY 4

1. Just imagine, if you can generate 12kV of electricity from l0g of hydrogen isotopes using the process of nuclear fusion, for how long will it last?

Differences between nuclear fission and nuclear fusion

Classification	Nuclear Fission	Nuclear Fusion
Definition:	 Splits a larger atom into two or more smaller ones.	 Joins two or more lighter atoms into a larger one.
Fuel type:	Uranium (U) Plutonium (Pu)	Hydrogen (H)
By products:	Used nuclear fuel	Helium (He)
Use:	In energy production	Under development
Energy:	1 million times greater than other energy sources.	3 to 4 times greater than fission.

Summary

- Nuclear energy is the energy emitted by a nucleus as it becomes more stable.
- The mass of a nucleus is always less than the mass of constituent nucleons (i.e., protons + neutrons). This difference in mass is called mass defect.
- The energy required in order to break apart the constituent nucleons of a nucleus into free nucleons is called its binding energy (BE).
- From Einstein's law of inter-conversion of mass and energy, the binding energy and the mass defect are related as

$$BE = \Delta m.c^2$$

- The average energy required to remove a nucleon from the nucleus to infinite distance is known as the binding energy per nucleon.
- Nuclear stability is a concept that helps to identify the stability of a nuclide.
- Nuclei with high binding energies are very stable as it takes a lot of energy to split them and nuclei with lower binding energies are easier to split.
- In order to become more stable, unstable nuclei tend to release some of their energy. Releasing this energy would decrease the amount of energy they contained, and therefore increase the amount of energy that must be added to them to split them apart.
- Nuclear fission is the process of splitting a large nucleus to form two smaller, more stable nuclei.

- The energy released in a fission reaction comes from the difference between the mass of the original nucleus and the combined mass of the fission fragments.
- Nuclear fusion is the process of joining together two light nuclei to form a larger, more stable nucleus.

Self-check for Learning

1. U^{235}disintegrates as follows:

   $$U^{235} \rightarrow Ce^{140} + Zr^{94} + n$$

   Find the energy released in this reaction.

   U^{235}= 235.0439 u

   Ce^{140}= 139.9054 u

   Zr^{94} = 93.9063 u

   n = 1.00866 u
2. What safety measures a nuclear engineer must consider while designing a nuclear reactor?
3. Would you recommend a nuclear reaction as an alternative source of energy in Bhutan? Why?

COMMERCE STREAM

1. ECONOMICS

1.1 Inflation

- Define inflation.
- List and explain the different types of inflation.
- Explain the causes of inflation.
- Explain the different cases of inflation i.e. demand-pull inflation and cost-pull inflation with the help of diagrams.

Introduction

Inflation

It is a process of a persistent and appreciable rise in the general level of price. It shows that there is a continuous increase in the price of goods for a long time.

Key points to be remembered while learning inflation.

- It is a process of rising prices of goods and services and not a state of high prices.
- It is a situation of an appreciable or considerable rise in prices.
- The rise in prices should not only be appreciable but prolonged.
- It is measured as the rate of increase in the price level as indicated by the price index.

If the price increases by 1% or 2% per annum, it will not have any negative effect on the economic development of a country. However, if the price continues to increase by more than 10% for a longer period then it will have negative impacts on the economic development of a country. Hence, inflation has consequences for people and firms throughout the economy, in their roles as lenders and borrowers, wage-earners, taxpayers, and consumers.

Types of Inflation

On the basis of rate, speed or inflation has the following categories:

1. **Creeping inflation:** It occurs when there is a continuous rise in price at a mild rate that is 2-3% per year. It is also known as mild inflation. If a rate of price rise is kept at this level, it is considered to be helpful for economic development.
2. **Walking or trotting inflation:** When the rate of inflation is 3% to 6% per annum it is known as walking inflation. When mild inflation is allowed to fan out, walking inflation appears.
3. **Running inflation:** If the rate of inflation is 8% to 10% per annum it is called running inflation. Running inflation is dangerous. It is a warning signal indicating the need for controlling it.

4. **Hyper or galloping inflation:** It occurs if the annual increase in price is 20% to 30% or more. At this stage price rise goes out of control. Money becomes worthless and economic and political life is disrupted (collapse).
5. **Open inflation:** Inflation is open when there is no barrier to price rise. It occurs where there are no controls and checks on price rise. The prices are permitted to rise without being suppressed by government price controls or similar techniques.
6. **Suppressed inflation:** It is a situation when there exists inflationary pressure in the economy but prices are controlled by certain measures such as price control and rationing. Price increases are suppressed by the government.

Causes of Inflation

1. **Increase in money supply**: Increase in money supply represents an increase in purchasing power (ability to buy goods) of the people. Unless an increase in purchasing power is offset by an increase in the supply of goods and services, it will put upward pressure on prices.
2. **Deficit financing:** It is taken as a means to cover the gap between revenue and expenditure. This deficit is financed by borrowing from the central bank. Deficit financing, therefore, leads to an increase in the money supply and hence is responsible for the price rise.
3. **Increase in export demand:** Increase in export demand results to increase in aggregate demand for goods and services produced in an economy. Given the supply of goods and services, it creates a situation of excess demand and it leads to demand-pull inflation.
4. **Higher taxes:** When the government imposes higher taxes for commodities, the prices of the product will increase and it creates inflationary pressure in the economy.
5. **Increase in population growth rate:** Increase in population leads to an increase in demand for consumer goods and it puts pressure on the existing supply of goods and services.

Explanation of Inflation

1. **Demand-pull inflation:** Demand-pull inflation occurs when the aggregate demand for goods and services exceeds the supply available at the existing price, i.e when there is excess demand for goods and services. The occurrence of demand-pull inflation is explained with the help of a diagram below.

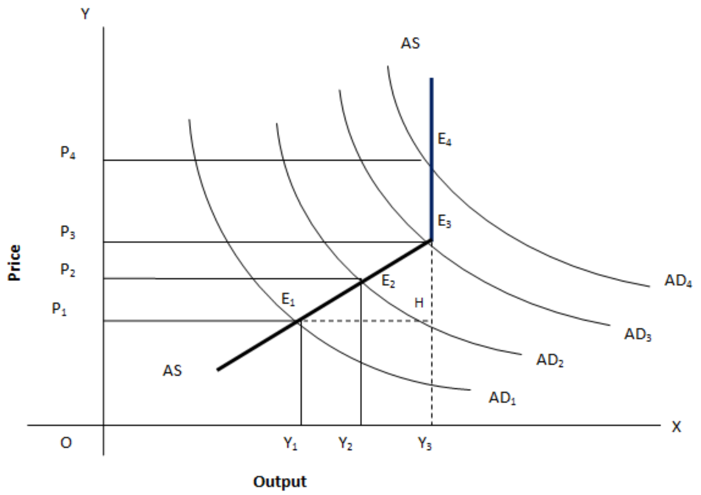


Figure: Demand-Pull Inflation

In the figure given, the x-axis shows output and the y-axis represents the price of a commodity. AD and AS represent aggregate demand and supply respectively. AD_1 curve intersects AS curve at E_1, giving Y_1 and P_1, the original output and price respectively. An increase in the aggregate demand shifts the aggregate demand curve to AD_2. This leads to excess demand for E_1H at P_1. New equilibrium takes place at E_2 corresponding to the intersection of AD_2 with AS. Excess demand pulls up the price and output to P_2 and Y_2 respectively. Thus, a one-time shift in aggregate demand gives rise to a one-time increase in price.

If there is another and then yet another increase in demand, there will be a rightward shift in the AD curves, there will be another and then yet another increase in the price level. It will happen up to the full-employment level of output (Y_3) only. Thereafter, an increase in the aggregate demand will lead to an increase in price only, and output will remain the same.

An increase in the aggregate demand is may be due to an increase in real factors such as an increase in government spending, a decrease in taxes, an increase in export demand, etc. and due to monetary factors i.e. increase in the money supply.

1. **Cost-push inflation:** When the price of a commodity increases continuously due to an increase in the cost of production, it is known as cost-push inflation.

Cost increases mainly due to two reasons;

i. **Increase in the wage rate.**

   The primary cause of cost-push inflation is the rise in the money-wages in excess of the rise in the productivity of labour. Strong trade unions can press employers to increase their wage rates greater than the increase in the productivity of labour. This leads to an increase in the cost of production and as a result producer raise their prices to cover the higher cost. A series of increase in wage rates leads to a series of increases in prices (inflation).

ii. Increase in profit margin.

Another cause is due to the increase in the profit margin. Oligopolists and monopolist firms raise the price of their product to earn higher profits. A series of increase in profit margins will lead to an increase in the cost of production and thereby prices, resulting in inflationary pressure.

The cost-push inflation can also be illustrated with the aggregate demand and supply curves as shown below.

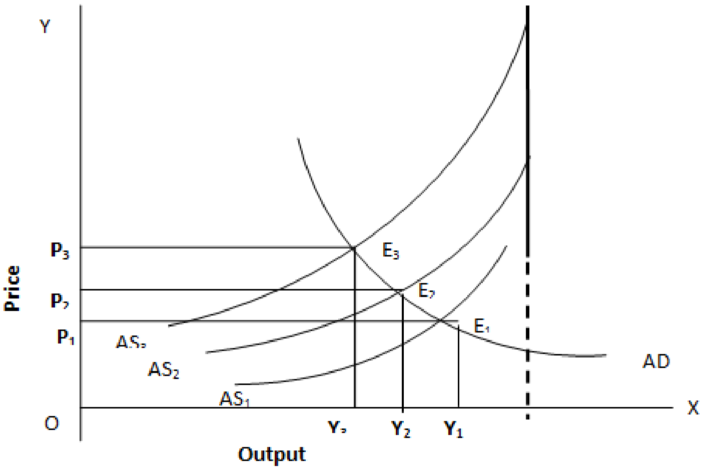


Figure: Cost-push Inflation

AD curve intersects AS1 curve at E1, giving P1 and Y1 as the equilibrium price and quantity respectively. An increase in the cost of production due to an increase in wage rate or an increase in profit margin result in an upward shift of aggregate supply curve to AS2, aggregate demand remaining the same, resulting in the shift of equilibrium to E2. As a result, price increases to P2 and quantity to Y2. A series of increase in the cost of production will result in a series of upward shifts in AS curve leading to an inflationary rise in prices.

ACTIVITY 1

1. Imagine there is a rapid increase in the population of Bhutan,
   a) What do you think will happen to the demand for goods and services?
   b) Do you think it will put pressure on the existing supply of goods and services?
   c) What will happen to the price?

2. What do you think will happen if the government increases the indirect taxes like excise duties and sales tax? In case if you are a seller, what do you think should be your sole responsibility in the current situation that our country and the world are undergoing?

Summary

- Inflation is a process of a persistent and appreciable rise in the general level of price.
- There are six types of inflation:
  - i. Creeping inflation occurs is a continuous rise in price at a mild rate.
  - ii. Walking or trotting inflation occurs when the rate of inflation is 3% to 6% per annum.
  - iii. Running inflation when the rate of inflation is 8% to 10% per annum.
  - iv. Hyper or galloping inflation occurs if price increases to 20% to 30% per monthly
  - v. Open inflation is open when there is no barrier to price rise and
  - vi. Suppressed inflation is a situation when there exists inflationary pressure in the economy but prices are controlled by certain measures such as price control and rationing
- Demand-pull inflation: When the demand for goods and services is more than the supply at the existing price, it is known as demand-pull inflation
- Cost-push inflation: When the price of a commodity increases continuously due to the increase in the cost of production is known as cost-push inflation

Self-check for Learning

1. Name the type of inflation that occurs when there is no barrier to price rise.
   a. Creeping inflation
   b. Hyper Inflation
   c. Open inflation
   d. Suppressed inflation

2. 'At this stage, there is no limit to price rise, and the price goes out of control. Money becomes almost worthless causing severe hardship to people. There is a complete collapse of the currency and economic and political life is disrupted.' Which type of inflation does the given statement best describe about?
   a. Galloping inflation
   b. Trotting inflation
   c. Suppressed inflation
   d. Creeping inflation
3. If inflation is a process of persistent and appreciable rise in the general level of price, what do you think deflation is?
4. Why are inflation and deflation considered to be economic problems?
5. How does the strength of the dollar in foreign markets affect the inflation rate?

1.2 Money and Banking

- Explain the evolution of money in Bhutan.
- Examine the roles and functions of Central Bank of Bhutan.
- Describe the monetary policy operation.

Introduction

In the early human civilization, human wants were limited to those goods and services that were necessary to sustain life. With the economic growth and development, human wants are increasing and thus, pushing to increasing interdependence on each other. No one can produce everything that one needs. Therefore, people have to exchange goods and services among themselves to satisfy their wants. Thus, money was invented to serve as a medium of exchange.

Definition of Money

Money, in some forms, has been part of human history for at least 3000 years. In ancient times, the barter system prevailed. The difficulties of barter system made it necessary for people to devise some means to overcome the limitations. This led to the invention and use of money. Since then money has been playing a significant role in an economy. However, money evolved through a number of stages and its nature has been changing from time to time and from region to region. Anything that can be used as a medium of exchange, a measure of value and store of value is called money.

Evolution of Money

Money in the present time came into existence through a long process of evolution from commodity money to fiat money and today, in virtual form. The origin of money carries a long history of social evolution.
Thus, the stages of evolution of money are explained below:

Stage I: Commodity Money

Commodities were the earliest form of money. Commodities like rice, wheat, shells, and beads were used as money because many people were willing to accept those in exchange for their produce. Thus, a commodity is a physical item that is easily interchangeable with another item of the same type.

Stage II: Metallic Money

In the earlier times, precious metals like silver, gold, and bronze were used as money. These metals were more durable, divisible, scarce, and valuable than commodity money. However, the use of precious metals did not solve the complicated problems of exchange. It was difficult to measure the value with those pieces of metal besides the problems of bulkiness, transportation, and storage. The problems associated with precious metals were solved through the

development of coins. To make the process of exchange easier, the concept of coinage was adopted. The government took control of all the coins. Coins were stamped with a logo, with uniform weight and the value was guaranteed. These coins were standard as both their face and intrinsic (value in themselves) were equal. However, standardized coinage was unable to catch the minds due to

1. Too much time in the extraction of metals from mines
2. Scarcity of metals.
3. Mobility

Stage III: Paper Money

Goldsmiths who were acting as moneylenders discovered paper money. These goldsmiths used to keep the valuables of the people in the safe rooms and issued receipts as a proof of the goods stored. These receipts became convenient credit instruments and were freely used for borrowing, lending and making payments. However, the owners of the paper receipts soon realized that they were holding worthless papers. This resulted in the collapse of goldsmith bankers.

With the collapse of goldsmith banks due to over-issuance of paper receipts beyond their worth, the government took over the role of goldsmiths and started issuing currency notes. The invention of currency notes greatly facilitated trade and commerce resulting in economic growth and development. Today the central bank of a country reserves the sole authority to issue paper notes.

Stage IV: Credit Money/Deposit Money

In the present-day modern economies, bank money is used for making personal business payments. In the developed countries, transactions are taking place with the help of deposits or checking accounts with paper money. Demand deposits or money sited in current accounts are easily convertible cash, therefore they are convenient and safe.

Stage V: Modern Money (Plastic/digital)

Plastic money gained popularity in the form of Credit and Debit cards. With the invention of such money, it has become more convenient for the people to carry out economic transactions. Moreover, it has reduced the risk of carrying cash in bulk. Today The invention of the computer and its application has changed the way in which business is carried out. The concept of e-commerce is gaining popularity. The mode of payment is being changed from cash to electronic transactions. This form of electronic payment is referred to as Digital money. The transaction of such money uses technologies such as smartphones, credit cards, and online cryptocurrency exchanges. In some cases, the digital money can be transformed into physical cash, for example, by withdrawing cash from an Automated Teller Machine (ATM).

The evolution of money is a never-ending process, it will never come to an end. As economies of the world are changing their forms and features, money is also changing accordingly to meet the needs of the changing economies. Globalization and expansion of e-commerce has given new dimension to modes of payment and has shaped the nature and features of money.

Importance of Money

Money has become so important that the modern economy is described as a money economy. Money performs many functions in the modern economy. The most important functions are described below.

a. **Medium of exchange:** One of the most important functions of money is that it acts as a medium of exchange. Money is accepted freely in exchange for all goods and services.
b. **Measure of value:** Money acts as a common measure of value. It is a unit of account and a standard of measurement. Whenever we buy a good in the market, we pay a price for it in the form of money. Price is a value expressed in terms of money. Therefore, the value of a good is measured by the amount of money paid for it.
c. **Store of value:** Money acts as a store of value. A person who wants to store his or her wealth in some convenient form of money suitable for that purpose. Suppose, one has thousands of cows, their value can be preserved in the form of money by selling them.
d. **Standard of deferred payments:** Money is used as a standard for future payments. Business in modern times is based on credit largely. Therefore, money acts as the basis for credit transactions without losing its value.

Roles and Functions of Central Bank

The evolution of money and its increasing use in daily business transactions have given rise to a need for financial institutions. Various banking and non-banking financial institutions were established over the period of time for financial regulations, and financial products and services. In the following paragraphs, we will discuss the role and functions of the central bank as apex financial institutions in Bhutan.

ROYAL MONETARY AUTHORITY (RMA)

RMA is the Central Bank of Bhutan established in 1982 under the Royal Monetary Authority Act passed by the 56th session of the National Assembly of Bhutan. The current Governor is Dasho Penjore. The RMA primarily issues currency, controls and regulates banking and financial structure of the country.

Functions of RMA

- **Issue currency:** The RMA has complete control over the issue of banknotes and coins in the country. While issuing the currency, RMA ensures that inflation in the economy is kept under control, and at the same time, there is sufficient circulation of money within the country.
- **Act as banker to the Government and Commercial Banks:** The RMA accepts deposits and provides loans to the government and the commercial banks at agreed interest rates. It also provides the ultimate financial help during emergencies. For this reason, RMA is also called "the lender of last resort".

- **Promotion of Financial Sector Development:** The RMA takes responsibility to establish an effective financial system in the country. It supports financial transactions necessary for the smooth functioning of the economy.
- **Regulate the Financial Institutions:** The RMA formulates various financial rules and regulations for the prudent conduct of all the financial institutions in the country. It fixes maximum and minimum rates of interest on deposits and loans, determines cash reserves ratio, issues licenses for financial institutions, and supervise daily banking activities.

Roles of RMA

Primary roles

- To formulate and implement monetary policy to achieve and maintain price stability. What do you think Monetary Policy is? Monetary Policy is an action taken by RMA to influence Money Circulation in the economy to achieve price stability using different monetary instruments such as Expansionary Policy (increase the money supply) and Contractionary Policy (decrease money policy).
- RMA maintains price stability in the economy to control inflation issues in order to maintain the value of Money, for sustainable economic growth, to stabilize the exchange rate and for Positive real interest rate on saving and investment

Secondary roles:

- To ensure the stability & integrity of the financial system and promote an efficient payment system;
- Promote an efficient financial system comparable to international best practices;
- Promote, supervise and, if necessary, operate national and international payment and settlement system including electronic transfer of funds by financial institutions, other entities and individuals;
- Promote sound practices and good governance in the financial services industry to protect it against systemic risk; and
- Promote macro-economic stability and economic growth in Bhutan.

Financial Institutions

The financial institutions are established to provide different financial products and services to their clients. It serves as a link between savers and borrowers by accepting deposits and providing loans. A financial institution also performs other financial activities such as investments, exchange of currencies and transfer of money.

There are two types of financial institutions namely, banking and Non-Banking Financial Institutions. Banking financial institutions are those that accept deposits, provide loans, manage withdrawals and provide general utility services to its clients. On the other hand, Non-banking Financial Institutions are those financial institutions that do not accept deposits repayable on demand but provide all other forms of financial services to its clients.

A. **Banking Financial Institutions (Commercial Banks)**

- **Accepts Deposits:** Commercial banks accept deposits from the general public. Deposits are accepted in various forms at different rates of interest.
- **Provide Loans:** providing loans is another primary function of commercial banks. Banks mobilize funds of the savers and provide loans to the clients. Loans can be defined as the amount of money granted to the clients at a specific rate of interest for a fixed period of time. In most cases, the borrowers must mortgage their assets to avail the loan.
- **Transfer of Funds:** Banks also facilitate the transfer of funds by means of draft, telephonic, and electronic transfers. Fund transfers can be from place to place, person to person, and institution to institution.
- **Purchase and Sale of Foreign Currencies:** on authorization by the central bank of Bhutan, commercial banks deal with foreign exchanges. Commercial banks buy and sell foreign currencies in the country.

B. **Non-Banking Financial Institutions**

Non-Banking Financial Institutions are those that offer various financial services to the clients but do not accept demand deposits. They are considered supplementary as well as competitors to the commercial banks. Financial services offered by them include loans, credit facilities, insurance, pension, and money transfer.

- **Risk Pooling:** Non-Banking Financial Institutions such as insurance companies facilitate economic activities by underwriting risks associated with death, illness, damage, or loss of property. Such risks are transferred from the clients to insurance companies.
- **Provides social securities:** Non-Banking Financial Institutions like National Pension and Provident Fund provides social securities such as pensions and provident funds to its members on retirement, disability, and illness. The benefits are also provided to the nominee(s) in case of the death of the member.

ACTIVITY 1

1. Differentiate between banking and non-banking financial institutions.
2. Why it is important to monitor inflation in the economy?
3. List out banking and non-banking institutions in Bhutan

Summary

- Anything that can be used as a medium of exchange, a measure of value and store of value is called money.
- Commodities like rice, wheat, shells, and beads were used as money and it was called as commodity money.
- Precious metals like silver, gold, and bronze were used as money as these metals were more durable, divisible, scarce, and valuable than commodity money. This was called as metallic money.
- Precious metals in predetermined weights were minted as coins often with the face of a king or queen on one side and its value on the other. These coins were used as money and it was termed as coin money.
- Goldsmiths who were acting as moneylenders kept the valuables of the people in the safe rooms and issued receipts as a proof of the goods stored. This receipt was used as money and called it as paper money.
- With the collapse of goldsmith banks due to over-issuance of paper receipts beyond their worth, the government took over the role of goldsmiths and started issuing currency notes.
- Money gained popularity in the form of Credit and Debit cards and they were called as plastic money.
- The invention of the computer and its application has changed the way in which business is carried out. The mode of payment is being changed from cash to electronic transactions. This form of electronic payment is referred to as Digital money.
- Functions of Money: Medium of exchange, Measure of value, Store of value and Standard of deferred payments .
- Functions of Royal Monetary Authority: Issue currency, Act as banker to the Government and Commercial Banks, Promotion of Financial Sector Development, and Regulate the Financial Institutions .
- Primary roles of Royal Monetary Authority: To formulate and implement monetary policy to achieve and maintain price stability to control inflation issues in order to maintain the value of Money, for sustainable economic growth, to stabilize the exchange rate and for Positive real interest rate on saving and investment.
- Secondary roles of the Royal Monetary Authority: To ensure the stability & integrity of the financial system and promote efficient payment system.
- Banking financial institutions are those that accept deposits, provide loans, manage withdrawals and provide general utility services to its clients.

- Non-banking Financial Institutions are those financial institutions that do not accept deposits repayable on demand but provide all other forms of financial services to its clients.
- Banking Financial Institutions (Commercial Banks): Accepts Deposits, Provide Loans, Transfer of Funds, and Purchase and Sale of Foreign Currencies.
- Non-Banking Financial Institutions: Risk Pooling, and Pension and provident fund.

Self-check for Learning

1. Why did the usage of the barter systems disappear from the economy?
2. Besides the barter system, which stage of money do you prefer? Why?

ARTS STREAM

1. MEDIA STUDIES

1.1 Uses of Multimedia tools and applications

Learning Objectives

- Define multimedia
- State the importance of multimedia tools and their applications

Introduction

Multimedia is simply multiple forms of media integrated. An example of multimedia is a web page with animation. Several data types can be characterized as multimedia data types. These are typically the elements or the building blocks of or generalized multimedia environments, platforms, or integrating tools. A multimedia application is an application that uses multiple media sources e.g. text, graphics, images, sound/audio, animation, or video. It comprises audio, video processing, virtual reality, and 3-D imaging, multimedia, and artificial intelligence. Multimedia applications are the creation of exciting and innovative multimedia systems that communicate information customized to the user in a non-linear interactive format.

Multimedia concept

The advent of the Internet and the World Wide Web (www) in the mid-90s extensively had widened our scope of learning into a global perspective and connected our learners to educational resources and information worldwide. Multimedia, gained its popularity since then in various fields of study.

The term, “multimedia” is composed of “multi” and “media” which refers to content that uses a combination of different forms. These forms can be text, images, audios, videos, or animations.

- Multimedia is simply using multiple forms of media integrated to represent information.
- Multimedia is a combination of text, graphic, animation, audio, and video which are everything we can see and hear in our daily life. (Vaughan, 2006)

An example of multimedia is a written text (textbook/prayer book), images, audios/music in Sound Cloud, Videos/documentaries in YouTube or Netflix, Software and Application in Google Play Store, and a web page with animation.

Thus, by integrating the digital personal computer (PC) and multimedia technologies into the teaching and learning process, a new paradigm is created. Such a paradigm has a great impact on our traditional method of delivering educational content particularly in terms of innovative ways of delivering instructional materials to the learners.

ACTIVITY 1

1. Mention an example of multimedia that you have used.

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Multimedia tools

In the past, each entertainment medium had to be played on a specific device. Video displayed on a television through some type of video player, music came through a tape deck or Compact Disc (CD) player, and video games were played through a console of some sort. But now all these are integrated into one tool. Take Facebook as an example. For your profile, a picture/video is uploaded. When you update your status you use text. You post videos of your journey to a new place and when you chat you make use of emojis. Thus, we see all are integrated into one social networking application. Social Media Apps, Games, and Websites all use multimedia.

Why Multimedia Tools in Education?

As technology progresses, so will multimedia.

Over recent times, multimedia has become a huge force in human culture, industry, education, and so on. In our daily lives, we receive various information in multiple forms: from television to magazines, to newspapers, to web pages, to movies and the list goes on.

Education is evolving to create electronic multimedia materials which are becoming an excellent alternative to traditional teaching. In modern classrooms, teachers and learners use various methods of teaching and learning including multimedia applications. Considering that different learners possess different learning abilities, adopting suitable methods have become very essential. Internet and the World Wide Web have extensively widened our scope of learning.

In addition to reading and writing, the current definition of literacy also includes the ability to learn, comprehend and interact with technology in a meaningful way. With computers as tutors, each student has the ability to work at his or her own pace alongside the school.

- Multimedia is a technology engaging variety of media.
- Multimedia is the collection of text, audio, video, animation, and graphics.
- The concept of a paperless society is effective with the invention of multimedia.
- Multimedia helps the user in providing information from different media on one platform.
- It enhances the concept of networking and resource sharing.
- It is more powerful than printed learning resources such as printed textbooks.
- It also allows learners/users to interact with information quickly and accurately.

Now, let us see how multimedia applications help learners.

With multimedia becoming integral in many industries, the education field is also evolving to create electronic multimedia materials as multimedia offers an excellent alternative to traditional

teaching. By allowing students to explore and learn at different paces, every student has the opportunity to learn at his or her full potential.

Now, let's have a look at the most important types of multimedia tools for learners and teachers.
"Multimedia Applications" meaning
Multimedia Applications are often used to deliver information that is more powerful than printed learning resources such as printed textbooks. It also allows learners/users to interact with information quickly and accurately.
For example: World Wide Web, interactive TV, computer games, and virtual reality.

ACTIVITY 2

1. How do multimedia play an important role in today's society?

Open Educational Resources or OERs

Open Educational Resources or OERs are learning and teaching materials that are shared online and for everyone openly in the public domain. These materials can be used for many purposes which may include translating, reusing, or maybe modifying because the creators of contents have already granted permission to do so via open licensing.

Open Educational Resources (OER) are defined as 'technology-enabled, open provision of educational resources for consultation, use and adaptation by a community of users for non-commercial purposes'. They are typically made freely available over the Web or the Internet and include learning objects such as lecture material, references and readings, simulations, experiments and demonstrations as well as syllabi, curricula, and teachers' guides *(UNESCO, 2002).*

Benefits of using OER for learners

1. It is an educational platform open to everyone.
2. Before even signing up, learners can try out the course.
3. Affordable learning, ideally free of cost.
4. Learners can learn and work at his/her own pace.
5. Accessible from anywhere and have no limit to access to college or school.
6. Provide access to a variety of study materials.
7. A lot of intellectual capital is offered to be reused.
8. Provide supplementary learning materials for courses.
9. Determine what classes or programs to enroll in.
10. Better prepared for classes

Now, let us look at some of the examples of OER

Examples of OERs

1. Curriki

A well-known and leading Kindergarten to Grade 12 (global) community for instructors, students, and also parents to share create and search open learning resources which may improve the effectiveness of teachers along with students' outcomes.

2. Khan Academy

A popular non-profit OER with the mission to provide free, world-class education for anyone and anywhere.

3. Udemy

Udemy is an online learning and teaching marketplace with over 100000 courses and 24 million students.

4. Coursera

Coursera is a world-wide online learning platform founded in 2012 by Stanford professors Andrew Ng and Daphne Koller that offers massive open online courses, specializations, and degrees.

5. Digital educational games

E.g: Scrabble, word search, Mystery file, summertime spot the shape

On the other hand, we have Multimedia applications such as Google Classroom. Of late, the Ministry of Education encouraged the teachers and students to use multimedia applications such as Google Classroom across the country during the shutdown of schools due to COVID-19. Such multimedia is used by teachers to convey information through notes, slides, assignments, and many other resources.

Since Multimedia uses different platforms, it helps learners to learn at their own pace, to achieve the outcome that they desire, in a way it is assistive. Technologies are assisting learners in their learning. Such technologies are known as Assistive Technologies. Assistive Technologies (AT) is used to assist students in a variety of instruction modes. For example a visually impaired person might use JAW to help to read what's there on the screen. Technology has enabled learners of all abilities.

Note: JAWS (screen reader) JAWS ("Job Access With Speech") is a computer screen reader program for Microsoft Windows that allows blind and visually impaired users to read the screen either with a text-to-speech output or by a refreshable Braille display.

ACTIVITY 3

1. What are some of the benefits of OER to our learners?

Summary

- Multimedia is the field concerned with the computer-controlled integration of text, graphics, drawing, still, and moving images (video), animation, audio, and any other media where every type of information can be represented, stored, transmitted, and processed digitally. In education, multimedia can be used as a source of information. Students can search encyclopedias such as Encarta, which provide facts on a variety of different topics using multimedia presentations. Teachers can use multimedia presentations to make lessons more interesting by using animations to highlight or demonstrate key points.
- Open Education Resources (OERs) are readily available resources, that is, they are free for the masses. These online materials help corporate learners expand their knowledge and deepen their understanding of specific topics or tasks.

Self-check for Learning

1. Which Multimedia are you familiar with?
2. Mention a few examples of OER facilities available in your school.
3. Explore the digital educational game “barista sim” and write how it can benefit you.

1.2 Journalism and its Principles/ Research Ethics versus Media Ownership

- Define journalism.
- Explain the five principles of journalism.
- Define research, research ethics, and media ownership.
- State the importance of research ethics.
- Explain the relation between media owners and journalism.

Introduction

The word journalism applies to the occupation, as well as citizen journalists who gather and publish information. Journalism is the production and distribution of reports on events. Journalists educate the public about events and issues and how they affect their lives. They spend much of their time interviewing expert sources, searching public records and other sources for information, and sometimes visiting the scene where a crime or other newsworthy occurrence took place. After they have thoroughly researched the subject, they use what they uncovered to write an article or create a piece for radio, television, or the internet.

In addition to serving the public interest; journalists must also follow the professional “Code of Ethics”. Journalism ethics and standards describe the principles of ethics and good practice journalists adopt in response to specific challenges. These basic codes commonly appear in statements drafted by professional journalism associations and individual print, broadcast, and online news organizations. While various existing codes have some differences, most share common elements: notably, the principles of truthfulness, accuracy, objectivity, impartiality, fairness and public accountability as they apply to the acquisition of newsworthy information and its subsequent dissemination to the public.

Concept of Journalism

Journalism includes producing media messages, working for newspapers or magazines, writing behind the scenes for broadcast networks, and going on location to gather information on events. Journalists inform the public about important news and information.

A person who writes for newspapers or a magazine and prepares news to be broadcast is called a journalist.

His works include gathering information, writing, editing, photographing, and also broadcasting news among many others.

A journalist's work is called journalism.

What is Journalism?

1. Journalism is a discipline of collecting, verifying, reporting, and analyzing the information gathered regarding current affairs or events including trends, issues, and people.
2. The main activity of a journalist is the reporting of events by stating who, when, where, why and who and explaining the significance and impact of the trends or events. Journalism exists in a number of media, newspapers, television, radio, magazine, and the internet.
3. It is collection, preparation, and distribution of news and related contemporary and features materials through media such as pamphlets, newspapers, magazines, radio, film, television, and books. The term was originally applied to the reportage of current affairs in printed forms, especially newspapers but in the late 20th century it came to include electronic media. It is sometimes used to refer to writing characterized by a direct presentation of facts or description of events without an attempt interpretation. (Britannica concise encyclopedia)

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ACTIVITY 1

1. Explain the term 'journalist' in your own words.

Keywords from the definition

- Collecting- gathering of information from different sources
- Verifying- confirming the authenticity of the gathered information whether they are true or correct
- Reporting-covering an event, writing an account on the event
- Analyzing- investigating in detail in order to explain the event

The main activity of a journalist is the reporting of events by stating who, when, where, why, and how, and also explaining the significance and impact of the trends or events. Journalism exists in a number of media; like newspapers, television, radio, and magazine and also the internet.

The five principles of Journalism

1. Truth and accuracy
2. Independence
3. Fairness and impartiality
4. Humanity
5. Accountability

- **Truth and Accuracy-** The journalist must report the facts about the story. They must not distort the shreds of evidence and facts collected from the sources or other relevant organizations or individuals. Before publishing the story they have to reread and further comprehend and only then make it public. Overall, the journalist must maintain truth and accuracy in the story collected for the publication.
- **Independence** – Journalists must not report the news story in favor of others. Any personal allegiances should be made clear to an editor or public. They have to work independently and write without fear/favor.
- **Fairness and impartiality-** Impartial reporting builds trust and confidence. Wherever possible, stories should be objective in nature and balanced by opposing views or opinions.
- **Humanity-** Journalists are not supposed to be harmful to anyone. What is being published should not be harmful or hurtful in nature. They must be aware of what depth of impact the published words and photographs will have on others' lives.
- **Accountability-** Once they report the news they must be accountable to clarify the doubts raised by the readers. Any errors made must be corrected with sincere regret and take remedial. Journalists should be open to listening to what the audience has to tell.

ACTIVITY 2

1. Which principle do you think is the most important? Why?

Journalism and Research Ethics

1. Do you have an idea of what research is?
2. Have you conducted any kind of research?
3. When you hear people saying, "I am conducting research on so and so topics" what do you think they are doing?

Let us look at definitions given by media educationists and organizations about research.

- "Research is the systematic investigation into and study of materials and sources in order to establish facts and reach new conclusions."
- According to Oxford Advanced Learner's Dictionary, research is a careful study of a subject in order to discover new facts or information about it.

Simply put, research is the collection of information from various sources about a particular subject.

Importance of Research

Now let us see why research is important for media professionals.

In media, research is indispensable as most of the principles of journalism cannot be fulfilled without it. The journalist is always seeking information that has the most value for the people and without research, this is quite impossible because reliable and accurate facts can be achieved only by making inquiries or with the help of research.

So as not to violate the five principles of journalism and to promote the principles of journalism, research becomes vital for media professionals. It is important for the journalist to do a thorough study of a particular subject before it is published in the media. Research not only adds depth to what is written or said, but it also has the ability to portray information from different perspectives. It helps the media consumers to validate the information and come to the conclusion in their own terms after what they hear, read, or view. And that's how the information becomes deep and accurate.

Research is paramount to journalism; it does not mean that journalists can conduct researches at their own will. They must follow the research ethics, which by definition, are moral principles that journalists cater to while conducting or reporting the research findings.

Now, let us look at Research Ethics.

1. Practice principles of journalism-Journalists must always try to uphold the five principles of journalism while doing the research.
2. Seek for informed consent - Research should be based, as far as possible on the freely given informed consent of those under study.
3. Avoid deceptive and covert research- A researcher should endeavor, wherever possible, to avoid the use of deception in their research as this violates the principle of informed consent. If a researcher uses a deceptive and covert research, he or she must seek prior approval from the relevant authority before such is used.
4. Maintain confidentiality and anonymity- Anonymity and privacy of research participants should be respected at all times and personal information relating to participants should be kept confidential unless the participants have no objection in making the information public.
5. Be correct in the interpretation of research findings -Journalists should not distort or misinterpret the findings from the research. Rather it must be interpreted as accurately as possible, and the information must be used for the stated purpose only.

ACTIVITY 3

1. Why is research indispensable in journalism?

Media Owners and Journalism

Let us explore some examples to know more about media owners in Bhutan

The BBS (Bhutan Broadcasting Service) is a government-owned media house. It has the liberty to cover a range of topics and issues without having to worry too much about the profit-making aspect of commercialism.
Kuensel is a corporate media house in which Royal Government of Bhutan, as well as some private stakeholders, support. Compared to the BBS, Kuensel focuses more on the commercial aspect in the form of generating revenue from advertisements although both the media houses have the same mandate to keep the citizens informed with the right information.
And we also have Private media houses like Kuzu FM, Radio Valley, The Bhutanese, etc… These are totally private-owned and are even more focused on the concept of commercializing the media.
Ownership can have impact on the contents and practices of journalism. Different types of media owners have different expectations from their media houses. Media houses whose focus is more on commercializing media might slack a little when it comes to journalistic ethics. Media owners want to make a profit; journalists want a balanced view of everything. Be it private or public owned media there are some conflicts over the interest of owners and journalist's views. The interest of owners and journalist collide. However, in an ideal situation, the interest of the owner to make profit, and journalists' independence and ethics are to be balanced.

Summary

- The work of journalism is different from any other works. In journalism, we need knowledge and skills to collect, identify, analyze, evaluate, and publish news and information to the public. The work of journalism is guided by the principles of journalism, and journalist code of ethics framed by BICMA. Journalism ethics include the principle of "limitation of harm". This often involves the withholding of certain details from reports such as the names of minor children, crime victims' names, or information not materially related to particular news reports release of which might, for example, harm someone's reputation. Research ethics helps reporter to become a profound journalist who can bring the news updates with facts, accuracy, and relevancy to the societal norms.

Self-check for Learning

1. What makes Bhutanese journalists different from other journalists?
2. What would be the consequences of not carrying out proper research by the news producer?

1.3 Global Economy, E-Commerce and Media Ownership

Learning Objectives

- Define the term global economy.
- Define E-commerce (examples of Bhutanese e-commerce apps).
- Tell how media ownership influence the patterns of communication.
- Explain media ownership and its control in the global village.

Introduction

In the past when traditional media was dominant, communication was very difficult. In our country in particular conveying messages from one place to another was difficult. But now with the advent of new media, communication has become easier. Electronic mass media have fused space and time barriers in human communication. Satellite technology and the internet have globalized communication, and allowed users from around the globe to connect and interact with each other instantaneously. News travels instantaneously across the globe, mobile phones make communication easier and internet smashes old barriers of communication. When global communication and media messages happen on a global scale, our world has become a small community, a global village.

The first set of the cell phone was introduced in Bhutan in 2003 with just about 2,255 users. Now, almost everyone in the country owns a cell phone. Initially, they used 2G technology which allowed only two features; text message and call. After launching 3G service in 2008 and also with the evolution of mobile handset, things have changed. We have moved from ordinary mobile phones to smart phones with multiple features."People would wait for hours to connect to the internet but now with the change in technology things have changed. Also, with competitions, we have moved from narrowband internet to broadband internet," (Kuensel news, 14, 2016).

Bhutan Broadcasting Service was established in 1973 as a radio service. The service also started television broadcasts in 1999, making Bhutan the last country in the world to introduce television. In Bhutan, media has historically been government-owned, although this has changed in recent years. The country has its newspapers, television, and radio broadcasters owned by different media owners and internet service providers. Some examples of privately owned media in Bhutan are; The Journalist, The Bhutanese, Kuzu FM, Radio Valley, and magazines like Drukpa, Yeewong.

Global Economy or World economy

What is the "Global economy" or "World economy"?

"Global economy or World economy generally refers to the economy which is based on the economics of all of the world's countries' national economies".

Do you think our country's economy will also be included in the global economy?
Yes, of course. However, our focus would be more on how we use media to boost the economy.

E-commerce

Let us see what e-commerce is and how it is related to the global economy.
Electronic commerce, in short, 'e-commerce' refers to buying and selling of goods or services via electronic channels such as social media platforms using the internet.
We are sure many of us are now familiar with online shopping which is slowly gaining popularity in Bhutan. Similarly, other forms of e-commerce are increasingly gaining popularity.

Examples of E-commerce:

Utility bills payments

- Electricity, telephone bills, insurance, and taxes can be paid online.
- We can recharge our mobile phones via the e-load system.

Can you think of some more examples?

Online Banking Services. (M-BoB, e-Pay, m-pay, B-wallet, etc…)

Now, let us look at a few examples of electronic commerce within the country and beyond.

In Bhutan	Outside Bhutan
1. B Bay Buying and selling 2. Nowai Chala 3. Oii App 4. Drukride 5.Superdeals	1. Amazon 2. Flipkart 3. Aliexpress 4. Uber 5. Hotel Trivago

When e-commerce is done on a global scale, it has a tremendous impact on the global economy indeed. For instance, according to Business News Daily (2015), worldwide e-commerce sales reached $1.2 trillion in 2013.
Technological advances in the worldwide market economy have encouraged the growth of global media companies.

Advantages of E-Commerce

- There is no need to physically visit shops
- We can get goods and services within a short span of time
- We can get products from all around the world
- Sellers can advertise goods and services
- We need not set up shops to sell

Disadvantages of E-Commerce

- Chances of being cheated
- dissatisfied customers over the quality of the product

ACTIVITY 1

1. Define global economy
2. Define e-commerce
3. Mention some examples of e-commerce in Bhutan

Media ownership and control in Bhutan

Journalists promote democracy in the exercise of free speech and press. Editorial independence and pluralism of media at local and international levels are important. The way the media and communication are owned, produced and controlled has pervasive consequences for the character of public debate, the attitudes people form towards social issues and social conflicts, and ultimately of social change in a democracy. If the freedom of speech and press is to reign in society, media should enjoy its independence and the state should have as little control over media as possible.

Privately Owned Media

Private media are the media organizations that are owned, controlled, and funded by private entities or individuals. Private media play a critical role in bringing 'independent voices and balanced views.'

Examples of Private Owned media

- Newspapers like The Journalist, The Bhutanese, Kuzu FM, Radio Valley, and magazines like Drukpa and Yeewong.

Government-Owned Media

Government-owned media are those State-media which are controlled and funded by the state. State media are more prescriptive, dictating the audience what to think and how. In more controlled regions, the state may censor content which it deems illegal, immoral, or unfavorable to the government.

Examples of Government-owned Media

- Kuensel and BBS TV and BBS radio

Public media organizations

Public media organizations work with motifs to render 'public service'. They are not for profit as they get funding from various sources including license fees, individual contributions, and public financing and commercial financing.

Examples of Public media organizations

- Aljazeera, CCTV, NHK, etc. BBS also plays the role of public media.

Community media

Community media refers to media that is created and controlled by the community, be it a geographic community or a community of identity or interest. People are actively involved in the production of media materials. It's a powerful agent of social change. They ensure a great degree of freedom of speech, maintain media pluralism, foster cultural diversity, and promote gender-balanced access.

Example of Community media

- The Sherubtse FM

ACTIVITY 2

1. Write the differences between privately owned and government-owned media in Bhutan.

Media ownership and influence on the patterns of communication.

A different form of media sources with different media information. The information received differs from one media source to another in terms of pattern, format, and news content. The freedom of journalists or journalist independence is influenced by the financial and political concerns of media owners or employers.

Do you think that media ownership could influence the patterns of communication?

- Advertisement and circulation are the main sources of revenue for media houses.
- While journalists are aware of their freedom and obligation, they cannot override the financial and political concerns of media owners. As a result, they are compelled to act according to the will of their employers.
- In this way, journalists don't enjoy full independence; they cannot execute their professional duties effectively.
- Private media companies are mostly profit-oriented. They enjoy greater independence but they are also not free from the web of influences.
- The monopolistic ownership of media, like state-controlled media, can pose a threat to media diversity and pluralism, which in turn can affect freedom of expression.
- Therefore, competition in the media market must be regulated and a variety of forms of media ownership (private, public, joint, not for profit) must be encouraged.

ACTIVITY 3

1. Do you think that media ownership could influence the patterns of communication? Give your justification.

Summary

- We are living in the global media world bounded by digital forms and modern technology. The e-commerce system is a part of the global digital economy and banning and stopping is unfair for many of our citizens who make a living out of this. It also provides new business opportunities to the citizens and therefore, they need to participate. The e-commerce business is gaining popularity in our country. Many started experiencing online shopping and money payments.
- As today's consumer spends up to nine hours per day online, social media has proven to be the most effective way for a business to reach new audiences on a global scale. Social media is also helping to fuel the global economy by creating new jobs, democratizing information, and pushing brands far beyond their borders.

Self-check for Learning

1. Should we encourage e-commerce in our country? Why? Why not?
2. Imagine you have a local product to sell during the fight against COVID-19 but you cannot reach your market. How would you apply the knowledge acquired from today’s lesson to sell your product?

1.4 Media Literacy (ML) and its Importance

- What media literacy is.
- What media literacy is not.
- Understand the importance of media literacy.

Introduction

From the President of the United States to a posh toddler everyone can carry an iPhone and send off mass messages to hundreds and thousands of online influencers. We connect at the touch of a button and make decisions with the flick of a wrist. As a result, it is especially important for employees, students, influencers, and everyday users to have media literacy and understand the consequences that follow online actions. Media rely on advertising to stay in business. Advertisers are constantly innovating new ways to reach target audiences through news and entertainment media. Passive media consumers are vulnerable in this media-saturated environment, especially when an advertisement or a biased message is packaged cleverly. And when we contemplate the numerous new forms of media joining the marketplace, it is clear that developing media literacy skills has never been more important. It is important that we develop critical thinking skills, and understand the impact media messaging has on society. We must evaluate the validity of words, produce original content and use our voice to improve the media landscape, and all those affected by a SEND, UPLOAD, or TWEET button.

Media Literacy (ML) definitions:

Media: is a mode or technology through which the information is spread.
Eg: Television, newspapers, and books.

Literacy: competence or knowledge in a specified area.

Let's look at a couple of definitions given by media educationists and organizations. As per Central for Media and Literacy (CML) definition focuses on education for the 21st century.

Media Literacy is "... about asking smart questions and making smart choices".

–Fran Trampiest

According to Fran, Media Literacy is all about using media selectively and reflectively, knowing how to filter what is not needed and how to access and then interpret, analyze, and evaluate what is useful.

Cyndy Scheibe and Faith Rogow have pointed out that media literate citizens are expected to exhibit four abilities and competencies: ACCESS, ANALYZE, EVALUATE, and PRODUCE media in a variety of forms from print to video to the Internet.

Media Literacy, therefore, is about helping students become competent, critical, and literate in all media forms so that they control the interpretation of what they see or hear rather than letting the interpretation control them.

So, what did the above definitions tell us?
Fundamentally, Media Literacy means, being able to ACCESS, ANALYSE, EVALUATE, and PRODUCE or CONSUME media critically.
Access: being able to critically and mindfully access what is useful and relevant to you.

Analyze: being able to examine the creative techniques that are used to attract the attention of viewers/decoding media messages in order to think critically and independently about them.

Evaluate: the ability to make informed decision or a decision based on reason, facts and figures, and the ability to use media for a specific purpose based on relevance, accuracy and reliability.

Produce/create: producing or creating media mindfully and understanding media ethics.

ACTIVITY 1

1. What is media literacy?
2. Explain some of the skills required to be a media literate person.

What media literacy is NOT?

- 'Media Bashing' is NOT media literacy; however, it sometimes involves criticizing the media.
- Merely producing media is NOT media literacy, although media literacy should include media production.
- Just teaching with videos or CD-ROMs or other mediated content is NOT media literacy; one must also teach about the media.
- Simply looking for political agenda, stereotypes or misrepresentations is NOT media literacy; there should also be explorations of the systems making those representations appear "normal".
- Looking at a media message or a mediated experience from just one perspective is NOT media literacy because media should be examined from multiple positions.
- Media Literacy does NOT mean 'don't watch'; it means 'watch carefully, think critically'.

Remember…
Now, remember what media literacy is and what media literacy is not.

ACTIVITY 2

1. What do you understand by this statement, "Media Literacy does NOT mean 'don't watch'; it means to watch carefully, and think critically."

Why is Media Literacy important?

- Media Literacy empowers people and communities through information. It is supposed to be an important prerequisite fostering equitable access to information and knowledge, and building inclusive knowledgeable societies.
- Media Literacy emphasizes critical thinking skills, as we make decisions, whether in the classroom, the living room, the workplace, the board room, or the voting booth.
- Media literacy helps us understand how the media create cultures, beliefs, and attitudes.
- Media Literacy enables people to have the skills, knowledge, and understanding to make full use of the opportunities presented by communication services. It also helps people manage content and communications, and protect themselves and their families from the potential risks associated with using these services.
- It enables people to become effective communicators.

Why is it important for young users?
It helps in

1. Critical Thinking

Media literacy is all about finding the untold story beneath film clips, radio spots, and newspaper articles. Even corporate-sponsored content has hidden messages that challenge us to think beyond what we hear and see. For instance, learning to deconstruct messages in an advertisement challenges us to expand our level of thinking and refuse to accept questionable content. Developing critical thinking skills through media messaging also strengthens observational skills. Questioning the norm and reinterpreting layers of everyday messaging gives us everything we need to become smart-decision makers in real-world scenarios.

2. Self-Expression

Film students watch classic films to understand how directors capture emotion effectively and artistically. Aspiring designers analyze successful advertisements to determine how color, proximity, font, imagery, and text contribute to reliable messaging. Writers read novels, scripts and magazine articles to understand sentence structure and powerful imagery. Studying how others relay media to communicate a particular message or emotion helps us effectively conceptualize and produce their own content. Thanks to fierce competition and market

saturation, media today is more out-of-the-box than ever before, and watching the best of the best is enough to inspire creativity in anyone.

3. Civic Responsibility

Without studying the ins-and-outs of media mayhem, we miss the unspoken moral guidelines that lead every digital decision. In a world where media spreads faster than air, media literacy is the key to keeping communities well-informed and well-represented.

ACTIVITY 3

1. Why is media literacy important for students?

Summary

- At home your parents turn off TV stating that media are so ingrained in our cultural milieu. But the fact is we still cannot escape today's media culture. Every day, we find ourselves watching a televised advertisement, listening to a radio broadcast, watching a film, reading a magazine, and interpreting complex messages sent through a variety of different digital channels. Media no longer influences our culture. They are our culture. Media Literacy education is intended to promote awareness of media influence and create an active stance towards both consuming and creating media. Media Literacy education is distinct from simply using media and technology in the classroom, a distinction that is exemplified by the difference between "teaching with media" and "teaching about media".

Self-check for Learning

1. What are the differences between media literacy and information literacy?

1.5 New Media World and Citizenship Orientation

- Tell the meaning of new media and citizenship orientation.
- Understand the role of mass media (new media).
- Tell a few roles of citizens towards the use of new media.
- Identify issues of political communication in this new era.

Introduction

New Media is more user-friendly compared to traditional media. It is based on modern computer technology with separate digital data controlled by software(s). It is faster compared to the old media. The application is with the help of internet connectivity and power supply. Where ever we are, we can connect ourselves to the new media. The only thing is we have to have the required devices with us.

Concept of New Media World

What clicks in your mind when you see these terms?

1. Computer animations
2. Computer games
3. Human-computer interfaces
4. Interactive computer installations
5. Websites
6. Virtual worlds

New media can be associated with the terms mentioned above.

New Media are forms of media that are computational and depend on computers for redistribution. Behind every new media lies a human creation. People created new things and started living with them. At present, the world is popularly known as the New Media World.

We might at times question ourselves, "Why are television, radio, and print media not the examples of New Media?"

Scholars in Communication and Media Studies state that "New media does not include analog broadcast television programs, feature films, magazines or books unless they contain technologies that are digital generative or interactive. So, one thing you need to know is that new technology is interactive. Even, online encyclopedia or Wikipedia is a good example of new media. It works with the internet which means it is a digital text with web-links and provides the space for interactive feedbacks.

ACTIVITY 1

1. What are some of the examples of new media?
2. Why they are called new media?

NEW Media and CITIZENSHIP Orientation

People's orientation towards new media is important as all of us live in the cyber world. Coming up of new media has indeed instigated mass movements (populist movements) popularly in politics.

What are the roles of new media to the citizens?

1. Citizens have greater access to the political world. Ordinary citizens can establish meaningful and effective roles.
2. Political news can be made available through various media so that the information fits even those who were under-represented. Example-cable television, call-in radio forums, and internet platforms allow citizens to receive information relevant to them and make contact with others who have a similar orientation.
3. New media shifts public participation from passive to active. Citizens can make their political presence and opinions. For example, calls-in, online polls, chat programs, online forums, and ask questions to their representatives.
4. New media bridges the gap between and public and decision-makers allowing greater citizen inputs into the policy arena. Citizens become a greater resource for the government.
5. To encourage people to embrace new media participation, a new media environment should provide the public with quality information.

The roles played by the new media towards citizenship orientation may not be limited to these points. On the other hand, we need to consider even the citizens' roles towards new media platforms.

Social media etiquettes

- Be aware of what is allowed and what is safe and genuine
- Learn to select the content you want and learn to manage the account that you use in new media platforms
- Beware of fake information
- Beware of online abuse
- Get an education on the safe use of online materials
- Do not engage in plagiarism

As new media has become popular in the phase of politics today, there are also many issues pertaining to political communication.

1. Political contents turn to be profit-oriented rather than public service. Media entertains people with more bad news highlighting political discord, malfeasance, and scandal.
2. The newer communication formats such as talk radio and the internet attract audiences from higher socio-economic and educational groups.
3. In some ways, political information is not available to millions of citizens who do not have the resources and skills to participate.
4. People may group into their interest groups and may lose some sights of greater societal good. Many good discussions may remain confined to only like-minded participants.

Remember…

When there are lots of issues regarding new media platforms, we need to think of ways to gain larger political advantages through new media platforms in positive ways.

ACTIVITY 2

1. Mention True or False

a) It is always good to use social media to complain or vent frustrations.
b) You would like to be untagged from photos or posts that could show you in a negative way.
c) In order to gain the knowledge of our candidates, it is wise for the media to stimulate political interest through various platforms.
d) Reading books from the library is simply an amazing example of digitalized media.
e) With the coming up of new media, it has tremendously increased political communication among all segments of people.

Summary

- New media are changing the nature of political communication because they are tools that can be used to inform and mobilize users in new ways. Users can connect directly to politicians and campaign managers and engage in political activities in new ways.The emergence of new media has changed how political communication takes place in our country, Bhutan. Political institutions such as politicians, political parties, and party institutions are all using social media platforms, like Facebook and Twitter, to communicate with voters. They can voice their opinions and keep them engaged with all like-minded individuals. The active participation of social media users has been an increasingly important element in political communication, especially during political elections.

Self-check for Learning

1. Why is it important to orient citizens in a new media environment of today?

1.6 Media Language and Basic Persuasion Techniques

- Define media language and its different types.
- Analyse any media text based on the use of media language.

Introduction

Media language is the way in which the meaning of a media text is conveyed to the audience. Each medium has its own language and grammar that works together to convey meaning in a unique way. Language refers to technical and symbolical aspects of codes and conventions that media professionals may select and use it to communicate ideas, information and knowledge.

One of the ways media language works is to convey meaning through signs and symbols suggested by the way a scene is set up and filmed. The different possible meanings in media texts depend on two things. The first is the way the signs and symbols in the text are read. The second is the cultural background of the person 'reading the text'.

For film and television, media language includes the way meaning comes across through the pictures and through the words or dialogue. Media language includes the way the camera sees the scene through the camera angle.

Media languages can also include the repeated use of particular words, phrases, and images, also known as a verbal or visual language. When we study media languages, three main questions should be considered: how are media languages understood by the media audience? What are some of the major codes and conventions used by people working in media and information today? Another important question is whether different people can derive dissimilar meanings from the same text or piece of information.

Concept of Media language

Media language means the way in which a text is constructed to create meaning for a reader or viewer of the text. All media texts are constructed; someone has made decisions about how they should be constructed so that the form matches the content and with a particular audience in mind.

First, the media provide an easily accessible source of language data for research and teaching purposes. Second, the media are important linguistic institutions.

There are different types of media languages and they are written, verbal, non-verbal, visual, and aural.

Written language – in print-based media, also in the text such as captions for photographs. The language chosen generates meaning. Captions allow the publication to present a story in a particular way.
Verbal Language – in media areas such as television, radio, and film. How the language is delivered and their contexts used are important factors in the way meaning is generated for the audience.
Non-verbal Language – this is in terms of body language: gesture and actions. The meaning received by the audience is seen through how the actor uses their body.
Visual Language- Television and film. What is on the screen has been chosen specifically to generate a series of effects and meanings. Specific camera angles and movement are chosen to tell the story and meaning of that scene.
Aural language – diegetic/non-diegetic sound. Sound can help create a scene and construct the environment, atmosphere, and mood. The aural language of a media text can also help us to define the genre of a piece.

Media CODES and CONVENTIONS
Messages are always constructed using a creative language with its own rule called codes. Each action, character trait, and line of dialogue has been carefully selected by the screenwriter and woven into the story.

Media codes and conventions are like the building blocks of all the media around us. Media codes generally have an agreed meaning, or connotation, to their audience. There are three types of media codes, symbolic codes, technical codes, and written codes. Conventions are expected ways in which codes are organized in a product.

MEDIA CODES AND CONVENTIONS			
SYMBOLIC CODES	TECHNICAL CODES	WRITTEN CODES	CONVENTIONS
SETTING	CAMERAWORK	PRINTED LANGUAGE	FORM CONVENTIONS
MISE EN SCENE	EDITING	SPOKEN LANGUAGE	STORY CONVENTIONS
ACTING	AUDIO		GENRE CONVENTIONS
COLOUR	LIGHTING		

SYMBOLIC CODES
Symbolic codes are social in nature. It means that these codes live outside the media product themselves, but would be understood in similar ways in the real life of the audience. For instance, if you saw somebody receive a red rose in a film, you would assume there is a romantic relationship between the two characters. Symbolic codes in media include setting, mise en scène, acting, and color.

The following illustrates beneath the surface of what we see (props, set, body language, makeup, hairstyle, costume, lighting, color, sound, etc.)

Setting

- Is the time and place of the narrative.
- Shapes the viewer's perspective of space and time.
- It provides some contextual information to help the audience understand some aspects of the narrative.

Body language

- Is a tool formed in fiction film and television series, which is used to convey meaning in a narrative context.
- Is used in accordance with the purpose of the presentation.

Colour

- Is used specifically to connect connotations to specific scenes, characters, or objects.
- Red, for instance, is typically seen as a color of passion, danger, romance, or violence.
- Green is connected with nature or sickness.
- Blue with calmness or depression.
- Yellow is warmth and invitation or a warning.

Lighting

- Constructed in the way that best creates meaning for a representation desired in a media product.
- Naturalistic lighting - Helps the audience to accept the film's fictional world is real.
- Expressive lighting - Can be used for emphasis to create a mood or atmosphere.

Sound

- May be used to provide mood and/ or continuity in visual sequences.
- It is also often used to give the audience an insight into a character's feelings.

TECHNICAL CODES

Technical codes are all the ways in which equipment is used to tell the story in a media text, for example, the camera works in a film. There are numerous camera techniques that can be used in making shots by incorporating a variety of camera moves in the shots. It can add to a person's visual interest in the media text. These techniques are expressive tools for filmmakers to develop a narrative. Media producer uses different camera technique to bring in extra visual effects and we as media literate should be able to identify the use of such codes and convention while analyzing a media text. The more we understand codes and conventions, the greater meaning we make out of the medium. For instance, our understanding of different camera shots and their connotations make sense when we look at films and photographs. Technical codes in media include camerawork, editing, audio, and lighting.

CAMERA MOVEMENTS

Zoom- is a camera technique of drawing the subject in the frame nearer or taking away to a distance. Zooming gives the impression of moving closer or further away from the subject. It can be used effectively to magnify a certain focal point in the frame. A quick zoom can help add a sense of drama and energy when used correctly.

Pan- the camera is moved horizontally from one side to another on a central axis. This is a rotating movement in which the camera position remains in place but the direction that it faces changes. Panning can be used to follow a moving character or to fit more into a frame.
For example: panning across a landscape so as to create a sense of the entire place.

Tilt

Vertical movement of the camera angle, i.e. pointing the camera up and down (as opposed to moving the whole camera up and down).A slow upwards tilt can be very effective in making a subject appear bigger or more significant while a downwards tilt has the opposite effect.

Dolly

The camera physically follows the subject at a more or less constant distance. A dolly gives the illusion that the viewer is walking towards the subject. It can be a great way of creating a sense of intimacy between them.

CAMERA SHOTS

Full Shot/Long Shot

- Shows the entire body of the subject from head to toe. This shot tends to focus more on the character's movement and gestures, rather than their state of mind.
  Long Shot
- This allows the audience to get an idea of where the piece takes place.
- It also focuses on characters actions and dialogue.

Extreme Long Shot

- This shot can be used to establish the setting and the location in which the piece will take place.
- It is usually used to show an outside location.
- It is most commonly used in a war film or disaster movie.

Source: Internet

Medium Shot

- Typically shows the subject from the knees up.
- It allows the viewer to see the background environment and the character's gestures, while still being close enough to capture their emotions.
- It is usually used when characters are taking part in dialogue or to show actions in detail.

Source: Internet

Close-up Shot

- The subject's head/face takes up the majority of the frame.
- Allows their reactions and emotions to dictate the scene.
- The subject becomes the prominent focus and helps the audience build a personal connection, without being distracted by background interference.

Source: Internet

Extreme Close-up Shot

- Close that only one specific detail, such as a person's eyes or mouth, can be seen.
- It allows the viewer to see details that may have otherwise gone unnoticed and can really accentuate the emotions that the subject is experiencing.

Source: Internet

Point of View Shot

- Also known as the POV shot. It depicts an angle that shows what a character is looking at.
- This type of shot allows the viewer to take on the perspective of the character and begin to understand their state of mind on a more personal level.

Source: Internet

ACTIVITY 1

1. Imagine you are a photographer covering a community festival. What type of camera shots would you choose to use in your coverage and why?

WRITTEN CODES

Written codes are the formal written language used in a media product. Just like technical and symbolic codes, written codes can be used to advance a narrative, communicate information about a character or issues and themes in the media product. Written codes include printed language which is the text you can see within the frame and how it is presented and also spoken language, which includes dialogue and song lyrics.

- Are formal written language used in a media product.
- Includes printed language which is the text you can see within the frame and how it is presented.

Print Text

Specific use of language style and textual layout

- Headlines(the title for the main article, this would be normally catchy)
- Captions(description of a main image)
- Speech bubbles : (are a graphic convention used most commonly in comic books, comics, and cartoons to allow words to be understood as representing the speech or thoughts of a given character in the comic)

CONVENTIONS

Conventions are accepted ways of using media codes. Conventions are closely connected to the audience expectations of a media product. The different types of conventions include form conventions, story conventions, and genre conventions.

Form conventions

- Certain ways of arranging media codes
- For instance, an audience expects to have a title of the film at the beginning, and then credits at the end.
- For newspapers headlines at the top, followed by most important news on the front page and sports on the back page.
- Video games usually start with a tutorial to explain the mechanics of how the game works.

Story Conventions

- Story conventions are common narrative structures and understandings that are common in storytelling media products. Examples of story conventions include: narrative structures, causes and effects, character construction, point of view.

Genre Conventions

- Genre conventions point to the common use of tropes, characters, settings, or themes in a particular type of medium. Genre conventions are closely linked with audience expectations. Genre conventions can be formal and thematic.

ACTIVITY 2

1. Differentiate codes and conventions.

Basic persuasion techniques

Meaning of persuasion

It is the presentation of reasons and ideas in a way that will influence the audience. To convince an audience of an idea or point of view, you, the writer, must first understand how persuasion in writing works. Persuasive writing can be broken into three basic divisions: ethos, logos, and pathos.

1. Ethos is an appeal to ethics, and it is a means of convincing someone of the character or credibility of the persuader.
   Example: Many of you know me. I am your neighbor and a long-standing resident of this community. You know me and know how much I care about our community's development.

2. Pathos is an appeal to emotion and is a way of convincing an audience of an argument by creating an emotional response.
   Example: How many homeless people have you passed on the street this week? Can you imagine what it must feel like to sleep in an alley? To go to bed hungry and cold every night? We need to stop ignoring this issue and start helping because these people are the victims-not the enemy.

3. Logos is an appeal to logic, and is a way of persuading an audience by reason.
   Example: If you know jumping off of a cliff would most likely kill you, you probably wouldn't make the jump. What makes drunk driving any different?

Persuasion techniques

- We use persuasive language to convince others to agree with our facts, share our values, accept our argument and conclusions and adopt our way of thinking.

Reasons for using persuasion techniques

- Help sell products or services
- Convince people to accept a view or an idea

Example: Politicians often use persuasion techniques to get their audience to agree with their views on a particular topic.

Some Examples

1. **Association -** Link a product, service, or idea with something already liked or desired by the target audience, such as fun, pleasure, beauty, security, intimacy, success, wealth, etc. Viewers think if they buy the product, they'll get the feelings associated with it.

Source: Internet

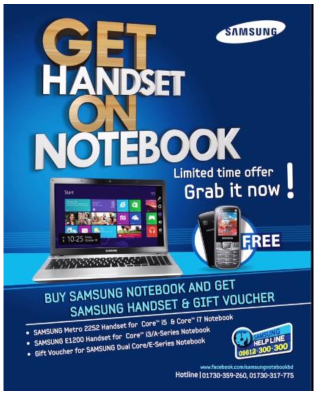
2. **Bandwagon -** If everyone is buying it, it must be good. Viewers buy because they want to fit in. Stresses the popularity of the product.

Source: Internet

3. **Beautiful people-** Beautiful people use good-looking models (who may also be celebrities) to attract attention.

Source: Internet

4. **Bribery-** Persuade us to buy a product by promising to give us something else, like a discount, a rebate (refund), a coupon, or a "free gift." Sales, special offers, and contests are all forms of bribery.



Source: Internet

5. Security (fear) - Draws on the viewer's fears by telling them their jobs or lives are in danger. It makes viewers feel unsafe. Viewers believe the product will protect them.

Source: Internet

6. **Humor-** When we laugh, we feel good. Advertisers make us laugh and then show us their product or logo because they're trying to connect that good feeling to their product.

Source: Internet

ACTIVITY 2

1. Why do we use ethos, pathos, and logos?

Summary

- Media language is a term used to define the codes and conventions used by institutions across a variety of media products. These communicate certain themes and ideas to the audience, often left for open interpretation. It is a specific element of a media product that communicates meanings to the audience.
- Every medium has its own 'language' – or combination of languages – that it uses to communicate leaning. Television, for example, uses verbal and written languages as well as the languages of moving images and sound. We call these 'language' because they use familiar codes and conventions that are generally understood. Any given media text is a series of codes and signs which communicate meaning. A sign, according to media language theory, is made up of two parts: a **signifier** that is something in a media text

which carries meaning and the **signified** that is, the meaning carried by that something. Therefore, we must identify the signifiers to analyze or argue what they signify. We should have knowledge and understanding of how the media, through their forms, codes, and conventions, communicate meanings.

Self-check for Learning

1. Complete a detailed media language analysis of one of your media products. Carefully conduct a textual analysis based on all those media languages used. Reflect as to how these languages have added meaning to the text.

2. HISTORY

2.1 Zorig Chusum: The Thirteen Arts and Crafts of Bhutan

- List down the Thirteen Arts and Crafts of Bhutan.
- Explain the importance of Thirteen Arts and Crafts of Bhutan.
- Suggest various measures to preserve and promote the Thirteen Arts and Crafts in Bhutan.

Introduction

Let us look at the concept of *Zorig Chusum, Zo is* ability to make, *Rig* signifies a science/craft and *Chusum* is thirteen. These are the traditional skills or crafts that the Bhutanese have mastered for centuries. *Zorig Chusum* in Bhutan was categorized, named and grouped during the reign of 4th *Druk Desi* Gyalse Tenzin Rabgay (1680-1694). For an economy to develop, hand-made products and cultural factors are seen as an asset today.

1. *Shing Zo* (Wood Work)

2. *Do Zo* (Stone Work)

3. *Par Zo* (Carving)

4. *Lha Zo* (Painting)

5. *Jim Zo* (Sculpture)

The 13 Arts & Crafts of Bhutan

6. *Lug Zo* (Bronze Casting)

7. *Shag Zo* (Wood Turning)

8. *Gar Zo* (Blacksmithy)

9. *Troe Zo* (Gold/Silversmithy)

10.Tsha Zo (Cane/ Bamboo Crafts)

11.*De Zo* (Paper Making)

12.Tshem Zo (Tailoring/ Embroidery

13.Thag Zo (Weaving)

Figure 1: Thirteen Traditional Arts and Craft of Bhutan

1. *Shing Zo*: Wood Work

The master carpenter is known as *Zowo/ Zo-chen*. Carpentry and craftsmanship play a major part in the construction of majestic fortresses or *dzongs*, temples, houses, palaces and bridges.

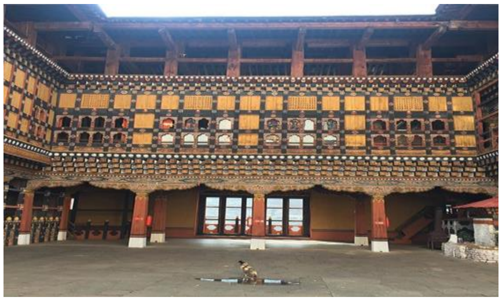


Figure 1: Wood work

2. *Do Zo:* Stone Work/Masonry

Figure 2: Paro Ta Dzong

The senior *Do zope (*master-mason) supervises the construction of stone structures. Masonry skills are reflected in religious structures and buildings. Rinchengang village in Wangduephodrang Dzongkhag is known for finest stone work. *Chorten Kora* in Trashiyangtse, Chendebji *Chorten* in Trongsa and Ta dzongs at Paro are the finest examples of the stone work.

3. *Par zo*: Carving

The carver engraves from wood, slate and stone. The slate artisan is known as *Do nag lopen*. Wood carving is very famous in Bhutan due to its availability in abundance. Mantras, deities and cultural motifs are carved on slates. The work of *Par Zo* can be found in Wangduephodrang and Pemagatshel.

Figure 3: Work of Par Zo

ACTIVITY 1

1. How has modernization affected architecture in Bhutan?
2. Write the merits and demerits of the modern machine replacing the primitive stone grinding mills.

4. *Lha Zo*: Painting

Figure 4: Art of Bhutanese Painting

Bhutanese paintings are the portrayal of human beings and their interaction with nature and their beliefs. Paintings often are the visual reflection depicting spirituality, the significance of Buddhism and all things that are sacred to Bhutanese identity. Master painters are known as *Lharips*. Paintings and their varied colors and hues symbolize the Bhutanese art and craft. Good example of Lhazo are *thongdrol*s or *thangkas* (huge scrolls depicting religious figures). The mere sight of these enormous scrolls is believed to cleanse the viewer's sins and bring him closer to attaining Nirvana. Thus, it brings merit not only to the believers but also, for the painters as well. The materials used in Bhutanese paint are extracted from natural pigment in soils.

5. *Jim Zo*: Clay Sculpture

Figure 5: Work of Jim Zo in Bhutan

Clay sculpture is more ancient than sculpture of metals like bronze. The making of religious items is done by men while pottery is done by women. Clay sculptures are typically found in temples, monasteries and dzongs, while earthenware pottery is still wildly used in everyday life. Today, the Folk Heritage Museum in Thimphu is trying to revive this tradition. Jim Zo or the art of clay sculpture are replaced by many other metals today. Pottery is replaced by aluminium pots. Only few houses are seen practicing and using the mud/clay pots these day.

6. *Gar Zo*: Blacksmithy

Figure 6: Work of Gar Zo in Bhutan

Tibetan saint known as Dupthob Thangtong Gyalpo was skilled in casting iron chains. The art of blacksmithy was introduced in Bhutan by Drupthop Thangtong Gyalpo. He built eight suspension bridges in Bhutan and the best example of his bridge can be found at Tachog Lhakhang at Paro. The remains of another bridge is displayed at the National Museum in Paro.

7. *Lug Zo*: Bronze Casting

Figure 7: Work of Lug Zo

The Newars from Nepal were first invited by Zhabdrung to cast bronze statues and religious items during the 17th century. Casting is skill based and requires masterfulness in two techniques that are practiced: wax and sand casting. Gyalsey Tenzin Rabgye mastered wax casting and crafted 1,000 Buddha statues including a big Buddha at the Punakha Dzong.

8. *Shag Zo*: Wood Turning

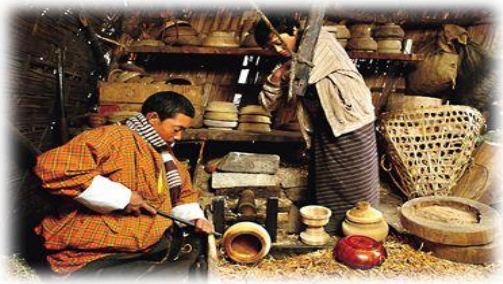


Figure 8: Wood Turning work

The master craftsmen of this vibrant art are known as Shag Zopa. Bowls were widely used by the Bhutanese until the advent of Steel and Brass. The people of Kengkhar in Mongar and Trashiyangtse are well known for this art. Wooden cups and bowls, *dapas* and *phobs* are also made of special wooden knots known as *Zaa* and are highly valued.

9. *Troe Zo*: Gold & Silversmithy

Figure 9: Product of Troe ko

Troe Zo is the vibrant craft of traditional ornament making. The master craftsman of an ornmanent making is known as *Troe ko Lopon.* Examples are ornaments and implements including necklaces, bangles, earrings, rings, brooches, amulets to contain ritual objects, traditional containers to carry the much-chewed beetle nut, ritual objects and many more.

10. *Tsha Zo*: Cane & Bamboo Crafts

Weaving cane and bamboo product are known as *Tshar Zo*. The best example of Tsa Zo are baskets, mats, containers known as *Palangs and bangchung*. The people of Kangpara in Trashigang and Bjoka in Zhemgang are the pioneers and masters of this craft. It is a source of income for the families living in these regions.

Figure 10: Tsa Zo products

11. *De Zo*: Paper Making

In the past this tradition was actually taken by the lay people for monastic use. Bhutan has many sacred scripts written on this paper since it is termite and insect repellent. This type of art is taken up by both men and women. It is popular in Trashiyangtse. Today, the paper is used for a wide range of purposes.

Figure 11: Art of paper making

12. *Tshem Zo*:Tailoring & Embroidery

Figure 12: Tshem Zo

The art of *Tshem Zo* is classified into three categories:

1. *Tshem drup* (the art of appliqué and embroidery)
2. *Lham drup* (the art appliqué and Tsho lham) and
3. Tailoring.

Traditional boots are worn by officials during special functions and gatherings. It denotes their rank based on color. Special craftsmen in the villages also make simple boots from uncured leather. However, this is a vanishing practice but with the government's support it has seen a recent revival in Bhutan's urban centers. These craftsmen are skilled at sewing the traditional Bhutanese garments of Gho and Kira.

13. *Thag Zo*: Weaving

The textile industry is an integral part of Bhutanese life and culture. Khoma in Lhuentse is famous for *kishuthara*. Radhi and Bidung are known for *bura* textile. Athang village in Wangdue Phodrang is known for textiles such as *Adang Mathra*, *Adang Rachu* and *Adang Khamar*. *Bumthaps* in central Bhutan are known for *Bumthap Mathra* and *Yathra*, both of

these textiles are woven out of Yak hair and sheep wool. Nabji and Korphu in Trongsa are known for textiles woven out of nettle fibers. Weaving is also a vocation amongst the people of Merak and Sakteng. Each one of the Bhutanese patterns has a significance, for instance, some represent tree of life, birds' eye, flies' wings, wind horse, coin, vase/bumpa, etc…

Figure 13: Work of Thagzo in Bhutan

ACTIVITY 2

1. Write the uses of *Desho* paper in the modern times.
2. Identify the limitations of Thagzo in the current situation with the import of low-priced modern clothes and suggest measures to keep a continuity of Thag Zo in Bhutan.
3. Provide an example each for *Tshem drup Lham* and *Lham drup.*

Summary

- *Zorig Chusum* in Bhutan was categorized and named during the reign of 4th *Druk Desi* Gyalse Tenzin Rabgye.
- Zorig Chusum are: *Shing Zo*, *Do Zo*, *Par Zo*, *Lha Zo*, *Jim Zo*, *Gar Zo*, *Lug Zo*, *Sha Zo*, *Troe Zo*, *Tsha Zo*, *Tshem Zo*, *De Zo* and *Thag Zo.*
- The master carpenter is known as the *Zowochen.*
- The master painter is known as the *Lharip.*
- The master craftsman is known as *Shag Zopa.*
- The art of blacksmithy was introduced in Bhutan by Drupthop Thangtong Gyalpo.
- The art of Tshem Zo is classified into three: Tshemdrup, *Lhamdrup and* Tailoiring .
- Carving are of three types; Wood carving, Slate carving and Stone carving.

Self-check for Learning

1. What do you think are the significances of *Zorig Chusum?*
2. What could be the probable reasons for taking least interest in traditional arts and crafts by the Bhutanese as a full-time employment?
3. As a responsible citizen of Bhutan, how can you contribute towards preserving and promoting the Zorig *Chusum?*
4. Against each traditional craft given in column A, write the names of the places in Column B, where it is mostly practised in Bhutan.

Column A	Column B
Tsha Zo	
Thag Zo	
Sha Zo	
De Zo	
Par Zo	

2.2 Bhutanese Literature

Learning Objectives

- Explain the Eleven Bhutanese Literature.
- Identify the examples of Bhutanese Literature.

Concept of Literature

Literature denotes all material, written or oral, and on any of the countless subjects. It is also regarded as writing that has been composed, which expresses ideas and values. In Bhutanese context literature also refers to general collection of texts like *Rigney* and *Zhung*, those texts that gives knowledge and have positive values.

Classification of Bhutanese Literature

ཆོས་འབྱུང་། Chhoejung	རྣམ་ཐར། Namthar	རྒྱལ་རབས། Gyal rab
ལོ་རྒྱུས། Logyu	གཏེར་མ། Ter ma	སྒྲུང་། Srung
ཚིག་མཛོད།། Tsig dzod	དཀར་ཆག Karchag	སྙན་ངག། Nyan ngag
ཉམས་འགྱུར། Nyam gyur	གླུ། Glu	

All of these literature deal mostly with religion and religious works. It also conveys information on the social set up, the form of government and the economic life of the Bhutanese in general.

Chhoejung

Choejung refers to dharma histories and religious literature that include *Kangyur* and *Tenjyur*. It is also referred to as the origin of dharma with reference to Buddhism that includes information on religious aspects. For example, *Lhoyi Chhoejung* is a text authored by the 69th *Je Khenpo*, Geshe Geduen Rinchen. This text deals with the religious movements in Bhutan and various schools of Buddhism that took root in Bhutan.

Namthar

Namthar is a biography of religious personalities. It not only mentions religious issues but also talks about socio-political issues. For instance, the Namthar of *Gyab Sindhu* or *Sindha raja* is the best example of a *namthar*. This work is a literary classic and has an important historical value for Bhutan.

Figure 1. Phajo Drugom Zhigpo

Another example of namthar is the *namthar* of Phajo Drugom Zhigpo. It is again one of great texts of historical importance. The visit of the important Buddhist saint Phajo Drugom Zhigpo who along with a line of lineage holders played a decisive role in shaping the religious movement in Bhutan. This biography is important as it reflects the social, religious and political aspects of Bhutanese life in the early years of the 13th century.

Gyalrab

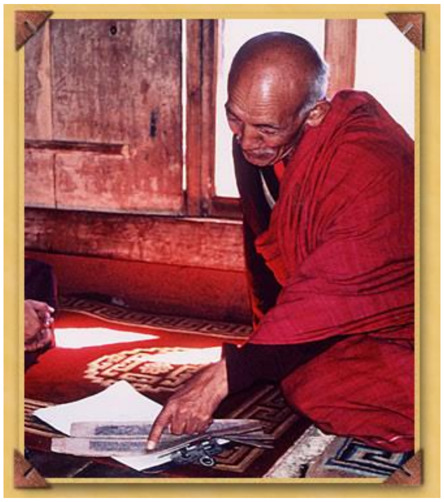


Figure 2. Lopen Pemala

Gyalrab is similar to Dungrab which literally means account or story of kings. It also refers to the historical chronicles or genealogies of dynasties or other important families.The work of Gelong Ngawang, a 17th century monk historian of Trashigang Dzong, is a good example.The work is titled "Gyal rigs jung khung sal wai dron me" which is translated as "The Lamp which Illuminates the origins of Royal Families".

"Druk gi gyal rab jung khung by Lopen Pemala is another example of gyalrab. The book comprises historical account of the ethnic composition of the people of Bhutan, spread and growth of Buddhism, the coming of Zhabdrung to Bhutan, the establishment of the dual system, emergence of the Wangchuck dynasty and the evolution of monarchy in Bhutan. Another considerable example of gyalrab is *Druk Karpo* by Lopen Nado. The book comprises cultural, religious and political developments in the country since the 7th century.

Logyu

Logyu is a Records or history of chronicles. It does not give a year by year account of subject, but rather presents a narrative of events that are historical. For example, the ballad of Pemi Tshewang Tashi and Gelong Sumdhar Tashi are Logyus.

Figure 3. Gelong Sumdar Tashi and Pemi Tshewang Tashi

Terma

Terma are the hidden text that are rediscovered at a later date. Tertoen Pema Lingpa, is one of the five major Bhutanese tertoens who discovered texts in Bhutan and also discovered important texts in Tibet.

Srung

Epics like that of Gesar of Ling is called Srung. Ling Gesar Gyalpo is the hero of one of the major epic cycles of central and east Asia, known throughout Tibet and Bhutan. Gesar is a Buddhist hero and considered as a representative of Guru Padmasmabhava. Such epics are recounted by people known as Srung Khen. The epic has been published in India, Bhutan and China. The Bhutanese version of this epic has thirty-one volumes.

Figure 4. Ling Gesar

Glu

Glu is a folk song. A large number of glu texts can be found in the term literature including Padma Kathang and Mani Kabum. The songs also form part of Bhutanese literature because songs;

1. describe nature, religion, political issues, social values.
2. uses figures of speech and beautiful expression.
3. throw light on many events such as the advent of Buddhism to Bhutan. Gyal poi Toed glu (Royal song) and Bang gi glu (popular song) are the classifications of glu.

Figure 5. Jetsun Milarepa

Nyam gyur

Nyam gyur is religious poetry. It is a part of glu which denotes a type of buddhist song which contain subjects dealing with spiritual realizations or religious instructions. Jetsun Milarepa was a great composer of gyur. These songs helped to popularize Buddhism. Another great composer of gyur was Lam Drukpa Kuenley.

Nyan ngag

It is an ornate poetry literally meaning speech agreeable to the ear. Nyan ngag has its origin in India. It was composed by people with literary background including saints who had monastic education.

Karchag

Karchag is a catalogue. It is a text that describes the construction of Buddhist structures like monasteries, temples, chhoetens and dzongs. It also contains a list of items like relics that chhoetens may contain. It may also contain the description of the sacred place along with a guide

(lamyig) to it. The names of devotees who extended help in the construction of these structures can also be found in this catalogue called Karchag.

Tshig dzoed

Tshig dzoed is a dictionary. Best examples of Tsig dzoed are Dzongkha gi Tshig dzoed published by Dzongkhag Development Commission in 1993 and Dzongkha gi Tshig dzoed chenmo published by KMT publishing house in 2002.

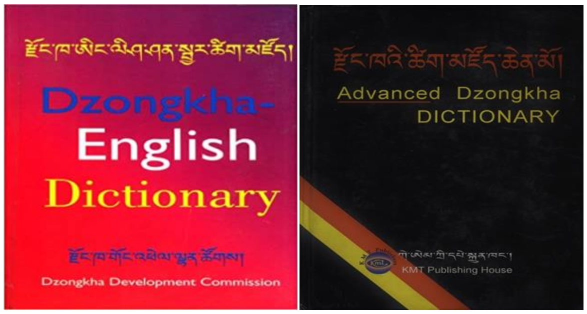


Figure 6. Dictionary

ACTIVITY 1

1. Identify the differences between Namthar, Choejung and Gyalrab.
2. Choose any of the Bhutanese Literature and identify examples available in your locality.

Summary

- Choejung refers to dharma histories and religious literature that include *Kangyur* and *Tenjyur*.
- Namthar is a biography of religious personalities.
- Gesar is a Buddhist hero and considered as a representative of Guru Padmasmabhava.
- Logyu is a Records or history of chronicles.

Self-check for Learning

1. Explore the classification and significance of Bhutanese literature.

2.3 Secular Songs and Dances in Bhutan

- Explain the significance of secular dances and songs in Bhutan.
- Discuss the roles of the traditional songs in safe guarding the sovereignty of the nation.
- Categorise the songs based on its theme and significance.

Introduction

Did You Know?

1. The secular songs are an integral part of Bhutanese social life and an essential element of entertainment and celebration.
2. The secular songs have deeper spiritual significance.

Classification of Songs

Songs can also be classified into religious and secular songs. *Choe lu* and *Gurma* are religious songs while *Alo, Khorey* and *Ausa* are secular. Secular songs and dances can be classified into two main groups: the traditional and the modern. Further, it can be classified into the songs with dances and the songs without dances as shown in the figure below.

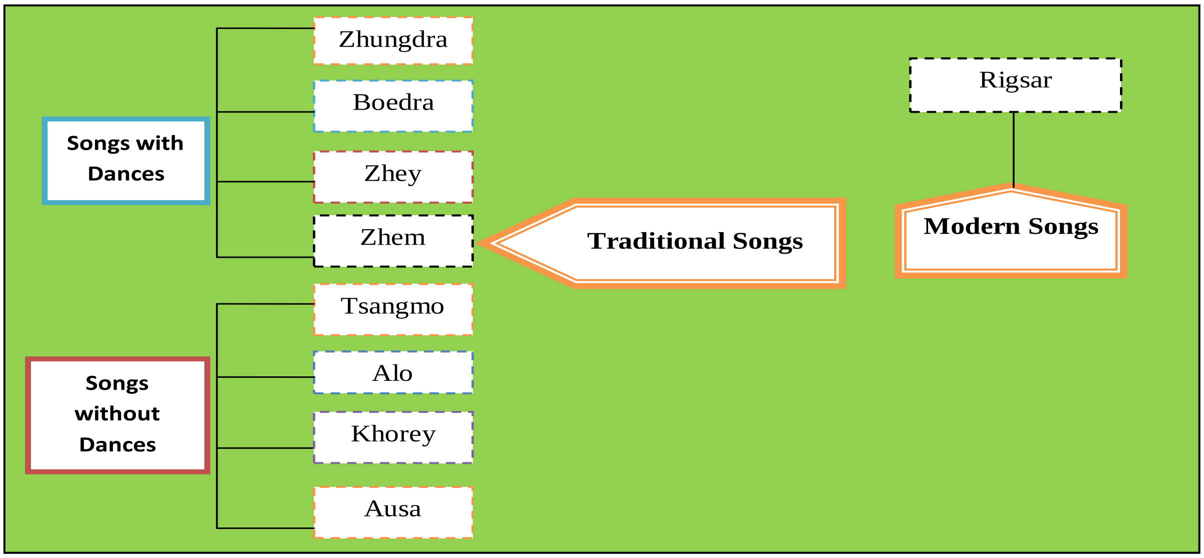


Figure 1: Types of secular songs

ACTIVITY 1

1. List down the types of traditional songs that you are aware of.
2. What do you think is the spiritual significance of the secular songs?

1. Songs with Dances

Zhey is regional in character and is identified with Zhabdrung in the seventeenth century. The most notable *Zhey*s in Bhutan are the *Wang zhey*, *Wochub-e-zhey*, and the *Nubi-e-zhey*.
Wang zhey is originally the dance from the valleys of Thimphu, *Wochub-e-zhey* from the village Wochu in Paro and *Nubi-e-zhey* from Trongsa. The *Zhey* is mainly performed by men and *Zhem* by women.

Figure 2: Wang Zhey

Figure 3:Wochub-e-Zhey

Figure 4:Nubi-e-Zhey

Zhungdra literally means the tune, melody or piece of music of the centre, often referred to the dzongs that were centres of administration and governance. Most of the themes of Zhungdra focuses on the establishment of the Buddhist doctrine in Bhutan.
Boedra are the songs of the Boe Garp, the attendants, and encompasses a variety of themes.

Figure 5:Zhungdra Dance

Figure 6:Boedra Dance

ACTIVITY 2

1. Explore the differences between *Zhungdra* and *Boedra* based on the following features;
   a. Concept b. Tune c. Theme

2. **Songs without Dances**

Alo is sentimental and is often sung to a departing friend or family members. It is sung mainly in the *Dzongkhags* of Lhuentse, Trashigang, Trongsa and Pemagatshel.

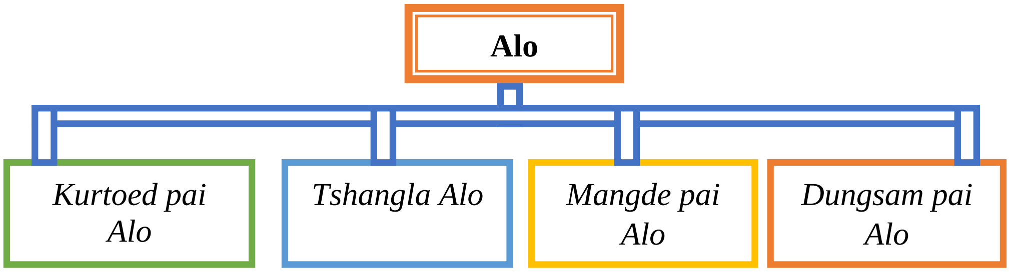


Figure 7: Types of Alo

Khorey can be danced as well as sung. It is also a feature of the people of Pemagatshel and Merak and Sakteng in Trashigang. Unlike *Alo*, *Khorey* are joyous songs.
Ausa are songs that are unique to the valleys of Haa in western Bhutan.

The Nine categories of Songs

The songs sung or sung and danced in Bhutan can be classified into nine categories. The examples given in the songs with dance and songs without dance will also fall in the nine categories as given below in figure 8.

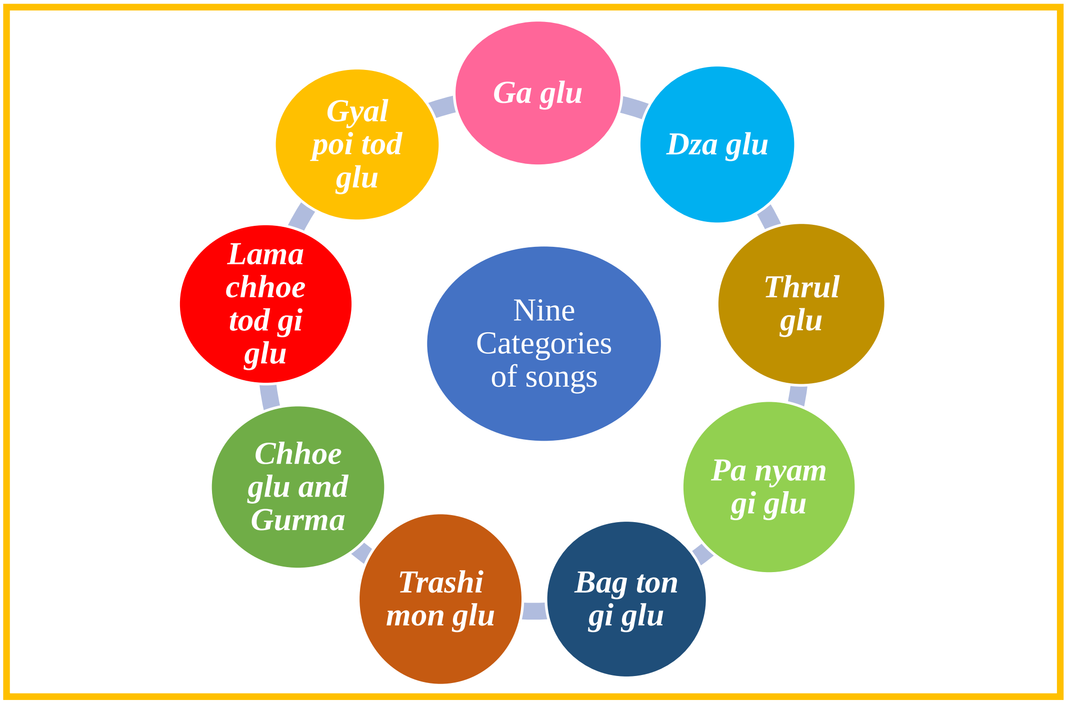


Figure 8 :Categories of songs

1. Chhoe glu and Gurma

Gurma are those taken from religious texts such as the songs of the great saint Milarepa. Similarly, *chhoe glu* also has some religious themes, or it honours great lamas or religious figures.

Figure 9: Examples of Gurma

2. Lama chhoe tod gi glu

These songs are composed in praise of lamas, monasteries and sacred places. Such songs accompany consecration of monasteries and temples and are sung during religious congregation.

3. Gyal poi tod glu

These songs are sung in honour of kings and of great personalities. The themes often revolve round kings and their dynasties, their contribution to the country and the development activities initiated and the welfare enjoyed by society.

4. Ga glu

These types of songs are sung and danced to celebrate happiness and to mark joyous and festive occasions in the life of an individual, a family, a society or a country.

Figure 10: Artist Performing Ga glu

5. Dza glu

It is a form of modern songs. The themes of most of the *rigsar* songs are love and befriending girls. The nature in all its grandeur is compared to the girl's beauty. These songs are sung mostly in public or on formal occasions for general amusement.

6. Thrul glu

It is a song of emotion. These type of songs are not sung during formal occasions but sung to an individual. These songs are not so popular as the love songs.

7. Pa nyam gi glu

Heroic songs are popular songs that recount the life and brave deeds of the culture's heroes and heroines. In olden days, family elders sang these songs to their children to encourage bravery and fearlessness and to revive the glorious past. The majority of such songs were taken from the Gesar epic, and others sung in praise of kings.

8. Bag ton gi glu

This type of song is sung and danced during the marriage ceremony. The day is of great significance for the bride and the bridegroom and for the family members. It is a day of great enjoyment and marriage songs form an indispensable part of the occasion.

9. Trashi mon glu

These songs of good wishes are sung on every festive occasion and during all social or cultural events of importance. Trashi Lebay song usually ends the occasion where everyone joins in the dance. The lyrics stress on the peace and harmony, prosperity and affluence, longevity and a promising future for the entire gathering.

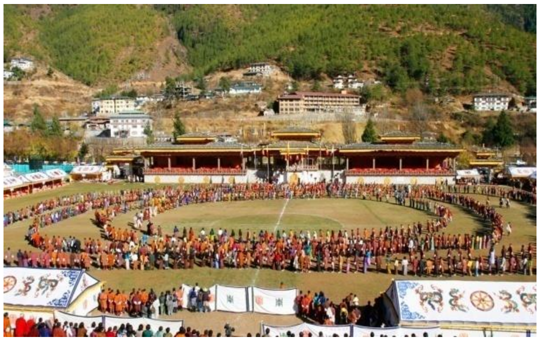


Figure 11: Mass participating in Tashi Lebay

ACTIVITY 3

1. Choose a song that is danced or just sung and comment on its theme and the occasion for performing it.
2. Choose any song specific to a locality and comment on its type, theme and significance.

Summary

- Secular songs and dances can be classified into two main groups: the traditional and the modern.
- The secular songs have deeper spiritual significance like ensuring accumulation of merit and as a vehicle of deliverance from sufferings and attainment of ultimate happiness.
- Most of the themes of Zhungdra focus on the establishment of the doctrine.
- The most notable *Zhey*s in Bhutan are the *Wang zhey*, *Wochub-e-zhey*, and the *Nubi-e-zhey*
- The dress worn by the *Zhey* dancers differs from region to region and *zhey* to *zhey*.
- Generally, songs are classified into nine categories based on its themes.

Self-check for Learning

1. "The Royal Academy for Performing Arts (RAPA) has been playing a vital role in preserving the Bhutanese traditonal songs and dances since its establishment."
   Do you think it is a sole responsibility of the Academy to preserve our cultural heritage? Explain your views.
2. "Preservation and promotion of culture and tradition is one of the pillars of Gross National Happiness." How does the promotion of secular songs and dances help in the attainment of this pillar of GNH?
3. Write the themes of the following categories of songs
   a. *Chhoe glu*
   b. *Lama chhoe tod gi glu*
   c. *Gyal poi tod glu*
   d. *Ga glu*
   e. *Dza glu*
   f. *Thrul glu*
   g. *Pa nyam gi glu*
   h. *Bag ton gi glu*
   i. *Trashi mon glu*

2.4 The Lhengye Zhungtshog in a Democratic Constitutional Monarchy

- Explain the roles of Lhengye Zhungtshog in a Democratic Constitutional Monarchy.
- Justify Prime Minister as an important figure in the executive branch of the government.

Introduction

With the adoption of the Constitution on 18th July 2008, Bhutan became a Democratic Constitutional Monarchy. In a Democratic Constitutional Monarchy, we have the Druk Gyalpo as the Head of the State and the Prime Minister as the Head of the Government. The Prime Minister is assisted by a group of Ministers known as the "*Lhengye Zhungtshog*." They are the members of the Ruling Party. *Lhengye Zhungtshog* is also called the Cabinet of Ministers.
In this lesson, we will discuss the *Lhengye Zhungtshog* in a Democratic Constitutional Monarchy.

Prime Minister

To be eligible for the post of the Prime Minister in a Democratic Constitutional Monarchy, a person should fulfill the following criteria.

a. He/she should be from the ruling party.
b. He/she should be an elected member of the National Assembly.
c. He/she should be a natural-born citizen of Bhutan.

The Druk Gyalpo confers *Dakyen* to the Prime Minister who is nominated from the ruling party by the members of his/her political party. The term of the Prime Minister is for five years. As per the Constitution of Bhutan (Article 17, Section 2), the same person cannot hold the office as Prime Minister for more than two terms. If he/she wins the election for a second time he or she can be the Prime Minister for the second term. However, he/she cannot become the Prime Minister for the third term.

Roles of the Prime Minister

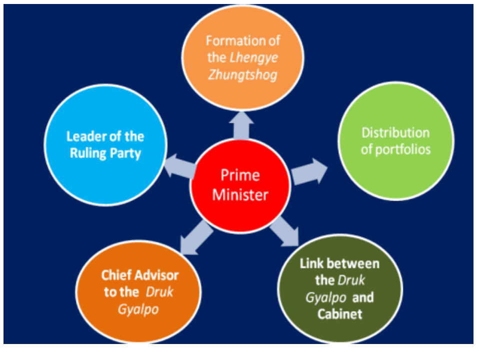


Figure 8 Functions of the Prime Minister

The Prime Minister as the Head of the Government plays a vital role in the executive branch of the government. Some important roles of the Prime Minister are;

a. Formation of the Lhengye Zhungtshog

For the smooth functioning of the government, the Prime Minister shall form the *Lhengye Zhungtshog* by selecting the most capable candidates from the ruling party and forward the lists to the Druk Gyalpo for the appointment. The Prime Minister summons and presides over the Cabinet meeting. He or she also coordinates and examines the works of the various Ministries. Therefore, the Prime Minister is also the *leader of the Cabinet.*

b. Distribution of Portfolios

The Prime Minister decides and allots the portfolio of the ministers. He or she can change the portfolio of the ministers or remove them if their work is not up to the set expectations.

c. Link between the *Druk Gyalpo* and the Cabinet

The Prime Minister keeps the *Druk Gyalpo* informed about the decisions of the Cabinet. He or she also conveys all suggestions and advices given by the *Druk Gyalpo* to the Cabinet. No minister can have direct discussions with the Druk Gyalpo without prior permission from the Prime Minister.

d. Provide Information to the *Druk Gyalpo*

The Prime Minister provides information to the Druk Gyalpo regarding the works carried out by Ministries. He or she informs the Druk Gyalpo when the emergencies arise.

e. Leader of the Ruling Party

The Prime Minister as a leader of the ruling party shoulders the responsibility of leading his/her party, forming the government and upholding the principles enshrined in the Constitution for the wellbeing of the State and the people.

In a nutshell, the Prime Minister performs the following responsibilities:

- Responsible for the execution of the policies and programmes for the wellbeing of the Nation and the people.
- Shoulders the responsibility of ensuring that the Directive Principles of the State Policy is respected and followed during the formulation of the policies and programmes.
- Responsible for ensuring that peace and order are maintained in the country.

The Prime Minister shall keep the Druk Gyalpo informed from time to time about the affairs of the State, including international affairs, and shall submit such information and files as called for by the Druk Gyalpo (Article 20, Section 4)

Lhengye Zhungtshog in a Democratic Constitutional Monarchy

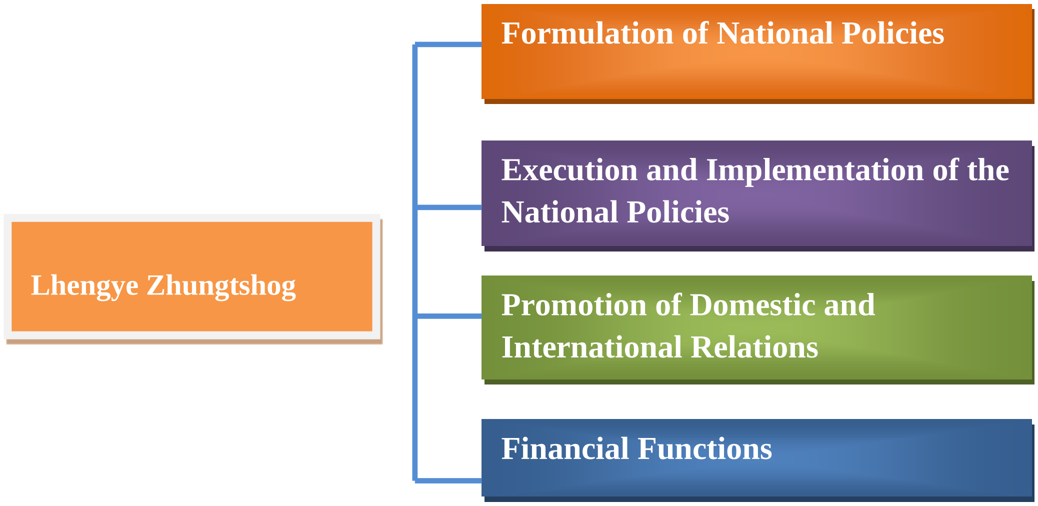


Figure 9. Functions of the Lhengye Zhungtshog

The *Lhengye Zhungtshog* or the Cabinet of Ministers is headed by the Prime Minister. It comprises ten ministers, each heading different ministry. They are also vested with the executive powers such as;

a. Formulation of National Policies

As per the Constitution, the ruling party is entrusted with the power to formulate national policies and programmes as per the Directive Principles of the State Policy enshrined in Article 9.

b. Execution and Implementation of the National Policies

The *Lhengye Zhungtshog* is responsible for ensuring the effective implementation of the plans and programmes for the wellbeing of the State and the people.

c. Promotion of Domestic and International Relations

The *Lhengye Zhungtshog* has the responsibility of strengthening the country' relations with other countries, promoting social and cultural cohesion, maintaining economic stability and sovereignty of the nation and people.

d. Financial Functions

The Cabinet of Ministers plans and looks for resources and allocates them to different sectors for the effective implementation of the plans and programmes of the government.

e. Promotion of an efficient civil administration

The *Lhengye Zhungtshog* is responsible for promoting an efficient civil administration based on the democratic values and principles enshrined in the Constitution.
The *Lhengye Zhungtshog* shall aid and advise the Druk Gyalpo in the exercise of his functions including international affairs as and when required.

As per the Article 20, Section 5 of the Constitution of Bhutan, the *Lhengye Zhungtshog* shall:

a. Assess the state of affairs from development in the State and society and from events at home and abroad;
b. Define the goals of the State action and determine the resources required to achieve them;
c. Plan and co-ordinate government policies and ensure their implementations; and
d. Represent the Kingdom of Bhutan at home and abroad.

ACTIVITY 1

1. Find out similarities and differences between the roles of Prime Minister and the *Lhengye Zhungtshog*.
2. "The Prime Minister is an important figure in the executive branch of Government in a Democratic Constitutional Monarchy." Justify the statement.
3. Fill in the table below: about the composition of the *Lhengye Zhungtshog*.

Sl.No.	Name of the Ministry	Incumbent Ministers

Summary

- Bhutan is a Democratic Constitutional Monarchy.
- In a Democratic Constitutional Monarchy, the Monarch is the Head of the State and the Prime Minister the Head of the Government.
- The *Lhengye Zhungtshog* headed by the Prime Minister is responsible for the formulation as well as the implementation of policies and programmes.

Self-check for Learning

1. Mention the roles of Lhengye Zhungtshog and explain briefly in your own words.
2. In your opinion, why should the Prime Minister be a natural-born citizen of Bhutan.

ENVIRONMENTAL SCIENCE

1. Land Conservation

- Explain the land conservation mechanisms practiced in Bhutan.
- Explain the impacts of poor waste management on land.
- Explore ideas on entrepreneurship from wastes.

Introduction

Land Conservation

Land is a vital part of the Earth to support diverse organisms. Humans need land for settlement, agriculture and industrial activities. There are numerous national and international conventions and declarations for the conservation of land. They underline the importance of land rights and land management to achieve sustainable development.

Land management is a process of managing the use and development of land resources. Land management process involve the conservation of land during the process of developmental activities such as urbanization and infrastructural development. These activities accelerate land cover change, resulting in unprecedented changes in ecosystems and environmental processes at local, regional and global scales.

Land conservation is a practical approach to protection of land and preventing land degradation due to anthropogenic activities or natural processes. An example is adopting land management practices like terracing to reduce soil erosion.

Some of the land conservation mechanisms are: legal instruments of land conservation; land conservation practices in agricultural practices and mining industries; and promoting traditional belief systems that benefit land conservation.

Land Management activities in Bhutan

In Bhutan, forest fires, excessive use of forest resources, overgrazing, unsustainable agricultural practices, poor irrigation system management, construction of infrastructure without proper environmental measures, mining, industrial development, and urbanization are the key causes of land degradation. Considering these factors that degrades the land, following land management activities are implemented in Bhutan.

Forest Fire Management activities:

Here, the assessment of the occurrence, trends and causes of forest fires, in-depth research on forest fire ecology in various forest ecosystems, development of forest fire management strategies for various fire-vulnerable forest ecosystems, and public education and awareness programs are carried out.

Sustainable Production & utilization of Resources

The development of technical capacity to effectively implement the planning guidelines for management of forest areas. Multi-disciplinary evaluation of the effectiveness of forest management units throughout the country in the context of environmental sustainability and socio-economic development are carried out.

Rehabilitation of Degraded and Barren

Assessment of the extent of degraded and barren forest lands, re-afforestation of the prioritized areas, and leasing of degraded or barren forest lands to private parties for plantation and

Participatory Forest Management

Under this activity, activities carried out include developing community skills for community and private forestry people; training of Dzongkhag and Gewog forestry staff for communications and extension approaches; and techniques for integration of sustainable use in various types of non-wood forest products in community forestry schemes.

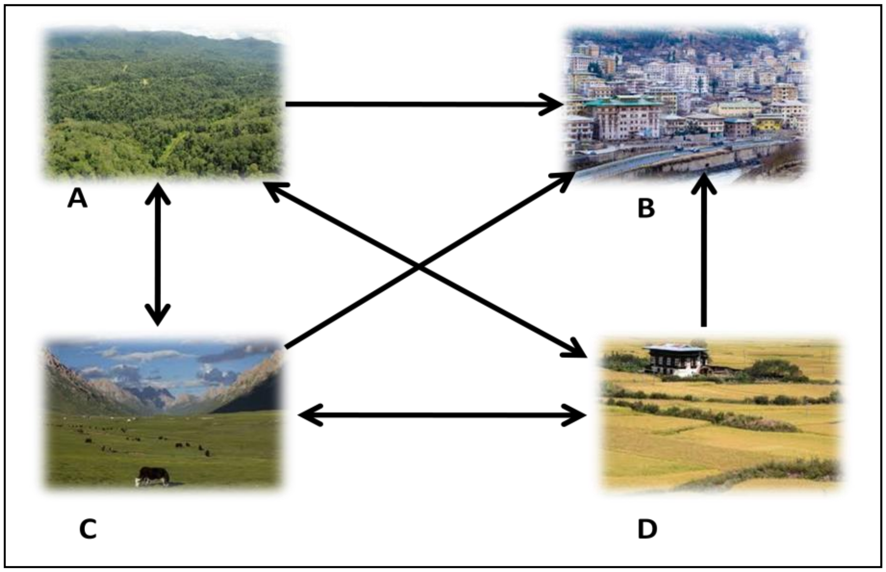
Livestock and Grazing Management

Here, studying the carrying capacity of livestock and development of a taxation scheme to discourage the rearing of livestock in excess of the carrying capacity, and lease of barren or degraded government lands to local communities for pasture development are carried out.

ACTIVITY 1

Investigating the impacts of land use change to land quality and other components of environment.

Instruction: The diagram below shows the possible land use change. Study the diagram and answer the following questions.



1. Complete the Table 1 and 2.

Table 1

Positive environmental impact	Negative environmental impact
E.g. Change C to A	E.g. Change A to B
1.	1.
2.	2.
3.	3.

Table 2

Land use change	Factors causing the change	Environmental impacts
A-B		
A-D		
A-C		
C-A		

2. Write some of your possible plans to reduce the impacts on land in place B, C and D.

Degradation of land due to waste

Waste is an unwanted or unusable material or by-products like rubbish, refuse, debris, litter and scrap. Generally, waste could be liquid or solid waste and both could be hazardous. If poorly managed, wastes can impact environment through contamination of soil, water and air. Waste that is not properly managed can also bring serious impacts on the health of living organisms. Wastes, especially excreta and other liquid and solid waste from households and the community, are a serious health hazard and lead to the spread of infectious diseases. Unattended waste lying around attracts flies, rats, and other organisms that may spread diseases. This unhygienic condition will lead to rise in the health and environmental hazards.

There are many factors that degrades the land such as pollution, deforestation, mining, extensive agriculture, grazing and natural disasters. Waste is one of the emerging factors that degrade the land. Huge amount of waste is generated by increasing population. Waste may be released in the form of solid, liquid or gas. This deteriorates the state of environment over the years, posing serious threat to public health and hygiene due to contamination of land, air, water and soil.

Wastes that is hazardous in nature poses substantial threats to land and people's health. It pollutes the land and other components of the environment and contributes to bioaccumulation. These wastes may cause long term health problems, and even death to human and animals. The common hazardous wastes polluting land include acids, disinfectants, glues, heavy metals, paint, pesticides, petroleum products, solvents, batteries and other electronic products.

The municipal solid wastes such as non-hazardous garbage, rubbish, and trash from homes, institutions, commercial establishments, and industrial facilities can also cause land degradation. Garbage contains mostly dry materials such as paper, glass, textiles, and plastic objects, and trash includes bulky waste materials and objects that are not collected routinely for disposal like discarded mattresses, appliances, pieces of furniture. These wastes occupy space on land and impact the growth of plants.

Bhutan has comprehensive waste minimization and management regulation in place. The regulation engages various agencies and monitoring authorities in enforcing the regulatory activities. The National Environment Commission (NEC) is the apex monitoring body under this regulation. The Royal Bhutan Police, Dzongda, Dungpa, Gup, Mangmi, Divisional Forest Office and Institutional Head, Department of Roads and sanitary committee assist in achieving the full compliance. The regulation imposes fines and administrative actions on individuals or organizations.

Entrepreneurship and Waste Management

The efficient and effective management of solid waste is essential in maintaining health and hygiene of people and the environment. Generally, inappropriate treatment of waste causes major environmental concerns, while recycling contributes significantly to environmental sustainability. For instance, many entrepreneurs around the world have built substantial businesses from the wastes, which aims to achieve "shared value" by making positive social and

environmental contributions to their societies. Some of these entrepreneurs have strikingly modern views of environmental challenges, scientific and engineering knowledge of waste materials, and their processing and utilization which benefited the management of waste across the globe.

The process of designing a new business offering a product, process or services is called entrepreneurship. Successful entrepreneurs must have or develop variety of skills like business know-how, innovation, creativity and good technology skills. Such entrepreneurs dedicate in making a profitable business of municipal solid waste, collecting difficult-to-recycle packaging and products to re-purpose the material into affordable innovative products. This provides essential services of maintaining the quality of life in urban areas and ensures better standards of health and sanitation.

In collection of waste for entrepreneurship, general process includes the collection, source separation of wastes, their proper treatment for better chance of recovering valuable materials from the waste stream, and ensuring the health and safety of workers.

ACTIVITY 2

1. If the waste management and disposal is poor, what are their impacts on the land?
2. What changes do you wish to make in the waste management and disposal at your home? Justify your opinion.

Summary

- Land management is a process of managing the use and development of land resources.
- There are many factors that degrade the land such as pollution, deforestation, mining, extensive agriculture, grazing and natural disasters.
- Waste management is challenged by the growing urbanization and industrialization trends.
- Waste entrepreneurship includes the collection and their proper treatment for better chance of recovering valuable materials from the waste stream and ensuring the health and safety of workers.

Self-check for Learning

1. List down some of the initiatives taken by government to manage the land.
2. How does the belief system of a community support the land conservation?
3. How do land pollution indirectly affect the health of people?

2. Energy Management and Conservation

- Explain Energy Management System.
- List down some of the ways to efficiently manage the energy.
- Understand the energy conservation initiatives in Bhutan.

Introduction

Energy

Energy is the ability to do work. Energy is required to perform every activity or work that we do in our everyday life. Energy is also required for vehicles to move, machines to run and bulbs to glow. Energy is very crucial for the existence of human beings. Different forms of energy are electrical energy, tidal energy, light energy, chemical energy, gravitational energy, nuclear energy and heat energy. These energies can transform one form of energy to another.

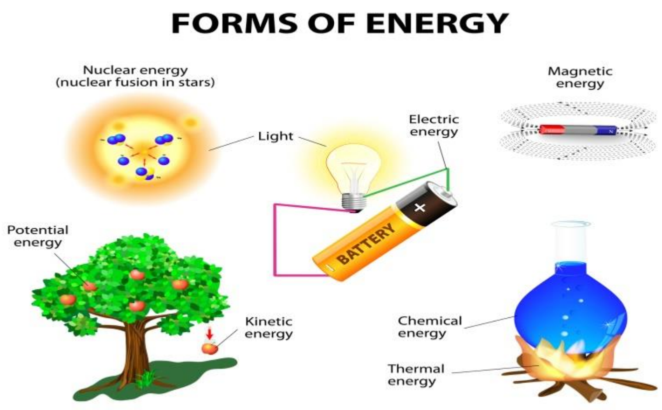


Figure 1. Forms of Energy.
Source: https://kidspressmagazine.com/science-for-kids/misc/misc/forms-energy.html

Energy Efficiency

Energy conservation is not about limiting the use of resources which will finally run out altogether. The ideal way of conservation is reducing demand on a limited supply and enabling that supply to begin to rebuild itself. Practices such as replacing the energy used with an alternative source and efficiently utilizing the energy are some examples of energy efficiency.

Energy efficiency means using energy in an effective way to provide services or reduce the wastage or minimize the overall consumption of energy. Energy efficiency uses advanced science and technology to provide services and products with less energy. For example, insulating a home allows a building to use less heating and cooling energy to achieve and maintain a comfortable temperature. Installing LED lighting, fluorescent lighting or natural skylight windows reduces the amount of energy required to attain the same level of illumination compared to using traditional incandescent light bulbs. Improvements in energy efficiency are generally achieved by adopting a more efficient technology or production process or by application of commonly accepted methods to reduce energy losses.

Table 1. Ways to improve energy efficiency

Home	Building Designs	Industry	Transportation
1. Insulating home effectively to eliminate air leaks. 2. Using water-saving shower head. 3. Using modern energy efficient appliances. 4. Hanging thick curtains on window. 5. Covering the floor with carpet. 6. Using compact fluorescent lighting.	1. In cold climate, tight building design with well-sealed door, energy efficient window, well insulated wall, dark roof minimize energy used in heating. 2. In cooler climates, designing northern hemisphere buildings with south facing windows and southern hemisphere buildings with north facing windows increases the amount of sun entering the building.	1. Advanced boilers and furnaces can operate at higher temperatures while burning less fuel. 2. Heat that is produced as a by-product in industrial process can be captured and used for other industrial purposes. 3. Use of variable speed drive allows the motor's output to match the required load.	1. Reducing vehicle weight can reduce fuel economy. 2. Improvements in pumps and compressor can be done by better maintenance practice and installing variable speed drive. 3. Using improved aerodynamics to minimize drag can increase vehicle fuel efficiency. 4. Use of electric vehicle and bicycle for short distance journey.

Purposes of Energy Conservation

There are many purposes to conserve energy. Some of the benefits are

Energy security

Energy security is to ensure a constant and stable supply of energy. In order to maintain the supply, it is necessary for countries to increase the domestic energy self-sufficiency ratio and to undertake diplomatic endeavours to secure stable energy suppliers. In order to increase the energy self-sufficiency ratio, it is necessary to develop and promote the use of domestic untapped energy such as wind and solar energy, and to enhance effective utilization of existing energies. Energy conservation contributes solution to the global issues such as energy security and possible future exhaustion of oil.

Measures of the Global Environment

Global warming has been one of the globally concerning issues. Concrete measures are required to regulate greenhouse gas emissions through combined efforts from governments and private sectors. Since energy conservation limits greenhouse gas emissions, CO_2 in particular, the measures for energy conservation functions as counter measure for greenhouse gas emission. In recent years, the issue of CO_2 level reduction in the atmosphere has been receiving a lot of global

attention. In many cases, energy conservation has been implemented as a measure for preventing global warming. The use of oil and natural gas contributes not only to global warming, but also to air pollution and environmental destruction due to earth excavation.

Income Saving

Income saving by reducing costs for energy utilities is a direct purpose and incentive of energy conservation. Through implementation of energy conservation strategies, we can reduce the expenses for wasteful energy consumption, and save income in proportion to the amount of the reduction in energy consumption.

Through energy conservation, payments for the utility of electricity and gas will decrease and these savings can be utilized for other expenditures at the household level. At the production levels, the decrease of energy consumption per unit of production (decrease in the cost of production) will enhance their competitiveness. Increasing income and enhancing business competitiveness at the national level contribute to economic growth. If the emission-trading scheme for greenhouse gas, based on the Kyoto Protocol Mechanism, can be effectively utilized, the reduced gas through energy conservation can be sold as assets. It allows not only reducing costs but also increasing income concurrently.

ACTIVITY 1

1. Choose one room in your house for your audit – the room should have at least 3 electricity consuming appliances/lights.
2. Determine the wattage for each of the power consuming appliances or lights in your room, enter into the table using one row for each light bulb or appliance.
3. Record the time that each of the power consuming appliances is on for each day of 1 week
4. Fill out the energy use tables

Name of the appliances and their watt.	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
	Number of hours used						
1…………							
2…………							
3…………							

5. Create a graph of energy used by each appliance. Take notice of which appliances use the most energy and which use the least.
6. Calculate the energy used and cost of energy used energy (kWh)= power(W)/1000 X time(h).

ACTIVITY 2

1. What two appliances consume the most electrical energy at your house?
2. Does an appliance or device that has a high wattage always use the most energy over the week or month? Explain.
3. What do you think you could do to reduce the amount of energy used in your house?

Energy Management System (EMS)

Energy management is saving energy in different areas like businesses, government organizations and homes. An energy management system is a systematic approach for continuously improving energy performance and to reduce energy use or to maximize energy savings. The main objective of EMS is to:

- Reduce energy wastage.
- Educate the students and the public about energy management.
- Document and publish information to achieve improvement.
- Uphold legal requirement regarding energy use.
- Continuously improve our performance and system.
- Effectively utilize energy efficient products and services.

The basics of EMS process is based on Plan-Do-Check-Act continual improvement framework:

1. Plan (Schedule): Involves comprehensive analysis of energy use, establish baseline data, set target and action plan to deliver improved energy performance.

2. Do (execution): Implement energy management action plans. This step involves using or installing low energy consumption devices. Such measures are passive approach to energy management or onetime improvement plan.

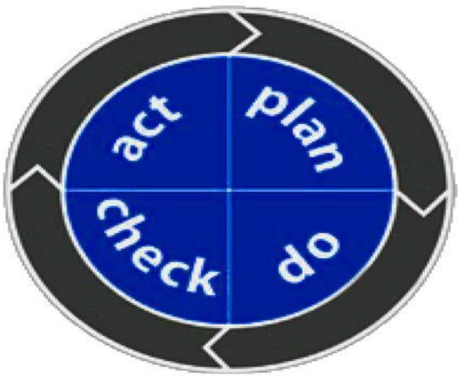


Figure 2. EMS framework

3. Check (Control): Monitor and verify the result of action taken, compare with the baseline data. This step involves energy bill verification and helps to enhance on-going energy efficiency improvement and help maintain improved energy and cost saving over time.

4. Act (Action): Take actions to continuously improve the energy performance and EMS. This step involves energy efficiency analysis and implementation of active energy management system like automatic sensory lighting. The successful implementation of EMS not only reduces the energy use and the cost, but also reduces maintenance and helps in mitigating climate change.

Initiatives and measures for energy conservation in Bhutan

With increase for energy demand and threats to climate change, energy security and environmental issue of the country, there is a need to take appropriate policy measures that would lead to the development of indigenous and clean source of energy. The Department of Renewable Energy Resources under the Ministry of Economic affairs serves as a central coordinating agency and focal point of Royal Government of Bhutan on all matters related to Renewable energy development.

The department has three divisions:

i. **Alternate energy division:** mainly focuses on implementation of alternative energy program.

ii. **Planning and coordinating division:** are responsible for planning and coordinating activities that deals with rural electrification.

iii. **Research and development division:** is responsible for undertaking applied research and development program including energy efficiency and conservation measures.

Hydropower (1,615 MW)

Solar energy

Biomass energy

Wind energy

Figure 3. Energy sources in Bhutan

Currently, the commitment of Bhutan towards conservation of energy can be seen in various ongoing energy efficiency activities such as formulation of National Energy Efficiency and Conservation Policy, standardization and labelling program for appliance and building energy laboratory.

In February, 2016, the Department of Renewable Energy (DRE) launched a project to provide public with subsidized Light Emitting Diode bulb (LED) in an effort to reduce electricity consumption. In the initial phase of the project, around 15,000 LED bulbs were distributed throughout the country and the bulbs were sold at subsidized rate of Nu.100. Further, solar LED street light pilot project has also been proposed in coming years. Mass awareness program on energy conservation and efficient use of energy is also conducted through various media.

Some important energy related policies and acts include: Alternative Renewable Energy policy (2013), Sustainable Hydro power Development Policy (2008), Electricity Act of Bhutan (2001), Economic Development Policy of Bhutan (2010) and Foreign Direct Investment (FDI, 2010).

With the adoption of Alternative Renewable Energy Policy in 2013, Bhutan has embarked on a journey to strengthen its energy security and production of clean renewable energy from sources such as wind, water and sun. These renewable sources of energy produce less pollution and have less impact on environment.

Summary

- Energy is the ability to do work.
- Energy efficiency means using energy in an effective way to provide services or reduce the wastage or minimize the overall consumption of energy.
- Energy management is saving energy in different areas like businesses, government organizations and homes.
- Bhutan has embarked on a journey to strengthen its energy security and production of clean renewable energy.

Self-check for Learning

1. Identify some of the energy saving devices that are used in your locality.
2. Prepare a plan to reduce energy consumption at your home.
3. Explain Energy Management System.
4. What are the purposes of conserving the energy?

3. Development and Green Economy

- Explain the term development.
- Discuss various dimensions of development.
- Identify the indicators of development.
- Explain green economy.

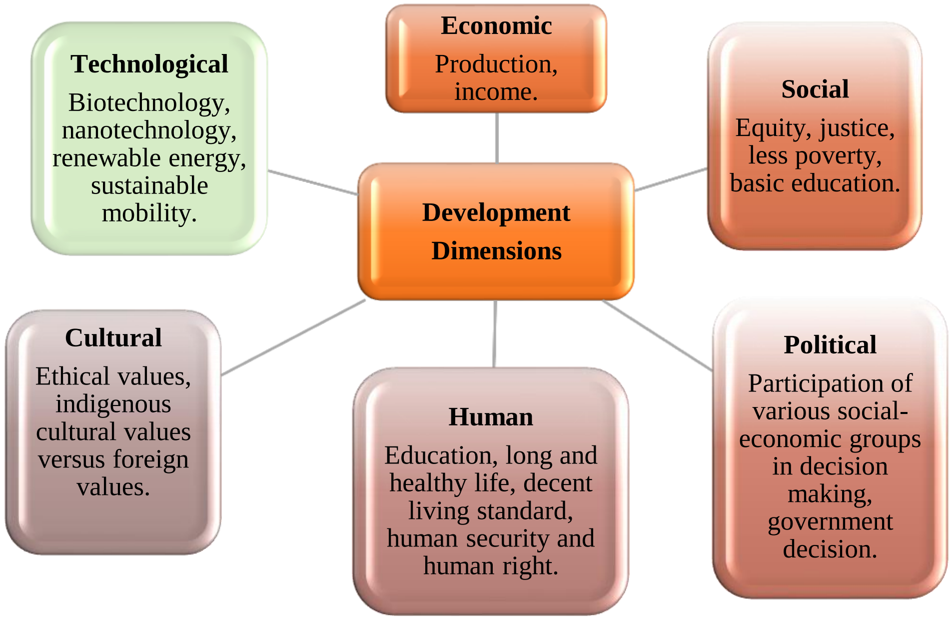
Introduction

Development

The purpose of development has shifted from the materialistic wellbeing to holistic approach which considers environment and social welfare as important dimensions of the development. World Vank defines Development as “A multi-dimensional process which involves transformation in structures, attitudes and institutions as well as the acceleration of economic growth, reduction of inequality and the eradication of absolute poverty.”

Dimensions of development

Initially, development was considered in economic growth. However, economic growth alone did not satisfy the basic needs of the people and bring prosperity and harmony in the society. It was realised that economic growth did not lead to better food security, education, health, sanitation, etc. These factors guided the inclusion of other dimensions such as social, cultural, technology, political and humans as illustrated in the figure below.



Development indicators

Development indicators are measures that show a country's progress in a certain area and compare to that of other countries. They play vital role in determining the current status of the economy in the country and for predicting the future economic developments. However, owing to more convenience in computing nation's income, the World Development Reports indicate that the Gross Domestic Product (GDP), Gross National Income (GNI) and Human Development Index (HDI) are widely used as the development indicators.

1. Gross Domestic Product (GDP)

The Gross Domestic Product (GDP) is the market value of all final goods and services produced within the country in a given period of time. It includes only the final value of the product. Therefore, the sale of used goods is not a part of GDP.
It is calculated using its components as:
GDP = Consumption (C) + Investment (I) + Government Purchases (G) + Net Exports (X-M)

Consumption (C): It is the total spending by households on goods and services.

Investment (I): It is the total spending on goods that will be used in future to produce more goods.

Government Purchases (G): It is all the spending on the goods and services purchased by government at the national and local levels.

Net Exports (X-M): It is given by the exports minus the imports. Exports represent foreign spending on the economy's goods and services. Imports include spending on goods and services produced abroad.

2. Gross National Income (GNI)

The Gross National Income (GNI) is the sum of a nation's Gross Domestic Product (GDP) plus net income received from abroad. Measures output from the citizens and companies of a particular nation, regardless of whether they are located within its boundaries or overseas. If the difference between incomes received by the country versus payment made to the rest of the world is not significant, GNI and GDP will almost be equal.
GNI = GDP + net income received from abroad

3. Human Development Index (HDI)

The Human Development Index (HDI) measures and ranks countries' level of social and economic development based on three indices: life expectancy index, education index and GNI index. It was introduced as an alternative to conventional measures of national development, such as the level of income and the rate of economic growth.

Indicators: Life expectancy; Education; and Per capita income

Life expectancy: It measures the health of individuals in the country. Health is measured by life expectancy at birth. It indicates the number of years a new born infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life.

Education index: This index measures the knowledge of individuals in the country. The education component of the HDI is measured by two indicators: mean of years of schooling for adults aged 25 years and older; the expected years of schooling for children of school going age.

GNI index: Income is measured by purchasing-power-parity (PPP), which is the adjusted per capita Gross National Income (GNI). It expresses the income accrued to residents of a country, including the international flows such as remittances and aid, excluding the income generated in the country but repatriated abroad.

Some limitations of development Indicators

GDP does not provide information about how the income is distributed. Even with high per capita GDP for a country, there will be people suffering with abject poverty.

GNI: Higher National wealth GNI may not necessarily increase the economic welfare. It depends on how it is spent. The higher GNI per capita may hide widespread inequality within a country. Inequalities in income distribution reduce welfare of the people. The richer sections of people, on the contrary, enjoy surpluses.

HDI: The HDI lacks power to capture differences among the industrialized and advanced countries. It is an index restricted to the socio-economic sphere of life, and does not take into consideration, the political and civil spheres, and gender inequalities and gender issues inside the countries.

ACTIVITY 1

Read the following excerpt taken from World Happiness Report and solve the question that follows.

'Happiness tells us how well a society satisfies the major concerns of people's everyday life. GDP is a measure limited to one aspect of economic life, the production of material goods. The aphorism that money isn't everything in life, applies here. If happiness were to supplant GDP as a leading measure of societal wellbeing, public policy might perhaps be moved in a direction more meaningful to people's lives.'

1. Suggest some public policies that will make people's lives meaningful or happier throughout the world.
2. Does the GDP of a country necessarily indicate its development? Explain.

GREEN ECONOMY

Green economy is an economy that results in improved human wellbeing and social equity and considerably reduces various risks on the environment such as pollution, overexploitation, and ecosystem disturbances. The transition towards green economy begins with the reformation of developmental policies followed by implementation of a legal, economic and regulatory instrument to stimulate green investments.

United Nation Environmental Program (UNEP) has identified possible sectors that could contribute to the development of green economy: Green buildings; sustainable agriculture and forest; water management; clean technologies; waste management; renewable energy; and green transport.

Green Building: Buildings are responsible for a huge share of land use, energy and water consumption, utilisation of various materials, emission of carbon dioxide and waste production. If the design, materials, construction, operation, maintenance, renovation, and demolition of the building are environmentally responsible and resource-efficient, it is considered a green building or sustainable building

The Green transport or low carbon transportation strategy involves avoiding unnecessary transport demand, improving fuel consumption technology, and shift transport to lower carbon modes such as cycling, walking, electric cars and public transport.

Green energy is renewable energy which can be naturally replenished, such as solar, wind, hydro, tidal, biofuel, and geothermal energy.

Sustainable farming has the potential to transform agriculture to bring about neutrality by acting as a GHG sink, reduce deforestation and freshwater use. Sustainable use of forest resources, reducing deforestation and increasing reforestation can ensure healthy environment with secure resources for future generations and contribute towards poverty alleviation

Integrated Water Resources Management (IWRM) is a process which promotes the coordinated development and management of water, land and related resources, in order to maximise equitable economic and social welfare without compromising the sustainability of ecosystems.

A regulated tourism can reduce poverty by creating local jobs and stimulating local business in establishing ecologically sustainable practices of tourism.

Encouraging the reduction of waste, reusing and recycling of waste could produce significant gains in decoupling waste production from economic growth.

Bhutan has also adopted some of the green Economy Initiatives such as framing and developing sustainable hydro and wind generated electricity, high-end low-impact tourism policy, promotion of organic agricultural products, and promotion of environment friendly businesses models.

Summary

- Development now is viewed as a more holistic concept and not just restricted to economic growth. Its dimension includes economic, social, political, human, cultural, and technology as well. We also looked at the three different indicators of development - GDP, GNI, and HDI.
- Green economy is an economy that results in improved human wellbeing and social equity and considerably reduces various risks on the environment such as pollution, overexploitation, and ecosystem disturbances.

Self-check for Learning

1. Explain Green Economy.
2. Discuss the opportunities and challenges of our governments' plan in encouraging green transportation system (electric vehicles).
3. How is Gross National Happiness different from Gross Domestic Product?
4. What are some of the Green Economy initiatives taken by Royal Government of Bhutan?

ANSWERS

1. ENGLISH

Transformation of Sentences: Types of Sentences

Self–check for learning

1. It is a very lonely place.
2. Isn't it kind of you to invite us for dinner?
3. How careless of him to leave the door unlocked!
4. Is there any greater feeling than love?
5. This is not the way to talk to your elders.
6. What a beautiful day.
7. We had a delicious lunch yesterday.
8. How pretty the child is!
9. Please, slow down your pace.
10. What a great pleasure it is!

Drama

Self–check for learning

Class 11

1. Antonio, Bassanio, Gratiano, Salerio and Solanio are friends in the play. Amongst them, Antonio and Bassanio are Antonio are the best of friends. Antonio, though was suffering from an unexplained sadness in the scene, Bassanio came to visit him with his own problems. Bassanio is in need of money to go to Belmont to woo the lady of his life, Portia. Antonio, as a true friend of Bassanio, is ever ready to help Bassanio although he confesses that he has neither the money nor the commodity to raise the present sum of money that Bassanio needs. However, Antonio asks Bassanio to go around in Venice and look for money. He says, 'where money is, I no question make', very much symbolizes their true friendship. It implies that Antonio is ready to help Bassanio, no matter what.
2. Reasons cited by Solanio and Salerio
   i. Solanio: Misfortune to his venture or perhaps being in love could be the reason for Antonio's sadness
   ii. Salerio: Antonio is worried about his ships at the sea and perhaps his mind is tossing on the ocean. He also says that the thought that Antonio's ship may wreck in the sea scattering all its silk makes Antonio sad. Finally, he says Antonio is sad because he isn't happy and happy because he isn't sad.
3. Gratiano adds humor to the play through his roles as a fool. Seeing Antonio unwell, he decided to play the role of fool and make Antonio happy. He talks about the reputed wise and asks Antonio to fish not with this melancholy bait. When Lorenzo accuses him of not letting him speak, Gratianio mockingly asks Lorenzo to keep him company for two years and Lorenzo may forget his own language. Gratiano also justifies how silence is commendable only in two tongue – in a neat's tongue dried and a maid not vendable.

Class 12

1. Shylock is exasperated due to ill-treatment by Antonio and he explains how Christian and Jews are alike. He says that both Jews and Christian have the same physical organs like eyes, hands, organs and dimensions. The Jews and Christian are also fed. with the same food, hurt with the same weapon, subject to the same disease, healed by the same means, cooled and warmed by the same winter and summer. He went to justify that just like the Christian bleed when pricked, laugh when trickled or die when poisoned, Jews will do the same. Hence, if Jews and Christians are the same in all these manners, he says Jews could take revenge if wronged just like how Christian does.
2. Bad and Good news
   As shylock is shattered due to the news of his daughter's elopement, Tubal came with both good and bad news
   Bad News:
   i. Though he was sent to look for Jessica, he failed to find her.
   ii. Jessica has spent fourscore ducats in a night
   iii. Jessica has exchanged Shylock's wedding ring with a monkey
   Good News:
   i. Antonio has lost a ship at Tripolis
   ii. Antonio's creditor said that Antonio cannot choose but break
   iii. Antonio is certainly undone
3. Darkest picture of Shylock
   i. When Salerio and Solanio indirectly tell him that he won't take the pound of flesh from Antonio, Shylock says, 'to bait a fish withal, if it feeds nothing else, it will feed my revenge'. If not inhuman, what can we call a person who can even think of extracting flesh as revenge?
   ii. When Tubal came informs Shylock about his inability to find Jessica, Shylock wails, 'why, there there a diamond gone'. Is diamond more precious than his own daughter?

He further went say, 'I would my daughter were dead at my foot and the jewels in her ears! Would she were hearsed at my foot, and the ducats in her coffin'. A father who could wish for a daughter's death is definitely an inhuman wretch. He is depicted as an inhuman person for he could accept the death of his own daughter if his jewels and ducats are brought back to him.

2. MATHEMATICS

Functions, Limits and Continuity

Self-check for learning

1. A and C are the function because first component of each ordered pair is associate with single output.
2. a) $-\frac{1}{3}$ b) 2

3. A function f(x) is said to be continuous at x=a, if it satisfies the following conditions:

a) f(a) is defined

b) $\lim_{x \to a} f(x)$ exists

c) $\lim_{x \to a} f(x)$=f(a)

Differentiation

Self-check for learning

1. $8x - 3$
2. $\frac{1}{2}$
3. $\frac{\tan x}{sec^2 x}$
4. 4. $\frac{6}{x^4}$
5. maximum point (- 2, 27) and minimum point (1, 0).

Indefinite Integral

Self – check for learning

1. $\tan x - \sec x + c$
2. $e^{3x} + c$
3. $\log|\sin \log x| + c$
4. $\frac{1}{2}\left[(x^2)\log|1+x| - \frac{1}{2}x^2 + x\right] + c$
5. $\frac{2}{3}\log|x+1| - \frac{1}{3}\log|x-2| + c$

Definite Integral

Self –check for Learning

1. $\frac{1}{3}$
2. $\frac{\pi}{2} - 1$
3. $\frac{112}{3}$
4. $3\ Sq.units$
5. $\frac{15}{2}\pi\ \ cu\ \ units.$

Points and their Coordinates in Two Dimensions and Straight Lines

Self –check for Learning

3. 7 units
4. (-1, 9)
5. A. Slope – Intercept form $y = mx + c$ B. Point – slope form $y - y_1 = m(x - x_1)$
   C. Two – point form $y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_1)$
6. x – intercept = (4,0) and y-intercept = (0,3)
7. m2 = 11
8. $2x + y + 7 = 0$

Coordinate Geometry: Conic Section

Self –check for Learning

1. Length of L.R $=\frac{4}{3}$ Focus $= \left(\frac{1}{3}, 0\right)$.
2. $e = \frac{3}{5}$ length of L. R $= \frac{32}{5}$.
3. $9x^2 + 8y^2 - 54x - 16y + 17 = 0$.
4. $x^2 - 4xy + y^2 + 4x - 4 = 0$.
5. eccentricity $e = \frac{5}{4}$, centre (1, - 2) vertices $(1 \pm 4, -2)$

   foci $(1 \pm 5, -2)$ latus rectum $=\frac{9}{2}$.

3. BIOLOGY

Human Heart

Self–check for learning

1. The heart receives its supply of blood from the coronary arteries. Two major coronary arteries branch off from the aorta near the point where the aorta and the left ventricle meet. These arteries supply blood to all parts of the heart muscle.
2. The arteries carry blood with oxygen and nutrients away from the heart to different parts of the body.

Sexual Reproduction in Flowering Plants

Self-check for learning

1. It is the failure of pollen from a flower to fertilize the same flower or other flowers of the same plant. Self-pollination does not lead to seed formation in self-incompatible species due to the interaction between the chemicals of the pollen and stigma. The plants which exhibit this phenomenon can prevent germination of pollen grains and thus, prevent the growth of the pollen tube on the stigma of the flower
2. Once the pollen lands on the stigma of the ovary of a female flower by pollinators, a pollen tube forms and male reproductive nucleus travel down to the ovary and fertilisation takes place in the ovary.

Feedback Mechanisms of Hormonal Action

Self-check for learning

1. Open ended
2. Ovulatory phase due to release of an ovum (ovulation)
3. Adrenaline is secreted in times of emergency situation. For example, encountering a bear. In such a situation, heart beat increases, the blood supply to the muscles increases, glucose supply is more to the muscles. This happens because we will have to have extra energy to either beat the bear or run away to save your life.
4. Use of female hormones estradiol and progesterone will increase their level in the blood, which will have negative feedback on the hypothalamus resulting in reduced secretion of GnRH. Subsequently, it will cause a reduction in the LH secretion from the pituitary gland which prevents ovulation.
5. Insulin and glucagon are antagonistic hormones because they work in opposite way. Insulin reduces the amount of sugar in the blood by making the liver and other body cells absorb glucose when the concentration of blood glucose rise. Glucagon increases

the blood sugar level by stimulating the liver to release glucose when the concentration of blood glucose drops.

4. CHEMISTRY

Raoult's Law and Vapour Pressure

Self–check for learning

3. 333.076 mm Hg
4. Raoult's law is applicable for binary solution since it is applicable for ideal solution of two components.

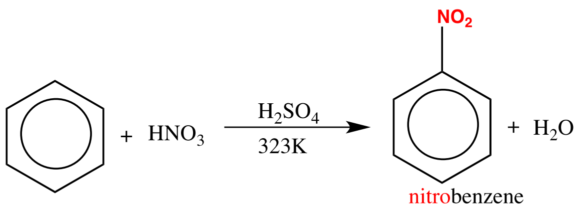
Amino acids

Self-check for learning

1. Amino acids are amphiprotic in nature because they contain both basic amino group (-NH_2) and acidic carboxyl group (-COOH).
3. Amino acids move to anode if electrolysed in NaOH because they become negative ion after accepting OH^- ion and forming water molecule. They move to cathode if electrolysed in HCl solution because they become positive ion after accepting a proton.

Aromatic Compounds

Self–check for learning

1. Benzene are very reactive and can easily undergo electrophilic substitution reactions readily because benzene ring contains a delocalized π- molecular orbital containing 6 π- electrons and thus acts as a greater source of electrons for attacking electrophile (electron deficient).
2. H_2SO_4 acts as catalyst and helps in production of electrophile.
3. 

Chemical Thermodynamics

Self–check for Learning

1. ΔE >ΔH
2. 1 mole of water at 25^0C and aqueous solution of KNO_3
3. For an adiabatic process, q = 0

$\Delta E = q - w$

$\Delta E = -w$ (the work is done at the cost of internal energy)

For isochoric process, ΔV = 0

$P\Delta V = 0$

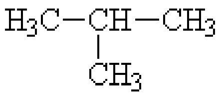
$\Delta E = q + w$

$\Delta E = q - P\Delta V$

$\Delta E = q_v$ (heat absorbed at constant volume); the heat absorbed is used up in increasing the internal energy)

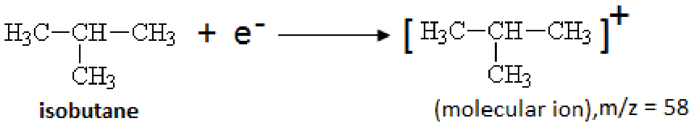
Mass Spectrometry

Self-check for learning

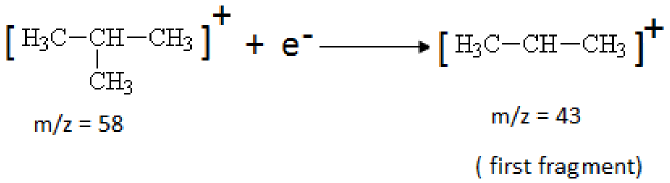


isobutane

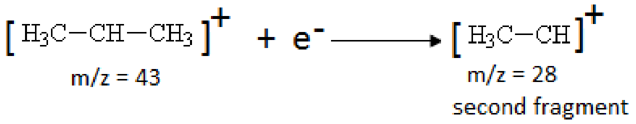
1. molecular mass - 58



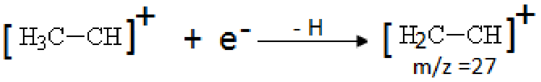
m/z value of molecular ion - m/z value of first fragment = 58 - 43 = 15. so CH_3(15) would be lost.



m/z value of first fragment - m/z value of second fragment = 43 - 28 = 15. so again CH_3 (12 +3) would be lost.



from the second fragment ,H would be lost so the m/z value becomes 27 for the third fragment



2. Mass spectroscopy is the analytical technique in which the vapour of the substance is bombarded with energetic electrons. The molecular ion and the fragment ions are formed which are separated according to their m/z or m/e ratio. Mass spectrum of a substance is a plot between m/z values of the ions versus their relative abundance.
3.
    1. Peak b
    2. Peak c
    3. 58
    4. Butane: C_4H_{10}

5. PHYSICS

Newtonian Gravitation and Kepler's Laws

Self-check for learning

2. (a) Perihelion
   (b) Aphelion
3. B increases
4. C perihelion

Gravitation Potential and Kepler's Laws

Self-check for Learning

1. Escape velocity is the velocity of an object required to overcome the gravitational pull of the planet to escape into space.
   A body which is revolving continuously in an orbit around a comparatively much larger body is called satellite.
   The specific minimum velocity required to put the satellite into a given orbit around the Earth is called orbital velocity.
2. One reason that manned missions to other planets are difficult to plan is that a ship would have to take enough fuel into space to blast off of the other planet when the astronauts wanted to go home. The weight of the fuel would make the spaceship so heavy it would be hard to blast it off Earth.
3. $v_e = \sqrt{\frac{2GM_E}{R_E}}$

   $v_e = \sqrt{\frac{2 \times 6.67 \times 10^{-11} \times 5.98 \times 10^{24}}{6.4 \times 10^{6}}}$

   v_e=1.116 x10^4 m/s
4. It is better to launch a ship into orbit from away from the satellite. The radius is greater at the equator than at the poles. This lowers the escape velocity.

Semiconductor

Self-check for Learning

1. P-type semiconductor.
2. Characteristics of n-type and p-type semiconductors

N-type semiconductors	P-type semiconductors
i. Excess of electrons	ii. Deficiency of an electron
iv. Majority charge carrier is electron	iii. Majority charge carrier is hole
vi. Dopant donates electrons	v. Dopant accepts electrons

3. Difference between intrinsic and extrinsic semiconductors

Intrinsic Semiconductors	Extrinsic semiconductors
1. It is a pure semiconductor material with no impurity atom in it.	It is the pure semiconductors doped with pentavalent or trivalent impurity atoms.

2. The electrical conductivity is low	The electrical conductivity is high
3. Electrical conductivity depends on temperature alone.	Electrical conductivity depends on temperature as well as on the amount of impurity doped in the pure semiconductor.
4. Number of free electrons in the conduction band is equal to the number of holes in the valence band	Number of electrons is never equal to the number of holes. Number of electrons is greater in n-type and number of holes is greater in p-type semiconductors.

4. There would be no mobile phones, no radios, no TVs, no computers, no video games, no bank ATMs, and poor medical diagnostic equipment.

Communication System

Self-check for Learning

1. Some of the applications of microwaves and infrared waves are listed below:
   Microwaves
   i. They are used in Radar systems for aircraft navigation.
   ii. They are used in microwave ovens for cooking food.
   iii. A Radar using microwaves can be used to detect speed of a tennis ball, cricket ball, or automobiles in motion.
   iv. They are used in communication satellites.

   Infrared waves
   i. Infrared lamps which are used in physical therapy (physiotherapy).
   ii. Infrared detectors used in Earth satellites.
   iii. Light-emitting diodes emit infrared waves and are used in remote switches of TV, CD player and air conditioners.
   iv. Solar water heaters and solar cookers.
   v. Maintaining Earth's warmth through the greenhouse effect.
2. Without communication system, knowledge would not have been disseminated efficiently throughout the world. The message would have been hard to deliver to the right audience at the right time at the right place. Without it, our technological growth would most certainly have been stunted from lack of information.
3. Some of the negative impacts of modern communication are as follows:
   i. Vast use of modern communication is likely to result in poor social skill since it replaces real-life communication and ends in social isolation.
   ii. Children sometimes over use technology which affects the learning process in negative way. Plagiarism and cheating have increased while analysis and critical thinking have declined. This puts young generation thinking abilities in jeopardy.
   iii. The most adverse effect of the modern communication is obesity. Being absorbed by a laptop or a tablet, people tend to snack a lot, keep late hours and exercise less.

iv. One of the most dramatic impacts of mass communication is the decline of the quality and quantity of sleep. The sleep chemical melatonin is influenced by the constant glow from screens. So, technology is likely to interfere our sleep and affect our general state.

Superposition of waves

Self-check for Learning

1. When a number of waves get superimposed, the resultant displacement is equal to the vector sum of displacement of all waves.
2. **Conditions for constructive interference**

   Phase difference: $\phi = 2n\pi$

   Path difference: $x = n\lambda$

   Conditions for destructive interference

   Phase difference: $\boldsymbol{\phi = (2n + 1)\pi}$

   Path difference: $\boldsymbol{x = [(2n + 1)/2]\lambda}$
4. Hint: First identify whether the resulting wave is constructive or destructive, and then solve the question.
5. Because sound waves are not transverse in nature.
6. Sound waves cannot be polarised.

Photon model of electromagnetic radiation

Self-check for Learning

1. $E_{photon} = hf$

   $= 6.626 \times 10^{-34}$ Js $\times 3.0\times10^{16}$ Hz

   $= 2.0\times10^{-17}$ J

   As the photon energy is greater than the work function of copper metal, photoelectron will be ejected from the metal surface.
2. $E_{photon} = KE_{electrons} + \emptyset$

   $KE_{electrons} = E_{photon} - \emptyset$

   $= (2.0\times10^{-17}\text{ J})-(7.53\times10^{-19}\text{ J})$

   $=1.9\times10^{-17}$ J

Electron Diffraction

Self-check for learning

1. 6.58×10^{-7} m
2. 005×10^{-18} m
3. Proton

Quark Model and Radioactive Decay

Self-check for Learning

1. Elementary particles of an atom are quarks and electrons.
2. All quarks have charm of zero except the charm quark has charm +1.
3. Yes, leptons can combine to form particles such as atoms.
4. For reaction $n \rightarrow p + e^- + \bar{\nu}_e$

   a) Charge is conserved Before: 0

   After: (+1e) + (-1e) + (0) = (0)

b) Baryon number Before: 3(+1/3) = +1
After: 3 (+1/3) + 0 + 0 = +1
c) Strangeness is conserved Before: (0)
After: (0) + (0) + (0) = (0)
d) Lepton number Before: (0)
After: (0) + (+1) + (-1) = (0)
Reaction is possible since charge, baryon number, strangeness, and lepton number are conserved.

Nuclear Energy

Self-check for Learning

1. $\Delta m = 235.04390\ u - (139.9054 + 93.9063 + 1.00866)\ u$
   $\Delta m = 235.04390\ u - 234.82036\ u$
   $\Delta m = 0.22354\ u$
   $Q = \Delta m \times 931\ MeV$
   $Q = 0.22354 \times 931\ MeV$
   $Q = 208.12\ MeV$
2. Safety measures that a nuclear engineer must consider while designing a nuclear reactor are:

- Aseismic measures
- Environmental radiation monitoring
- Preparing high-dose resistant protective clothing

3. Yes

Nuclear reaction is a clean form of energy that can be utilised in place of fossil fuel to genera electricity. Nuclear reaction isotopes are used to produce radio isotopes which are used in the medical field for treatment of many diseases.

OR

No

- Destructive weapons like atom bomb and hydrogen bomb.
- Danger for the workers due to radiation.
- Nuclear power plant accidents.

6. ECONOMICS

Inflation

Self-Check for Learning

1. Open Inflation
2. Galloping inflation
3. Deflation is the reduction of the general level of prices in an economy.
4. Inflation and deflation are considered as economic problems when prices are falling but wages are not, it increases the inflation-adjusted cost of labor, and that leads to unemployment. The rise in unemployment leads to less spending and that causes prices fall further. Once again, the economy can enter a downward spiral. Deflation can cause lower economic growth,

5. The is a two-way relationship between exchange rates and inflation. When U.S. consumers buy foreign products, they pay prices that reflect the exchange rate of the dollar against the currency of the country that produced the product. For example, If the importer of German beer to the United States must pay more dollars for the same amount of beer he usually buys, then U.S consumers will in turn pay more dollars to the importer when they buy the beer at their grocery story. Thus, the exchange rate between Germany and United States can impact inflation in the United States. Ofcourse, inflation in either country could also impact the exchange rate between the two countries.

Money and Banking

Self-Check for Learning

1. Barter system disappeared due to many reasons. Some of the reasons were:
   i. Lack of double coincidence of wants- when two persons trading not getting the commodity they are looking for. Person A wanted butter from person B which person B had but person B wanted cheese from person A which person A does not have, rather person A had flour.
   ii. Indivisibilities- Some commodities cannot be divided as per the requirement. If a person wanted just a few kilograms of a cow, the person selling the cow cannot cut the cow as per the other person's requirement.
   iii. No common measure of value- Commodities are measured in different units. Some are measured in liters, some in kilograms, and some in meters. These units created issues while trading commodities.
   iv. Problem of storage- Commodities are perishable and therefore, they need to be consumed immediately. Taking commodities for trade was very difficult as commodities were spoiled after a few days.
   v. The problem of transportation- Some commodities cannot be carried easily for longer durations and this acted as a hindrance to trade
2. Open-ended questions (students can choose any of the stages of money but they have to write the advantage of that stage explaining their preference)

7. MEDIA STUDIES

Use of Multimedia tools and applications

Self-Check for Learning

1. Classroom multimedia tools such as smartphones, digital cameras, and computers. Multimedia editing software like Photoshop and iMovie
2. Khan Academy and Open Culture
3. Baristasim, is a management simulation game. Students start their coffee shop business, determine their strategy, make business decisions and see their results for a period of five years. In Level 1, students set up their coffee shop, decide on a location and run their store. In Level 2, students can roast their own coffee, choose the type of coffee they serve and hire staff. In Level 3, the company starts international expansion in mature markets and emerging markets through the opening of its own stores and franchising. Baristasim supports learning in line with common High School courses in

business and entrepreneurship. Students can learn strategy, marketing, human resources, operations and finance.

Journalism and its Principles

Self-check for Learning

1. Bhutan's media are young and its democracy even younger. However, Bhutanese journalists prevail freedom of expression and government supports by providing proper guidelines and monetary benefits. Government also protect media and strengthen media capacity within and abroad. Journalists are less in number and has less experiences compare to a world journalist. Bhutanese journalists shoulder their professional roles keeping culture and old practices and one of the journalistic ethics. Bhutanese journalist also plays trust and faith upon stories or even to the information collected from the source. They have faith to the views shared by the government.
2. If news producer fails to carry proper research there will be high risk in misinterpreting news to a general public. The news and information may not be a reliable one or the interpretation may be from one side. As per the news publication ethics the reporter must bring the detail stories by balancing both sides. It is also very important for the journalist to have trust from the audience. As a result, to carry out the duty professionally they must keep on researching things and learning the good practices in this media world. People will not trust the source and will start criticizing media. Therefore, it is vital for journalists to keep on learning new things and finding good approaches for the news publication. They also act as a bridge between government and public.

Global Economy, E-Commerce and Media

Self-check for Learning

1. Yes we encourage e-commerce in our country. Now, things have change and everybody prefer easy methods and easy works for their livelihood. Many countries experienced digital world and has immense impacts out of it. Through e-commerce we can exchange currencies, and even goods and services with other countries online. Also we can proceed business, education, entertainment, trade and commerce, and PR relation online. Lots of developmental activities can be carried out with the help of e-commerce platforms. It is time for us the Bhutanese to learn and experience ourselves through all technologies and new opportunities that govern widely in an influential rate.
2. With the e-commerce knowledge I can easily find market to my product although the environment isn't fulfilling's or appealing one. Nowadays, people are all proactive and has knowledge on technology and information. Many prefer using online facilities and become accessible within no time. If I advertise my product online there will be many followers and will demand the product. Also, social media are getting popularity in our country therefore, such platforms also cater some opportunities to deliver my product to buyers irrespective of time and distance.

New Media World and Citizenship Orientation

Self-check for Learning

1. New media can be very influential on society in both positive and negative ways. It gives people a way to stay in touch with people who live far away. It lets people share fun, interesting, and informative content. It gives businesses a way to engage with customers. One of the problems, however, is that anybody can share anything, including material that may not be accurate. In some cases, real harm is done when people spread inflammatory, unverified, or outright false information. This can harm private individuals, as when someone is bullied online. It can also have a harmful impact on society as a whole. Thus, people need to be oriented with new media so as to safeguard oneself from the ills of new media. If used judiciously it can ensure that people play meaningful and effective roles in the political world and encourage people to embrace new media participation, a new media environment should provide the public with quality information.

Media Language and Basic Persuasion Techniques
Self-check for Learning

1. Analysis based on the product(Head and shoulders Shampoo)

Source: Internet

A popular brand of anti-dandruff shampoo gives confidence to both men and women who suffer from haircare issues like dry and itchy scalp and dandruff. Head & Shoulders has a range of shampoos which can be used by all hair types like dry, normal and oily hair and address hair issues like itchy scalp, dandruff, dry and frizzy hair.

Persuasive techniques like celebrity, beautiful people and testimonials are used.

- Famous celebrity and beautiful are used to trap our attention and to affect the emotion of wanting to look beautiful as shown in the ad.
- The person in the ad says that it is a good product and is satisfied with the product so we tend to believe them.

8. HISTORY

Zorig Chusum: The Thirteen Arts and Crafts of Bhutan

Self-check for Learning

1.

- Provides part-time employment.
- Source income for the family.
- Cultural expressions of the community.
- Represents country's culture and heritage.

2.

- lack of market for sale.
- availability of cheap foreign products in the market.

4.

Column A	Column B
Tsha Zo	*Bjoka in Zhemgang, Kangpara in Trashigang and certain parts in Mongar.*
Thag Zo	*Khoma, Radhi, Bidung in the eastern Bhutan.*
Sha Zo	*Kengkhar in Mongar, and Trashiyangtse.*
De Zo	*Bomdeling in Trashiyangtse*
Par Zo	*Wangduephodrang and Pemagatshel*

Secular Songs and Dances of Bhutan

Self-check for Learning

3.

a. Honours great lamas or religious figures.
b. Praises of lamas, monasteries and sacred places.
c. Honours kings and of great personalities.
d. To celebrate happiness and to mark joyous and festive occasions
e. Love and befriending girls.
f. Expresses emotions.
g. Recounts the life and brave deeds of the culture's heroes and heroines.
h. Sung and danced during the marriage ceremony
i. Songs of good wishes

Lhengye Zhungtshog

Self – check for Learning

1.

a. Formulation of National Policies
b. Execution and Implementation of the National Policies
c. Promotion of Domestic and International Relations

d. Financial Functions
e. Promotion of an efficient civil administration

2. Status as a natural-born citizen of Bhutan is one of the eligibility requirements established in the Bhutanese Constitution for holding the office of Prime Minister. This requirement was intended to protect the nation from foreign influence.

9. ENVIRONMENTAL SCIENCE

Land Conservation

Self-check for Learning

1. Some of the initiatives taken by the government to manage the land are management of forest fire, sustainable production and utilization of resources, rehabilitation of degraded and barren land, participatory forest management and livestock and grazing management.
2. The belief system that are prevailing in the communities help to support the land conservation. Many people in the communities consider some of the lands having big rocks, trees and presence of lake are considered sacred and prevented from any degradation. Some people also practice the culture like 'Lhadham' where people prohibited from traveling to mountains in some particular months. So, these belief systems help in conservation of land.
3. The pollution of land will indirectly affect the health of the people as most of the resources human depend on are found on the land. Once the land is polluted, it will no longer support the growth of crops, and the water and other resources will be contaminated. It will then impact the health of people mainly through biomagnifications where harmful materials will reach inside the human body through the food chain

Energy Management and Conservation

Self-check for Learning

1. Some of the energy saving devices that are used in the locality are use of energy saving bulb, energy saving rated refrigerator, solar charger and water saver toilet.
2. A plan to reduce energy consumption at home includes replacing devices with energy saving devices, putting off light when not required, reducing wastage of water, installing rain water harvesting method, recycling of materials, etc.
3. Energy management is saving energy in different areas like businesses, government organizations and homes. An energy management system is a systematic approach for continuously improving energy performance and to reduce energy use or to maximizing energy savings.
4. The purposes of conserving the energy are for the energy security, to minimize climate change and benefit the environment, and to increase the income.

Development and Green Economy

Self-check for Learning

1. Green economy is an economy that results in improved human wellbeing and social equity and considerably reduces various risks on the environment such as pollution, overexploitation, and ecosystem disturbances.

2. The opportunities in encouraging green transport systems will benefit in conserving the environment and reduction of anthropogenic ways of causing climate change. Since electric vehicles use renewable energy, there will be reduction in the dependency on fossil fuel. This will also help the socio economy of the country with reduction in importing fossil fuel. The challenges will be many people not able to afford electric vehicles and lack of technology advances in the country related to dealing with the green transport system.
3. The difference between Gross National Happiness and Gross Domestic Product:

Gross National Happiness	Gross Domestic Product
It is a developmental philosophy that guides the government of Bhutan. It includes an index which is used to measure the collective happiness and well-being of a population.	It is one of the developmental indicators. Gross domestic product (GDP) is the monetary value of all finished goods and services made within a country during a specific period.

4. Some of the Green Economy initiatives taken by the government of Bhutan are framing and developing sustainable hydro and wind generated electricity, high-end low-impact tourism, promotion of organic agricultural products and promotion of environmentally friendly businesses.