Training on development of HOTS questions in Physics and Chemistry for KRPs of Chhattisgarh and Maharashtra State

PAC - 23.29

2022–2023

Coordinator

Prof. Rashmi Singhai

Dr. Shivalika Sarkar

National Council of Educational Research and Training

REGIONAL INSTITUTE OF EDUCATION, BHOPAL

Development of Items for Enhancing HOTS in Physics at Senior Secondary Level

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Training on development of HOTS questions in Physics for KRPs of Chhattisgarh and Maharashtra State

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Approach Paper

One aim of education for the 21st Century Skills is to cultivate the problem solving, critical thinking and higher order thinking skills (HOTS). Higher order thinking skill basically means a thinking that is taking place in the higher levels of the hierarchy of cognitive processing. The most widely accepted hierarchical arrangement of this sort in education is the Bloom Taxonomy, viewing a continuum of thinking skills starting with knowledge-level thinking to evaluation-level of thinking. Higher order thinking skills are the ability to think not just recall, restate, or recite but it reaches several dimensions of knowledge, including metacognitive dimensions. Students who have higher order thinking skills will be have the ability of connect different concepts, interpret, problem solving, communication, reasoning, and make the right decisions. The National Educational Policy also envisages the development of higher-order thinking capacities, problem-solving abilities. It further stresses on the fact that, aim of assessment in the culture of our schooling system should be testing the higher order skills. Hence through this program development of items based on higher order skills in Physics will be done and the items will be tested also.

Specific Objectives:

1. Development of test items in Physics related to higher order thinking skills
2. To test the effectiveness of the test items in measuring the higher order thinking skills

(b)Methodology:

The items in HOTS in Physics will be developed based on higher order thinking skills indicators include the ability to analyze (C4), evaluate (C5), and create (C6). Instrument will consist of multiple choice test that will be validated by instrument experts, physics education experts, practitioners and peer reviewers.

(1) One day in-house meeting to plan overall program.

(2) Five days workshop for development of items in Physics based on HOTS

(3) Five days try out of the items in Demonstration School, RIE Bhopal

(4) Five days workshop to review the items of the HOTS test

Concept of Higher Order Thinking Skills

Higher Order Thinking is often linked with Bloom’s Taxonomy mainly for the highest three level of thinking in Bloom’s Taxonomy

- Synthesis, analysis and evaluation
- Anderson and Krathwool’s revision

- Analysis, evaluation and creation.

However, there are more enough types of thinking including in Higher Order Thinking category, for instance comprehensive thinking, deep thinking, rational thinking, critical thinking, logical thinking, reflective thinking, metacognitive, creative, and many others . There are many experts clarifying the Higher Order Thinking types like Brookhart adding critical thinking , reasoning and problem solving in Higher Order Thinking Skill category . While Martano known as his thirteen ideas level of thinking , and King with critical, logic, reflective, metacognitive thinking and creative as well as some others experts given their ideas related to the types of thinking which including to Higher Order Thinking level . In a knowledge field, we are not always able to explore all of those thinking types. There is need to discover the Higher Order Thinking level which is appropriate with the character and the fundamental from each knowledge field. Higher Order Thinking can be placed into three paradigms

(1) Non-specific discipline and non- specific skill,
(2) Non-specific disciplines and specific skills and
(3) Specific discipline and specific skills. Those paradigms strengthen that currently Higher Order Thinking level is actually still general so that it need to be discovered more Higher Order Thinking which is more specific appropriate with the characteristics of a knowledge field, for example appropriating with physics's characteristics.

- **Skill thinking by Brookhart framework**

The second paradigm is specific thinking skill in this is proposed by Brookhart such as logic and reasoning thinking, judgment and critical thinking, problem solving, creative thinking, transfer (analysis, evaluation, creation). Brookhart's thinking level may be chosen because its wider scope then others. Specifically, the taxonomy from Brookhart can be pursed to the three levels of thinking, if we refer to the definition of HOTS from Brookhart , such as transfer, critical thinking and problem solving. Transfer consist of analysis, evaluatiom, and creation. Analyzing covers with the ability to solve an unit to be some parts and determining how its parts are connected each other or part itself with the entirely . Evaluation is someone's ability to make consideration toward one condition, value and idea. Another definition from Anderson and Krathwohl, that evaluation is an ability to do judgment based on the criteria and particular standard. The criteria which often used is determining the quality, effectiveness, efficiency, and consistency, while the standard is used in determining both quality and quantity. Dadan Rosana reveal that creation is someone's ability in combining various informations and developing it to become something new. In other hand, Anderson and Krathwohl reveal that create is a process compiling the elements to be totality which is coherent and functional. Brookhart give the following definition related to the problem solving:

- ***A student incurs a problem when the student wants to reach a specific outcome or goal but does not automatically recognize the proper path or solution to use to reach it. The problem to solve is how to reach the desired goal. Because a student cannot automatically recognize the proper way to reach the desired goal, she must use one or more higher-order thinking processes. These thinking processes are called problem solving.***

Those are including remembering information, learning by understanding, evaluating idea critically, forming alternative, creative, and communicating effectively.

Higher Order Thinking in Physics

The characteristics of HOTS are divided into three paradigms, such as

1) General Thinking consisting of scholarship thinking, career thinking and extra-curricular thinking,

2) Skill Specific Thinking, such as Transfer, critical thinking and problem solving,

3) Discipline specific thinking including reasoning, mathematical thinking and problem solving.

- Learning model which can be applied such as problem based learning, inquiry based learning, context based learning and active learning. Tools which can be used for assessment such as multiple choice, description, wrongly-false, short field. Stimulus such as graph, flowchart, pictures, quantitative model, case study and contextual problem. The concept of learning model, tools and stimulus to assess the higher order thinking skill which is offered in this article is expected to help the teacher to develop the students' ability for higher order thinking skill in physics.
- There are three levels of thinking used, such as rational thinking,
- Mathematical thinking, and problem solving
- Rational thinking
- In physics learning, the knowledge about the concept, law and theory considered as an essential need. Students' ability in understanding the concept, law, and theory are not only by memorizing the form, but more than that they can find when the concept applying, how its phenomenon, and how it can be applied in a real life. Therefore, rational thinking in physics can be done by asking the concept, its applied in real life or contextual problem in daily life. Rational thinking ability related to the goal achievement in real life. The main dimension from rational thinking ability including scientific thinking, probabilistic thinking, literate financial, practical figure, personal confidence. Rational thinking focus on contextual cases but currently learning by focusing attention in real life or around environment is still rarely done. Learning should be more contextual, taking example or daily life background.
- Mathematical thinking
- In physics, language used to explore the natural event is mathematical language. Therefore, mathematical thinking ability become a requirement to maximize the mastery of physics. If we are accustomed to use mathematical thinking, it can be developed thinking ability, the ability of logical thinking, analytic and systematic. The use of mathematics in physics in not only by simple calculating activity, but it is a complex matter. Communicating mathematics thinking in physics can be done by using symbol, table, diagram, and other media.
- Mathematic is a basic science which is really required as a base for technology and modern knowledge. To mastering and creating the technology in the future required mastering strong mathematic since early stages. Basically, mathematic subject given to equip the learners with the logical thinking ability, analytic, systematic, critical, creative and the ability to cooperate, besides that, developing the ability by using mathematic in solving problem and communicating the idea by using symbol, table, diagram and other media. One of the advantages we often point out is that mathematics practice someone to think logically. Mathematics gives a high skill to someone

in abstraction power, analyzing the problem and reasoning logic. Therefore, mathematics useful to help in reviewing around the nature, so it can be developed become a technology for human welfare. Trend of science which is more quantitative, rest in mathematics which is finally make mathematics develop fast. In physics, language used to explore the natural event is mathematic language. Mathematics can be assumed as a support to make it easy to understanding physics. Mathematic has an important role in physics. Physics subject is one of the sciences which talk about the phenomenon and natural behaviour, as long as it can be observed by human. The way to explore is not only by quantitative but also qualitative.

- Mathematics as a level of thinking in physics has a meaning as students' skill in abstraction power, analysis problem and reasoning logic in problem solving and communicating the idea by using number, symbol, table, diagram, and other media.
- Problem solving
- Problem solving in physics learning demand mastering mathematics concept, reasoning, and mathematics competence to help students making creation in solving problem given, even though it can be done by mixing with material or concept with another relevant physics. The higher level in cognitive dimension in physics subject is problem solving. Students can be said having problem solving thinking ability if they are able to find out the right solution in solving problem given. Problem solving in principle is a rule or order done by someone to solve the problem by basic knowledge concept which has been learnt before. The problem is a situation when individual want to do something but they do not know the action needed to get what they desired. Problem solution in physics subject demand the mastering material concept by students. Students can have a different way of working which appropriate with mastering the material related to the task given, or even they also can combine with the other physics material or concept which is relevant. Consequently, in problem solving thinking level, students are required mastering basic knowledge, reasoning and mathematical skill to help them in creating problem solving which is given (including critical thinking and creative thinking)..
- In compiling HOTS questions, it recommended using multiple representations. There are several forms of expression in physics, namely verbal terms, image/diagram representations, graphical representations, and mathematical representations.
- Thinking processes in solving problems can be stimulated using multiple names, in addition to the real-life phenomena presented.
- The real-life phenomena to measured competencies are used as a stimulus in the stem of physics questions developed by the physics teachers. Several things that needed to consider in preparing the HOTS question stimulus are:
    1. Choose some information in the form of pictures, graphs, tables, discourses, etc. that have a relationship in a case;
    2. The motivation should require the ability to interpret, looking for a relationship, analyze, conclude, or create;
    3. Choose circumstances/problems that are contextual and interesting (current issue) that motivate students to read;

4. Directly related to the question and work as stimulation to solve the problems.

List of Resource Persons

1. Prof. M.N. Bapat, Ex Faculty, NCERT, RIE Bhopal
2. Dr. Shivalika Sarkar, Assistant Professor, RIE Bhopal
3. Dr. Jitendra Suryavanshi, Assistant Professor, Govt. Post Graduate College, Sendhwa, M.P.
4. Dr. Akash Yadav, Lecturer, Pandit Deen Dayal Upadhyay Rajkiya Model Inter College, Baruli Mathura
5. Dr. Mita Chourasia, PGT (Physics), KV1, Bhopal.
6. Dr. Manisha Havaldar, Supervisor, Bharat English School and Junior College, Pune
7. Dr. Deepak Sondhiya -

Session II

Introduction to HOTS

Dr. Shivalika Sarkar

The following points were discussed by the Speaker

Background of HOTS- WHAT : Development of Module for Exemplar Test-Items for Assessing Higher Order Thinking Skills at Secondary (Mathematics, Science and Social Sciences) and Higher Secondary Stage (Physics, Chemistry, Biology and Mathematics)

How initially the Program was proposed to develop higher order thinking skills in Social Sciences.

In DAB/Academic Committee it was advised to broaden the scope of the programme and include, Mathematics and Sciences. Considering the mandate of the Division, and similar programmes being proposed by RIE Bhopal for Higher Secondary Stage in Physics, Chemistry, Biology and Mathematics, As per the minutes of Programme Advisory Committee, ESD was entrusted the responsibility of developing guidelines and to share with RIE Bhopal. Teachers have to be aware that learning and assessment using Higher Order Thinking must be applied in learning process to prepare the students' ability in facing competition in 21st century.

Why HOTS??

Transformation of assessment for student development is one of the key concerns of the National Education Policy- 2020. The policy advocates for the shift in assessment practices from one that is summative and tests rote memorization skills to more regular and formative, competency based assessment wherein more emphasis is given on promotion of learning, development of our students and usage of testing higher order skills along with restructuring of students' progress card. NEP implementation Task Number106 for item development for enhancing higher order skills under Examination Reforms.

What are Higher-Order Thinking Skills?

Higher order thinking skills are skills which involve students moving beyond simply recalling facts and repeating back exactly what they have learned. It takes thinking to higher levels than restating the facts and requires students to do something with the facts — understand them, infer from them, connect them to other facts and concepts, categorize them, manipulate them, put them together in new or novel ways, and apply them as we seek new solutions to new problems.

EXEMPLAR ITEMS IN DIFFERENT SUBJECT AREAS (HIGHER SECONDARY)

- Concept of Higher Order Thinking Skills
- Characteristics Features of Higher Order Thinking Skills
- Purpose of Testing/Using of Higher Order Skills

- Understanding The Difference Between Essential Questions And Higher Order Questions.
- Benefits/Advantages of Using Higher Order Thinking Skills
- How To Create And Use Higher Order Thinking Skills In Classroom

HOTS distribution

- Different levels can be assigned to the HOTS questions-
- very low, low, medium, high and very high
- Thinking processes in solving problems can be stimulated using multiple names, in addition to the real-life phenomena presented.
- The real-life phenomena to measured competencies are used as a stimulus in the stem of physics questions developed by the physics teachers. Several things that needed to consider in preparing the HOTS question stimulus are:
- choose some information in the form of pictures, graphs, tables, discourses, etc. that have a relationship in a case;
- the motivation should require the ability to interpret, looking for a relationship, analyze, conclude, or create;
- choose circumstances/problems that are contextual and interesting (current issue) that motivate students to read;
- directly related to the question and work as stimulation to solve the problems.

How to measure Higher-Order Thinking Skills in your context?

Three item/task formats are useful in measuring higher order skills: (a) selection, which includes multiple-choice, matching, and rank-order items; (b) generation, which includes short answer, essay, and performance items or tasks; and (c) explanation, which involves giving reasons for the selection or generation responses.

Session III

Interactive Session on Convections and Approximations

Prof. M. N. Bapat

The following points were discussed by the resource person

1. What is *Nucleation*?
It's process & application. Is it a necessary condition and sufficient? Replies from participants would be analysed and discussed.

2. Cause of Earth's spin about its principal axis but in different orientation, i.e., at 22.5^°.

3. Ramp it's use in day today life. Its application in age old forts / temples, their relevance.

4. Relative truth.
What our eyes, ears, tounge, nose, and hands,
Examples from participants and their analysis.

5. Use of solar PV & heat
How it can be used to cause relief to live plants and animals?
Disadvantages if any.

6. Conservation. Can it break? Actually or apparently.
Plus points.

7. Relativity of events. In motion we accept, in other fields how to judge.

8. Conventions for
a) in direction
b) in temperature
c) in choosing axes.

Any point which does not of taste of participants can be removed. Topics suggested by participants would be included.

Session IV

Heat and thermodynamics

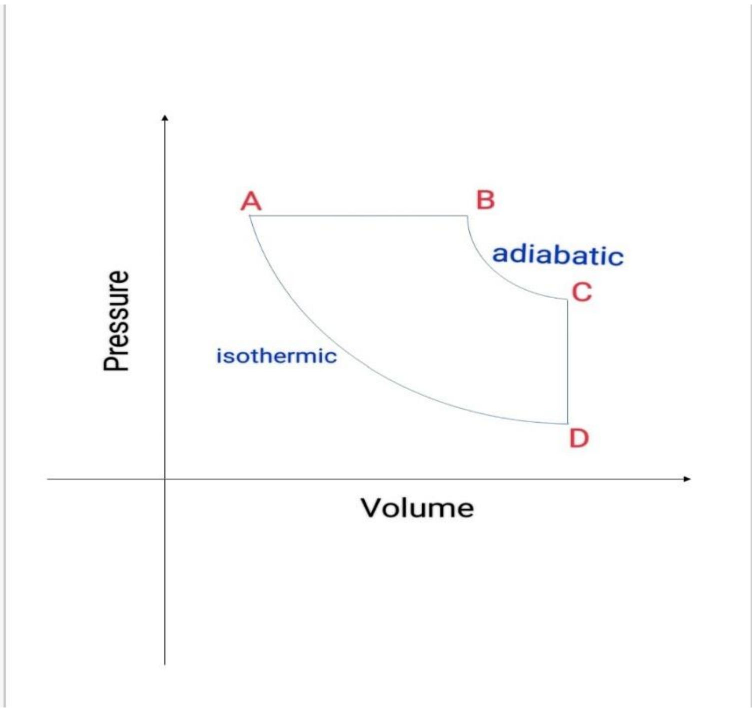
Dr. Jitendra Suryavanshi

Thermodynamics is study of Heat, work and Energy. The laws of thermodynamics deals with change in energy when a system performs work. Student can easily relate the theoretical aspects of thermodynamics with their daily life experiences. The higher order thinking questions can be easily framed to test the level of the learner. Higher order thinking and skill Questions are not only for higher level students but these are for all students to develop higher order thinking in daily life science. Higher order thinking question must be prepared as according to blooms taxonomy of cognitive domain. Thermodynamic physics as well as all science consists of scientific knowledge (such as facts, laws, theories, hypothesis etc.) and accusation of knowledge (as applications)

Very Short Questions

Q.1 What is necessary and sufficient condition for thermal equilibrium?

Q.2 Consider the following cyclic process (As shown in figure). Comment about the heat and work done in

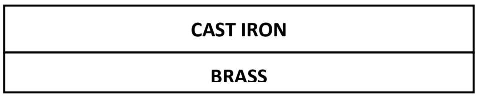


step of process.

Q.3 A system is heated by external source but there is no rise in its temperature. Where the heat energy being utilized by the system? Explain.

Short Questions

Q.4 Following device made up from welding of two different metals. When device get heated predict the shape of device. Justify your prediction.



Q.5 What would happen, if lake or river of water is cooled from bottom at cold places?

Q.6 In refrigerator, more heat is transferred to the outside then heat taken from inside. Whether the first law of thermodynamics is violated? Defend your answer.

Multiple Choice Questions

Q.7 which parameter is not important to calculate the efficiency of heat engine:

a) Heat transferred to the engine.

b) Heat transferred by the engine.

c) Change in the internal energy of the engine.

d) The work done by the engine.

Q.8 At its highest density, water will expand when it is:

a) Cooled, b) Heated, c) Ether cooled or heated, d) Pressure Applied

Q.9 Which of the following temperature is achievable?

a) 0°C b) 0°K c) -273.15°C d) -273.16°C

Long Questions

Q.10 If 15 g of 30°C water is mixed with 80 g of 55°C water. What would be the temperature of mixture?

Q.11 An adiabatic system is comprised of 1 mole of monatomic gas enclosed in a cylindrical container. It has a frictionless piston having mass 200 gm. If the piston is moved about 2 cm by the gas. Find the change in temperature of the gas. The cross section area of piston is 10 cm^3.

Q.12 A system of unit mass of water is given heat by three ways. It gains heat equal to 100 Joule in first way, 50 Calorie in second way and 200 calorie in third way. In which way temperature of water is increased most?

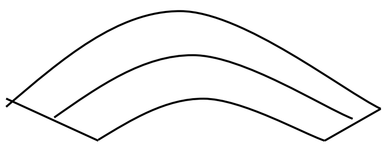
Solution 1: According to zeroth law : Equality of temperature is necessary and sufficient condition for thermal equilibrium.

Solution 2:

- A to B : Q>0, W>0
- B to C : Q>0, W>0
- C to D : Q<0, W=0
- D to A : Q = 0, W<0

Solution 3: When the system is heated externally and temperature of the system is not increased then this heat (latent heat) gained by the system is utilized in breaking the internal bonds of the system. By virtue of which system undergoes phase transition.

Solution 4:



Specific Heat of Iron is more than brass. Therefore Brass will expand more than iron.

Solution 5: If water is cooled from the bottom of a lake or river to the top, only shallow lakes would freeze solid.

Solution 6: In refrigerator, less heat is taken from inside and more heat is given to its surrounding. The access amount of heat is produced due to work in done in compressing the coolant which in turn, increases the temperature of coolant above surrounding temperature. Heat flows from coolant to surrounding which reduces the temperature of coolant. Therefore there is no violation of first law of thermodynamics.

Solution 7: c

Solution 8: c

Solution 9: b & c both

Solution 10:

Let $T_A > T_B$

Now, when water A is mixed with water B

Heat loss by $A = Heat\ gained\ by\ B$

$(\Delta Q)_A = (\Delta Q)_B$

$C_A m_A (T_A - T_m) = C_B m_B (T_m - T_B)$

$C_A m_A T_A - C_A m_A T_m = C_B m_B T_m - C_B m_B T_B$

$C_A m_A T_A + C_B m_B T_B = C_B m_B T_m + C_A m_B T_m$

$$T_m = \frac{C_A m_A T_A + C_B m_B T_B}{C_B m_B + C_A m_A}$$

Solution 11:

$Q = \Delta U + W_g$

$\therefore \Delta U = -W_g$ ....(1)

Now, work done by the gas

$W_g = \left(W_g\right)_{atm} + \left(W_g\right)_{piston}$

$W_g = PAd + mgd$..................(2)

Now, change in internal energy of the monoatomic gas is given by

$\Delta U = nC_V \Delta T$

$= n\left(\frac{3}{2}R\right)\Delta T$ $\left[\therefore C_V = \frac{3}{2}R\right]$ $for\ monoatomic\ gas$

$$\Delta U = \frac{3}{2}nR\ \Delta T$$

Using equation (2) and (3) in equation (1)

$$\frac{3}{2}nR\ \Delta T = -PAd - mgd$$

$$\therefore \Delta T = \frac{-(PAd + mgd)}{\frac{3}{2}nR}$$

Solution 12:

1 Calorie = 1000 calorie = 4.15 Joule

Specific heat of water = 1 Calorie/kg/^{o}C

Session V

Electromagnetic Waves

Prof. M. N. Bapat

1. What are Electromagnetic waves? Their properties and detection.

   What are probes and transducer. Examples related to their efficiency.
2. Electro magnetic waves & production and mode of propagation.

3. Consequences of longitudinal and transverse nature of waves.

4. What is window of em waves?

5. Communication by e-m waves.
Limitations and polarization.
How to show they carry energy?

6. Can e-m waves be stopped? Discussions on different ideas/information sought by the participants.

7. How the velocity of it changes. What remains constant
among c, lembda, and frequency?

Electromagnetic Waves

Q1. The direction of propagation of Electromagnetic wave is perpendicular to the direction of $\vec{E}$ and $\vec{B}$. Also $\vec{E}$ and $\vec{B}$ are perpendicular to each other. Develop a relationship between direction of $\vec{E}$, $\vec{B}$ and the direction of propagation vector $\vec{k}$ for electromagnetic wave travelling in Vacuum. Consider three dimensional displacement vector $\vec{E}$ and $\vec{B}$ as given below

$$E(\vec{r},t) = E_0 \exp[i(\vec{k}.\vec{r} - \omega t)]$$
$$B(\vec{r},t) = B_0 \exp[i(\vec{k}.\vec{r} - \omega t)]$$

here $\vec{k} = k_x\hat{i} + k_y\hat{j} + k_z\hat{k}$

$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$

Skills: Creating, Problem Solving

Ans: Direction of $\vec{E}$, $\vec{B}$ and $\vec{k}$ are related with a right handed screw.

From Maxwell's Equation

$\vec{\nabla} \times \vec{E} = \frac{-\partial \vec{B}}{\partial t} \dots\dots\dots..(1)$ə

Consider that $\vec{E} = E_x\hat{x} + E_y\hat{y} + E_z\hat{z}$

and $\vec{B} = B_x\hat{x} + B_y\hat{y} + B_z\hat{z}$

Thus $\vec{\nabla} \times \vec{E} = \begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ E_x & E_y & E_z \end{vmatrix}$

$= \hat{x}\left[\frac{\partial}{\partial y}E_z - \frac{\partial}{\partial z}(E_y)\right] - \hat{y}\left[\frac{\partial}{\partial x}(E_z) - \frac{\partial}{\partial z}(E_x)\right] + \hat{z}\left[\frac{\partial}{\partial x}(Ey) - \frac{\partial}{\partial y}(E_x)\right] \dots\dots(2)$

Also $\frac{\partial \vec{B}}{\partial t} = \hat{x}\frac{\partial}{\partial t}Bx + \hat{y}\frac{\partial}{\partial t}By + \hat{z}\frac{\partial Bz}{\partial t} \dots\dots..(3)$

Comparison of equation (1), (2) and (3) given that

$$\frac{\partial}{\partial y}(Ez) - \frac{\partial}{\partial z}(Ey) = -\frac{\partial Bx}{\partial t} \dots\dots\dots\dots(4a)$$

$$-\left[\frac{\partial}{\partial x}(Ez) - \frac{\partial}{\partial z}(Ex)\right] = -\frac{\partial By}{\partial t} \dots\dots\dots.(4b)$$

$$\frac{\partial}{\partial x}(Ey) - \frac{\partial}{\partial y}(Ex) = -\frac{\partial Bz}{\partial t} \dots\dots\dots.(4c)$$

Consider that E is polarized in x direction then

$$Ex = Eox \exp[i(\vec{k}.\vec{r} - \omega t)] \dots\dots\dots\dots.(5)$$

in equation (5) -$\vec{k}.\vec{r} = kx.x + ky.y + kz.z$

were k_x, k_y and k_z are components of propagation vector $\vec{k}$.

Therefore eq 5 becomes

$$Ex = Eox \exp[i(kx\,x + ky\,y + kz\,z - \omega t)] \dots\dots..(6a)$$

In a charge free region

$\vec{\nabla}.\vec{E} = \frac{P}{Eo}$ becomes

$\vec{\nabla}.\vec{E} = 0$

$$\Longrightarrow \frac{ə}{əx} Ex + \frac{ə}{əy} Ey + \frac{ə}{əz} Ey = 0 \ldots\ldots\ldots\ldots (7)$$

Equation (6a) is polarized in x direction. Similarly we can consider y and z direction as direction of polarization. Thus

$Ey = Eoy \exp[i(kx\,x + ky\,y + kzz - \omega t)] \ldots\ldots (6b)$

$Ez = Eoz \exp[i(kx\,x + ky\,y + kzz - \omega t)] \ldots\ldots (6c)$

Thus from equation for $Ex, Ey\ and\ Ez, i$ equation (7) becomes

$(i\ kx\ Eox + i\ ky\ Eoy + i\ k_2 Eoz) \exp[i(kxx + kyy + kzz) - \omega t)] = 0$

Since exponential part is not zero so

$ikx\ Eox + iky\ Foy + ikz\ Foz = 0$

or one can say that

$\vec{k}.\vec{E} = 0 \ldots\ldots.. (8)$

$\vec{k}\ and\ \vec{E}$ are perpendicular

Equations similarly to Ex, Ey and Ez, one can write equation for magnetic flux intensity

$$\vec{B} = Bx\ \hat{x} + By\ \hat{y} + Bz\ \hat{z}$$

$$Bx = Box. \exp[i(kxx + kyy + kzz - \omega t)] \ldots\ldots (9a)$$

$By = Boy. \exp[i(kxx + kyy + kzz - \omega t)] \ldots\ldots (9b)$

$Bz = Boz. \exp[i(kxx + kyy + kzz - \omega t)] \ldots\ldots (9c)$

From the definition that

$\vec{\nabla}.\vec{B} = 0$

We can conclude that

$\vec{k}.\vec{B} = 0 \ldots\ldots\ldots. (10)$

$\vec{k}$ and $\vec{B}$ are perpendicular

From equation (4), (6) and (9) for x-component

$[i\ ky\ Eoz - ikz\ Eoy] \exp[i(kxx + kyy + kzz - \omega t)]$

$= i\omega Box \exp[i(kxx + kyy + kzz) - wt]$

$\Rightarrow i[\vec{k} \times \vec{E}]_{x\_component}$

$= i\omega\ Box\ x$ ………….$(11a) \exp[i(kxx + kyy + kzz) - \omega t]$

Similarly for y and z component from equation (4), (6) and (9)

$i(\vec{k} \times \vec{E})_{y\_component}$

$= (i\omega Boy)X$ ……$(11b) \exp[i(kxx + kyy + kzz) - \omega t]$

and $i(\vec{k} \times \vec{E})_{z\_component}$

$= (i\omega\ Boy)X$ ……$(11c) \exp[i(kxx + kyy + kzz) - \omega t]$

Combining equation (11a), (11b) and (11c)

$\vec{k} \times \vec{E} = \omega\vec{B}$ ……….$(12a)$

If we change the vector $\vec{k}, \vec{E}$ *and* $\vec{B}$ in cyclic order than

$\omega\vec{B} \times \vec{k} = \vec{E}$ *or* ……….$(12b)$

$\vec{E} \times \omega\vec{B} = \vec{k}$ ……………$(12c)$

The direction of $\vec{E}, \vec{B}$ and $\vec{k}$ are related with a right handed screw.

Q2. A spacecraft in space is running out of fuel to complete its mission. What property of electromagnetic wave can be used to propel the spacecraft to save the fuel?

Skill: Creating

Ans: The property that electromagnetic waves carry momentum can be used to save the fuel. If this momentum is transferred to spacecraft then spacecraft behaves like a solar boat.

Q3. The spacecraft with solar sail (A thin sheet of material which catches the electromagnetic wave) arrangement may have two types of sails (a) a Sail made up of black material (b) a Sail made up of white material. Which sail gives maximum propulsion to the spacecraft. Justify your answer.

Skill: Analyze and Evaluate

Ans: Sail (a) absorbed all the momentum of electromagnetic radiation so the momentum delivered to the spacecraft is equal to the momentum of electromagnetic radiation.

Sail (b) reflect the electromagnetic radiation so its momentum is changed by twice of momentum of incident electromagnetic wave. Thus momentum it delivers to spacecraft is twice of incident electromagnetic wave.

So Sail (b) will be the answer.

Q4.An electromagnetic wave of wavelength 7000 A^0 travel between two points in free space. If the distance between two points is 7mm then how many wavelength will fill this distance. If the space between two points is filled with water of refractive index 1.33 then how many wavelength will fill the same space. What will be the phase difference in both the situations.

Skill: Analyze and Problem solving

10000wavelength

13300wavelength

3300*2π phase difference.

Given that the wavelength = $7000A^{\circ}$

$$= 7000 \times 10^{-10}m$$

The distance between two points $= 7mm$

$$= 7 \times 10^{-3}m$$

Thus one wavelength fill= $7000 \times 10^{-10}m$ length

(a) Total wavelength needed $= \frac{distance\ between\ points}{Length\ fill\ by\ one\ wavelength}$

$= \frac{7 \times 10^{-3}m}{7000 \times 10^{-10}m}$

$= 10000$

(b) In order the optical path length between two points will be

$= Reflective\ index\ \times 7mm\ of\ water$

$= 1.33 \times 7 \times 10^{-3}\ m$

Thus total wavelength needed will be

$= \frac{1.33 \times 7 \times 10^{-3}m}{7000 \times 10^{-10}m}$

$= 13300$

(c) If the difference in length is one wavelength thus corresponding phase diffference is 2π.

So a difference of $(13300 - 10000 =)3300$

wavelength results in phase difference of $= 3300 \times 2\pi$

Q5. A LED light bulb emits 3W power corresponding to wavelength of 6000 A^0 . How many photon's per second it should emit so that its power gets doubled.

Skill: Problem Solving

The energy emitted per second by the LED bulb $= 3\, Joule$

The energy of one photon $= hv$

$$= \frac{hc}{\lambda}$$

$$= \frac{6.626 \times 10^{-34} J.S \times 3 \times 10^{8}\, m/s}{6000 \times 10^{-10} m}$$

$$= 3.313 \times 10^{-19}\, J$$

Total photons emitted by this bulb

$$= \frac{3J}{Energy\ of\ One\ photon}$$

$$= \frac{3J}{3.313 \times 10^{-19}}$$

$$= 9.05 \times 10^{18}$$

To make the power double the number of photons should be doubled.

i.e. $2 \times 9.055 \times 10^{18}$

Q6. Amplitude modulated waves and frequency modulated waves are emitted from two different sources. Which type of waves will exhibit greater diffraction when they travel nearby us.

Skill: Problem solving

Ans: The frequency (530 kHz to 1710 kHz)of amplitude modulated wave is smaller than the frequency (88 MHz to 108 MHz) of frequency modulated wave. Therefore the corresponding wavelength (175 m to 565 m) of amplitude modulated wave is larger than the wavelength (2.77m to 3.4m) of frequency modulated wave. The objects nearby us are buildings and trees have size more than the wavelength range for frequency modulated waves. Thus AM modulated wave shows considerable diffraction.

Q7 You have observed a dish antenna to receive the digital signal for your television. Assume that the dish cross sectional area is circular and it has radius of 50 cm. The average intensity of

electromagnetic wave reaching the dish is 4×10^{-10} W/m2. Consider that a T20 match is completed in 3hrs. What is the average energy density (energy per unit volume) of the electromagnetic wave during T20 match.

Skill: Problem Solving

The average intensity

$$\bar{I} = \frac{Average\ Power}{Areaof\ dish\ cross\ section}$$

$$\Rightarrow \bar{I} = \frac{\bar{P}}{A}$$

Here $A = \pi \times r^2 = \pi \times (50 \times 15^2 m)^2$

$A = 0.785\ m^2$

The energy delivered to dish $int = 3hr$ is

$$E = \bar{P}t$$

$$= \bar{P} \times 3hr$$

$$= \bar{P} \times (3 \times 60 \times 60)s$$

The average Power

$$\bar{P} = \bar{I}A$$

$$= 4 \times 10^{-10}\,\frac{w}{m^2} \times 0.785m^2$$

$$= 3.14 \times 10^{-10}\ w\ or\ \left(\frac{J}{S}\right)$$

Thus the energy delivered in three hours

$$E = 3.14 \times 10^{-10} J$$

The energy density μ

$$\mu = \frac{E}{Volume}$$

$$= \frac{E}{\pi r^2 \times distance\ trevelled\ by\ EM\ wave\ in\ 3\ hrs.}$$

$$= \frac{E}{\pi r^2 \times (C \times 3\ hrs)}$$

$$\Rightarrow \mu = \frac{33912 \times 10^{-10}\ J}{0.785\ m^2 \times [3 \times 10^8 \times 3 \times 60 \times 60]\,\frac{m}{s}.s}$$

$\Rightarrow 1.33 \times 10^{-18}\,\frac{J}{m^3}$ **(This is the required energy density)**

Q8 Electromagnetic waves from an atomic transition emitted from Laser in the form of pulses. If the pulse duration is 10^{-8}s and emitted wavelength of light is 6328 A^0 calculate the number of waves emitted during this duration.

Skill: Problem Solving

Ans: 4740834

Time duration of Pulse is $= 10^{-8}s$

Speed of light in vacuum $= 3 \times 10^{8} m/s$

Thus pulse length $= 10^{-8}s \times 3 \times 10^{8} m/s$

$= 3m$

One wavelength $= 6328\ A^{\circ}$

$= 6328 \times 10^{-10} m$

The number of wavelengths emitted

$$= \frac{Pulse\ length}{One\ wavelength}$$

$$= \frac{3m}{6328 \times 10^{-10}}$$

$= 4740834$

Q9. The specific heat capacity of water is 4182 J/(kg.^{0}C). Consider that the electromagnetic waves coming from sun passes through a filter which permits wavelength 5500 A^{0}. The intensity of radiation coming from the filter is 1 kW/m^{2} and the area on which this intensity falls perpendicularly is 25 cm^{2}. Assume that mass of water under this area is 1 kg then how much time it will take to raise the temperature of this 1 kg water to 2^{0}C. Consider that energy is distributed instantly in whole 1kg water.

Skill: Problem Solving and Analyze

Ans: 3345.6s or 55 minute 45.6 sec.

Given that

$C = Specific\ heat\ capacity\ of\ water$

$$= 4182 \frac{J}{KG.℃}$$

The energy required to raise the temperature by one degree Celsius

$= C \times m \times \Delta T$

$= 4182 \times 1Kg \times 2℃$

$= 8364\, J$

The received intensity is $= 1000\frac{w}{m^2}$

The area of water exposed to radiation is $= 25cm^2$

$= 25 \times 10^{-4} m^2$

Thus the power received by water is

$$= 1000\frac{w}{m^2} \times 25 \times 10^{-4} m^2$$

$$= 2.5\, w$$

$$= 2.5\frac{J}{S}$$

Therefore, the time taken by radiation to raise the temperature by 2℃ will be

$$= \frac{Energy\ Required}{Energy\ delivered\ per\ second}$$

$$= \frac{8364\, J}{2.5\, J/s}$$

$$T. = 3345.6\, S$$

Session VI

Gravitation

Dr. Akash Yadav

The following points were discussed by the resource person

- Newton's Law of Universal Gravitation
- Concept of Gravitation
- Weight and Mass
- Air Resistance

Objective Type Questions

Q.1. If a body is carried from surface of the earth to moon, then

(a) The weight of a body will continuously increase,
(b) The mass of a body will continuously increase,
(c) The weight of a body will decrease first, become Zero and then increase,
(d) The mass of a body will decrease first, become Zero and then increase.

Answer: (c)

Q.2. The earth is revolving round the sun in an elliptical Orbit. If $\frac{OA}{OB} = x$, the ratio of speeds of earth at B and A will be:

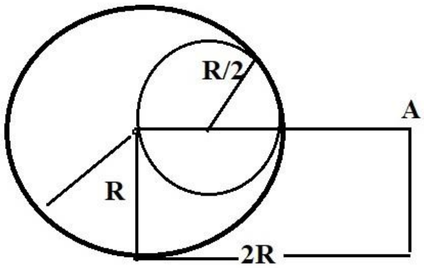
(a) x^{-1} (b) $\sqrt{x}$

(c) x^2 (d) $x\sqrt{x}$

Answer: (a)

Very Short Questions

Q.1. A solid sphere of uniform density and radius R applies a gravitational force of attraction equal to F_1 on a particle at point A placed at a distance $2R$ from the centre of the sphere. A spherical cavity of radius $\frac{R}{2}$ is now made in the sphere as shown in figure. The sphere with Cavity now applies a gravitational force F_2 on the same particle. The ratio $\frac{F_2}{F_1}$ is:



Answer: $\frac{7}{9}$

Q.2. A space ship is launched in a circular orbit close to earth's surface. What additional velocity has now to be imparted to the spaceship in the orbit to overcome the gravitational pull? (Radius of earth= $6400\ Km, g = 9.8\ m/s^2$)

Answer: The orbital velocity of spaceship, $V_0 = \sqrt{\frac{GM}{r}}$

If space, ship is very near to earth's surface,

r = Radius of earth = R

$$V_0 = \sqrt{\frac{GM}{R}} = \sqrt{Rg} = \sqrt{6.4 \times 10^6 \times 9.8}$$

$= 7.9195 \times \frac{10^3 meter}{sec} = 7.9195\ km/s$

The escape velocity of space-ship

$V_e = \sqrt{2Rg} = 7.9195\ \sqrt{2} = 11.2\ km/s$

It is true for all material bodies on earth.

Additional velocity required $= 11.2 - 7.9195 = 3.2805\ km/s$

Q.3. The mass and radius of earth and moon are M_1, R_1 and M_2, R_2 respectively. Their centers are d distance apart. With what velocity should a particle of mass m be projected from the midpoint of their centers so that it may escape out to infinity?

Answer: Total energy of the particle at P

$E = E_K + U$

$$= \frac{1}{2} m v_e^2 - \frac{GM_1 m}{\frac{d}{2}} - \frac{GM_2 m}{\frac{d}{2}}$$

$$= \frac{1}{2} m v_e^2 - \frac{2Gm}{d}(M_1 + M_2)$$

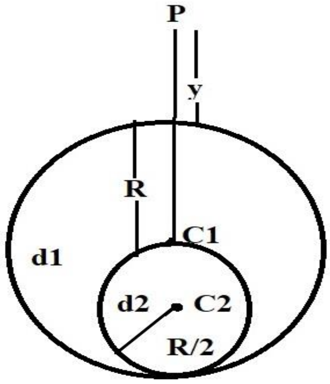
At infinite distance from M_1 and M_2, the total Energy of the particle is Zero.

$$\therefore \frac{1}{2}\ m v_e^2 = \frac{2Gm}{d}(M_1 + M_2)$$

$$\therefore v_e = \sqrt{\frac{4G}{d}(M_1 + M_2)}$$

Short Questions

Q.1. On to a sphere of radius $\frac{R}{2}$ and density d_2 with center at C_2 a second sphere is moulded with density d_1 radius R and centre C_1. Find the force experienced by a point mass m at point P at a distance y from the combination as shown in figure.



Answer: If we consider that a sphere of radius R is placed with centre at C_1 of density d_1 the force on the mass at P is:

$F_1 = \frac{G\frac{4}{3}\pi R^3 d_1 m}{(R+y)^2}$ towards the sphere

If we consider that a sphere of radius $\frac{R}{2}$ is placed with centre at C_2 of density d_1 the force on the mass at P is

$F_2 = \frac{G\frac{4}{3}\pi\left(\frac{R}{2}\right)^3 d_1 m}{\left(\frac{R}{2}+R+Y\right)^2}$ towards the sphere

If we consider that a sphere of radius $\frac{R}{2}$ is placed with centre at C_2 of density d_2 the force on the mass at P is:

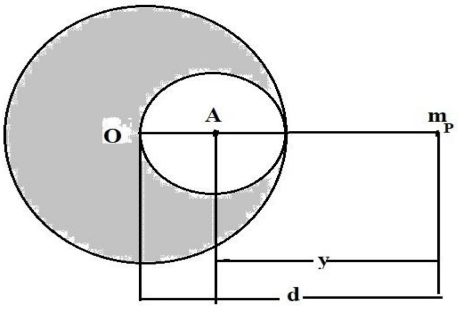
$F_3 = \frac{G\frac{4}{3}\pi\left(\frac{R}{2}\right)^3 d_2 m}{\left(\frac{R}{2}+R+Y\right)^2}$

By the principle of Superposition

$F = F_1 + F_2 + F_3 = \frac{4}{3}\pi R^3 Gm\left[\frac{d_1}{(R+y)^2} + \frac{(d_2-d_1)/8}{\left(3\frac{R}{2}+y\right)^2}\right]$ **Answer**

Q.2. A spherical hollow sphere is made in a lead sphere of Radius R such that its surface touches the outside surface of the lead sphere and passes through its centre. The mass of the lead sphere before hollowing was M. What is the force of attraction that this sphere would exert on a particle at point P of mass m which lies at a distance d from the center of lead

sphere on the straight line joining the centers of the sphere and the hollow sphere. (as shown in figure)



Answer: As the point mass m is outside the lead sphere. We can assume its mass to be concentrated at the centre. Here we will apply the principle of Superposition which gives net force on mass m due to two spheres of radii R and $\frac{R}{2}$ and mass m . We should calculate the force due to the solid sphere and subtract from this the force which the mass of the hollowed sphere would have exerted on m i.e.

$$F = \frac{GMm}{d^2} - \frac{GM'm}{y^2}$$

But from figure:

$$y = \left[d - \frac{R}{2}\right]$$

and as $M = \frac{4}{3}\pi R^3 \rho$

$M^1 = \frac{4}{3}\pi \left(\frac{R}{2}\right)^3 \ \rho = \frac{M}{8}$

So $F = \frac{GMm}{d^2} - \frac{GMm/8}{\left[d-\frac{R}{2}\right]^2}$

$$= \frac{GMm}{d^2}\left[1 - \frac{1}{8\left[1 - \frac{R}{2d}\right]^2}\right]$$

Q.3. An artificial satellite (of mass m) of the earth (radius R and mass M) moves in an orbit whose radius is n times, the radius of the earth assuming resistance to the motion to be proportional to the square of Velocity, that is, $F = av^2$, find how long the satellite will take to fall on to the earth.

Answer: Energy of the satellite

$$E = \frac{-GMm}{r} + \frac{1}{2}mv^2$$

By the dynamics of the circular motion

$$\frac{GMm}{r^2} = \frac{mv^2}{r}$$

$$v = \sqrt{\frac{GM}{r}}$$

$$\therefore E = \frac{-GMm}{r} + \frac{1}{2}\frac{GMm}{r} = \frac{-1}{2}\frac{GMm}{r}$$

$$\frac{dE}{dr} = \frac{1}{2}\frac{GMm}{r^2}$$

Also $-dE = power \times dt = Fv\ dt = av^3 dt$

Now $v^3 = \left(\frac{GM}{r}\right)^{\frac{3}{2}}$

$$\therefore \frac{1}{2}\frac{GMm}{r^2}dr = -a\left(\frac{GM}{r}\right)^{\frac{3}{2}}\ dt$$

$$dt = \frac{-m}{2a\sqrt{GM}}\ r^{-\frac{1}{2}}dr$$

The time taken for the satellite to fall on the surface of the earth

$$\therefore t = \frac{-m}{2a\sqrt{GM}}\int_{nR}^{R} r^{-\frac{1}{2}}dr$$

$$= \frac{m\sqrt{R}}{a\sqrt{GM}}\left(\sqrt{n} - 1\right)$$

$\because GM = gR^2,$

$$t = \frac{m}{a\sqrt{gR}}\left(\sqrt{n} - 1\right)$$

Long Questions:

Q.1. A planet moves around the Sun in an elliptical orbit of semi major axis a and eccentricity e. If the mass of Sun is M, find the velocity of the planet at perigee and apogee.

Answer: Let m be the mass of the planet

As it is clear from the figure

$r_P = a - c$

$r_a = a + c$

Applying the conservation of angular momentum at the perigee and apogee.

We get $mv_P r_P = mv_a r_a$

$$\frac{v_P}{v_a} = \frac{r_a}{r_P} = \frac{a + c}{a - c}\ \ldots\ldots\ldots(1)$$

Using conservation of mechanical energy, we get

$$\frac{1}{2}mv_P^2 - \frac{GMm}{r_P} = \frac{1}{2}mv_a^2 - \frac{GMm}{r_a}$$

$$v_P^2 - v_a^2 = 2GM\left(\frac{1}{r_P} - \frac{1}{r_a}\right) \dots \dots \dots (2)$$

From equation (1) and (2), we get

$$v_a^2 = \frac{2GM}{r_P + r_a}\left(\frac{r_P}{r_a}\right)$$

$$= \frac{GM}{a}\left(\frac{a-c}{a+c}\right)$$

Since $e = \frac{c}{a}$, then $v_a = \sqrt{\frac{GM(1-e)}{a(1+e)}}$

and $v_P = \sqrt{\frac{GM(1+e)}{a(1-e)}}$

Q.2. A Cosmic body A moves towards the Sun S with velocity v_0 when far from the Sun and aiming along a line whose perpendicular distance from the Sun is d. Find the minimum distance of this body from the sun (Mass of the Sun is M).

Answer: By the law of conservation of Energy

$$\frac{1}{2}mv_0^2 = \frac{1}{2}mv^2 - \frac{GMm}{d_{min}} \dots \dots \dots .. (1)$$

By conservation of angular momentum of the body about S (remember moment of momentum is angular momentum)

mv_0d = mvd$_{min}$ ……………………(2)

from equation (1) and (2)

$$\frac{1}{2}v_0^2 = \frac{1}{2}\left(\frac{dv_0^2}{d_{min}}\right)^2 - \frac{GM}{d_{min}}$$

$$d^2v_0^2x^2 - 2GMx - v_0^2 = 0$$

Let $\frac{1}{dmin} = x$

$$x = \frac{2GM \pm \sqrt{4G^2M^2 + 4V_0^4d^2}}{2d^2v_0^2}$$

$$\therefore d_{min} = \frac{d^2v_0^2}{GM + \sqrt{G^2M^2 + v_0^4d^2}}$$

$$= \frac{d^2v_0^2\sqrt{G^2M^2 + v_0^4d^2} - GM}{v_0^4d^2}$$

$$d_{min} = \frac{GM}{v_0^2}\left(\sqrt{1+\frac{d^2v_0^4}{G^2M^2}}-1\right)$$

Q.3. With what speed v_0 should a body be projected as shown in figure, with respect to a planet of mass M, so that it would just be able to graze the planet and escape? The radius of the planet is R. (Assume that the planet is fixed)

Answer: By conservation of angular momentum we obtain

$$mv_0d = mvr$$

$$v = \frac{mv_0d}{mr} = v_0\left(\frac{d}{r}\right)$$

By conservation of energy at A and B, we have

$$\frac{1}{2}mv_0^2 - \frac{GMm}{\sqrt{d^2+D^2}} = \frac{1}{2}mv^2 - \frac{GMm}{r}$$

When $r \approx R$ we obtain

$$\frac{1}{2}mv_0^2 - \frac{GMm}{\sqrt{D^2+d^2}} = \frac{1}{2}m\frac{v_0^2d^2}{R^2} - \frac{GMm}{R}$$

$$\frac{1}{2}mv_0^2\left(\frac{d^2}{R^2}-1\right) = GMm\left[\frac{1}{R}-\frac{1}{\sqrt{D^2+d^2}}\right]$$

$$v_0 = \sqrt{\frac{2GM\left(\frac{1}{R}-\frac{1}{\sqrt{D^2+d^2}}\right)}{\left(\frac{d^2}{R^2}-1\right)}}$$

Session VII

Atom and Nuclei

Dr. Jitendra Suryawanshi

The following points were discussed by the resource person

- Analysis: Analyze the behavior of atoms and nuclei under different conditions, such as high temperatures or pressure.
- Evaluation: Evaluate the accuracy and limitations of different models of atoms and nuclei, such as the Bohr model or the nuclear shell model.
- Synthesis: Create a model or representation of an atom or nucleus that incorporates new or unusual properties.
- Application: Apply the principles of atomic and nuclear physics to solve real-world problems, such as designing nuclear reactors or medical imaging techniques.
- Comparison: Compare and contrast the properties of different isotopes or elements and their implications for atomic and nuclear physics.
- Interpretation: Interpret and analyze data from experiments involving atoms and nuclei to draw conclusions and make predictions.
- Problem-Solving: Develop strategies for solving problems related to atomic and nuclear physics, such as calculating decay rates or determining the energy levels of an atom.
- Prediction: Predict the behavior of atoms and nuclei in different situations, such as how they will behave in a magnetic field or how they will decay over time.
- Generalization: Generalize the principles of atomic and nuclear physics to other areas of physics, such as quantum mechanics or particle physics.
- Creativity: Use imagination and creativity to design novel applications or uses for atomic and nuclear physics that have not been explored before, such as using nuclear reactions to generate clean energy or developing new cancer treatments based on radiation therapy.

Very Short Answer:

Q.1. Find the specific charge of an electron by application of magnetic field.

Solution 1: The e/m ratio was first measured by J.J. Thomson in 1897. He won a Nobel Prize on study of electron. To calculate e/m ratio, a beam of electron is accelerated through known potential that is why velocity of electron is also known. A uniform and measurable magnetic field is applied at right angle to the electron beam. This magnetic field deflects the electron beam in a circular path.

In circular path, electron beam is provided by centripetal force

$$\therefore \frac{mv^2}{r} = evB$$

$$\Rightarrow \frac{e}{m} = \frac{v}{rB} \dots \dots \dots \dots \dots \dots (1)$$

Using above relation, e/m (specific charge) can be calculated.

Q.2. Why Thomson atomic model was discarded after Rutherford's gold foil experiment,

Solution 2:

1. Gold foil experiment showed that there is a lot of empty space in an atom but Thomson atomic model suggested there is no empty space in the atom.
2. There is no nucleus like entity according to Thomson atomic model but gold foil experiment showed that there is a very dense, small and positive charge region inside the atom.

These were the results of the gold foil experiment due to which Thompson atomic were discarded.

Q.3 Why electron of any atom does not collapse into the nucleus, although it continuously accelerates in the electric field of nucleus.

Solution 3: When a charge particle accelerates in electric field then it radiates energy. According to Bohr's atomic model, when electrons revolve around the electric field of nuclear in certain discrete stationary orbits than it does not radiate energy. They do so only when they make transition between these stationary orbits.

Short Answer:

Q.4 Why emission spectra has more lines than absorption spectra of most of the elements?

Solution 4: In emission spectra, excited electrons come to ground state making transition to various intermediate states between exited state and ground state. Each transition corresponds to spectral line emission spectra. While, in absorption spectra, spectral line corresponds to a single transition of electron from its ground state to excited state. Therefore usually more lines occur in emission spectra of element then its absorption spectra.

Q.5 An electron in Hydrogen atom jumps from an energy level "-0.378 eV" to energy level "-3.40 eV". Find the colour of corresponding spectral line in emission spectra of hydrogen atom.

Solution 5:

As we know

$\Delta E = hv$

$\Longrightarrow v = \frac{\Delta E}{h}$

$\Longrightarrow \frac{C}{\lambda} = \frac{\Delta E}{h}$

$\Longrightarrow \lambda = \frac{hC}{\Delta E} = \frac{hc}{(E_n - E_P)}$

∴ Substituting the values

$$\lambda = \frac{6.62 \times 10^{-34} \times 3 \times 10^{8}}{(3.40 - 0.378) \times 1.6 \times 10^{-19}} m$$

$= 410.7\ nm$ (Violet)

Q.6 Why the positions of spectral lines are same in emission and absorption spectra of any element?

Solution 6: In absorption spectra, certain wavelengths are observed due to transition of electron from ground state to excited state. This appears as a dark line in absorption spectra. This same wavelength appears in emission spectra when that same electron makes transition between the same excited state to same ground state. Therefore lines in the emission and absorption spectra appear at the same position on wavelength scale.

Multiple Choice Questions

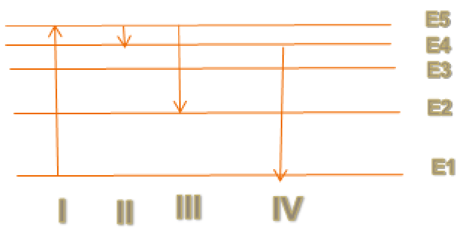
Q.7 Bohr atomic model is based on:

- **a) Only classical theory of physics,**
- **b) Only quantum theory of physics,**
- **c) Both classical and quantum theory of physics,**

Solution 7: c) Both classical and quantum theory of physics

Q.8 Following diagram shows electron energy levels with electron transitions. Which transition corresponds to the shortest wavelength?

- **a) I,**
- **b) II,**
- **c) III,**
- **d) IV**



Solution 8: a) I

Q.9 Elements of outer planet are identified by:

a) Absorption spectra,

b) Emission spectra,

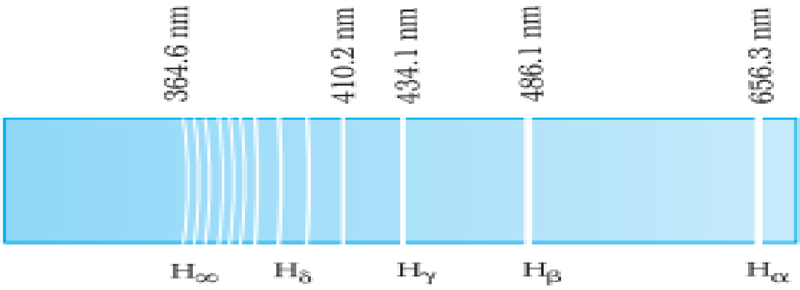
c) Continuous spectra,

d) Visible spectra.

Solution 9: a) Absorption spectra

Long Questions

Q.10 Following figure shows the Balmer's series in the emission spectrum of hydrogen atom:



Explain the emission spectrum by drawing the corresponding energy level diagram and transition for Hα spectral line by Balmer's empirical formula.

Solution 10: Hα line is the Balmer series is a specific deep red visible spectral line with wavelength of 656.28 nm in air and 656.46 nm in vacuum. It occurs when a electron of hydrogen atom falls from its third lowest energy level to second lowest energy level. It is a brightest line in hydron emission spectra.

Thus, by Balmer's empirical formula

$$\bar{v} = \frac{1}{\lambda} = R_H \left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$$

$$\therefore \frac{1}{\lambda} = R_H \left[\frac{1}{2^2} - \frac{1}{3^2}\right]$$

$$= R_H \left[\frac{1}{4} - \frac{1}{9}\right]$$

$$\frac{1}{\lambda} = \frac{5R_H}{36}$$

$$\therefore \lambda = \frac{36}{5R_H} = 6.5628 \times 10^{-7} m$$

$\lambda = 656.28$ nm

Q.11 Density of tungsten and gold are 9.300 gm/cm^3 and 9.320 g/cm^3 respectively. Can we use the tungsten foil instead of gold foil in Rutherford gold foil experiment? Defend your answer.

Solution 11: Gold is the most malleable of all known metals. It can be easily be converted into very thin sheets. Although the density of tungsten is almost same to that of gold, but gold is more malleable and ductile than any other elements. In Rutherford experiment, very thin sheet of metallic foil (only for atomic layer thin) was required. It was possible with only gold foil. Therefore we do not use tungsten foil instead of gold foil in Rutherford's experiment.

Q.12 In a head on collision between an alpha particle and gold nucleus (Z=79), the distance of closest approach is 39.5 fermi. Find the maximum repulsive force between the alpha particle and gold nucleus.

Solution 12: In Rutherford's gold foil experiment, the distance of closest approach is 39.5 Fermi. The maximum repulsive force between alpha particle (2e) and gold nucleus (79e) can be calculated by coulomb's law i.e.

$$F = \frac{1}{4\pi E_0} . \frac{(2e)(79e)}{(39.5\ F)}$$

$$= \frac{9 \times 10^9 \times 2 \times 79 \times (1.6 \times 10^{-19})}{(39.5 \times 10^{-15})^2} N$$

$$= 1.458 \times 10^{20}\ N$$

Session VIII

Magnetism

Dr. Akash Yadav

The following points were discussed by the resource person

- Magnetic Fields and Force
- Magnetic Force on a Current-Carrying Wire
- Torque on a Current Loop
- The Magnetic Dipole Moment
- Magnetic Fields Produced by Currents
- Faraday's Law of Induction and Lenz's Law

Magnetism

Objective Type Questions:

Q.1. The magnetic moment of an electron orbiting in a circular orbit of radius r with a speed v is equal to:

(a) $\frac{evr}{2}$ (b) evr (c) $\frac{er}{2v}$ (d) None of these

Answer: (a)

Solution: Magnetic movement $\mu = nIA$

Where $n =$ number of turns of the current loop, and $I =$ current

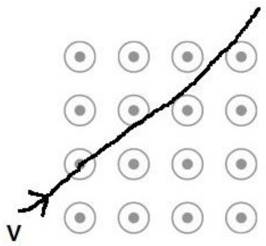
Since the Orbiting electron behaves as a current loop of current I,

So $I = \frac{e}{T} = \frac{e}{2\pi r/v} = \frac{ev}{2\pi r}$

$A =$ Area of the loop $= \pi r^2$

$\mu = (1)\left(\frac{ev}{2\pi r}\right)(\pi r^2) = \frac{evr}{2}$ **Answer.**

Q.2. A particle enters the region of a uniform magnetic field as shown in figure. The path of the particle inside the field is shown by a dark line. The particle is:



(a) Electrically neutral

(b) Positively charged

(c) Negatively charged

(d) Nothing definite can be said about the nature of the charge as the information given is inadequate.

Answer: (c)

Q.3. An electron moves straight inside a charged parallel plate capacitor of uniform surface charge density $\boldsymbol{\sigma}$. The space between the plates is filled with constant magnetic field of induction $\vec{B}$ as shown in figure, Neglecting gravity, the time of straight line motion of the electron in the capacitor is:

(a) $\frac{\sigma}{\varepsilon_0 l_B}$ (b) $\frac{\varepsilon_0 l_B}{\sigma}$ (c) $\frac{\sigma}{\varepsilon_0 B}$ (d) $\frac{\varepsilon_0 B}{\sigma}$

Answer: (b)

Solution: The net electric field

$$\vec{E} = \vec{E}_1 + \vec{E}_2$$

$$E = \frac{\boldsymbol{\sigma}}{2\varepsilon_0} + \frac{\boldsymbol{\sigma}}{2\varepsilon_0} = \frac{\boldsymbol{\sigma}}{\varepsilon_0}$$

The net force acting on the electron is zero because it moves with constant velocity

$$\vec{F}_{net} = \vec{F}_e + \vec{F}_m = 0$$

$$|\vec{F}_e| = |\vec{F}_m|$$

$$e_E = evB$$

$$v = \frac{E}{B} = \frac{\boldsymbol{\sigma}}{\varepsilon_0 B}$$

∴ The time of motion inside the capacitor

$t = \frac{l}{v} = \frac{\varepsilon_0 lB}{\sigma}$ **Answer**

Q.4. Two wires wrapped over a conical frame form coils 1 and 2. If they produce no net magnetic field at the apex *P*, the value of $\frac{I_1}{I_2}$ =

(a) $\sqrt{\frac{r2}{r_1}}$ (b) $\frac{r_1}{r_2}$ (c) $\left(\frac{r_1}{r_2}\right)^2$ (d) $\sqrt{\frac{r_1}{r_2}}$

Hint B = $\frac{\mu_0 I}{2r}$

Answer: (b)

Solution:

For loop 1

$$B_1 = \frac{\mu_0 I_1}{2r_1}(+\hat{j})$$

For loop 2

$$B_2 = \frac{\mu_0 I_2}{2r_2}(-\hat{j})$$

∵Net Magnetic field at P is zero

So

$$\vec{B}_1 + \vec{B}_2 = 0$$

$$B_1 = B_2$$

$$\frac{\mu_0 I_1}{2r_1} = \frac{\mu_0 I_2}{2r_2}$$

$\frac{I_1}{I_2} = \frac{r_1}{r_2}$ **Answer**

Very Short Answer

Q.1. The magnetic field at Q, where Q is the centre of the circular loop lying in $y - z$ plane is:

$$\vec{B}_1 = \frac{\mu_0 I}{2a}(-\hat{\imath})$$

Magnetic field due to the Z-axis at Q point

$$\vec{B}_2 = \frac{\mu_0}{4\pi a} 2I(+\hat{\imath})$$

Magnetic field due to the X-axis at Q point

$$\vec{B}_3 = \frac{\mu_0}{4\pi a} 2I(+\hat{k})$$

Resultant Magnetic field of B_1 and B_2

$$B^1 = B_1 - B_2$$

$$B^1 = \frac{\mu_0 I}{2a}\left(1 - \frac{1}{\pi}\right)(-\hat{\imath})$$

Resultant Magnetic field of B_1 and B_3

$$B = \sqrt{B_3^2 + B_1^2 + 2B_3.B^1 \cos 90^\circ}$$

$$= \sqrt{B_3^2 + B_1^2}$$

$$= \sqrt{\left(\frac{\pi_0}{4\pi a} 2I\right)^2 + \left[\frac{\mu_0 I}{2a}\left(1 - \frac{1}{\pi}\right)\right]^2}$$

$= \frac{\mu_0 I}{2a}\sqrt{\left(\frac{1}{2\pi}\right)^2 + \left(1 - \frac{1}{\pi}\right)^2} = \frac{\mu_0 I}{2a}\left(\frac{1}{\pi} - 1\right)$ Answer

Magnetic field at O point due to Circular loop (radius a)

$\vec{B}_1 = \frac{\mu_0 I}{2a}(+\hat{K})$

Magnetic field at O point due to Circular loop (radius b)

$\vec{B}_2 = \frac{\mu_0 I}{2b}(-\hat{K})$

Magnetic field at O point due to the linear

$\vec{B}_3 = \frac{\mu_0}{4\pi b} 2I(-\hat{K})$

Because not magnetic field at O point is Zero

So $\vec{B}_1 + \vec{B}_2 + \vec{B}_3 = 0$

$B_1 - B_2 - B_3 = 0$

$\frac{\mu_0 I}{2a} - \frac{\mu_0 I}{2b} - \frac{\mu_0 2I}{4\pi b} = 0$

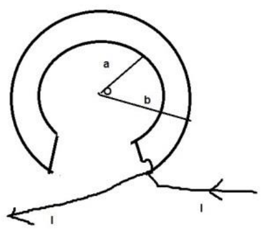
$\frac{\mu_0 I}{2a} = \frac{\mu_0 I}{2b}\left(1 + \frac{1}{\pi}\right)$

$\frac{1}{a} = \frac{1}{b}\left(1 + \frac{1}{\pi}\right)$

$\frac{1}{a} = \frac{1}{b}\left(\frac{\pi + 1}{\pi}\right)$

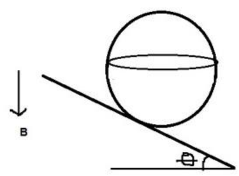
$\frac{a}{b} = \left(\frac{\pi}{\pi+1}\right)$ **Answer**

Q.2. The value of $\frac{a}{b}$ so as to get a zero magnetic field at O is:



Answer. $\frac{\pi}{(\pi+1)}$

Q.3. In the figure shown, a coil of single turn is would on a sphere of radius r and mass m. The plane of the coil is parallel to the inclined plane and lies in the equatorial plane of the sphere. If the sphere is in rotational equilibrium, the value of B is (current in the coil is I)



Answer. The gravitational torque must be counter balanced by the magnetic torque about O, for equilibrium of the sphere. The gravitational torque:

$\tau_{gr} = mg \times r \sin\theta$

$\tau_{gr} = mgr \sin\theta \ldots\ldots\ldots (1)$

The magnetic torque, $\tau_m = \vec{\mu} \times \vec{B}$

Where the magnetic moment of the coil = $\mu = I\pi r^2$

$\tau_m = \pi I r^2 B \sin\theta \ldots\ldots\ldots (2)$

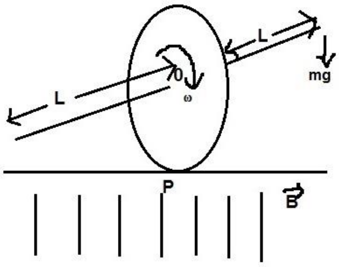
By equation (1) and (2)

$\pi I r^2 B \sin\theta = mgr \sin\theta$

$\boldsymbol{B = \frac{mg}{\pi I r}}$

Short Questions:

Q.1. A wheel of mass M and radius r having charge Q, uniformly distributed over its rim is rolling on rough horizontal ground without slipping about a light rod of length $2L$. A uniform magnetic field B, directed opposite to the gravitational field, is switched on in the space. Find the value of mass m that should be placed at the end of rod to prevent the toppling of wheel.



Answer. Torque acting on the wheel due to magnetic field,

$$T_B = \frac{q}{\frac{2\pi}{\omega}} \times \pi R^2 \times B = \frac{q\omega B R^2}{2}$$

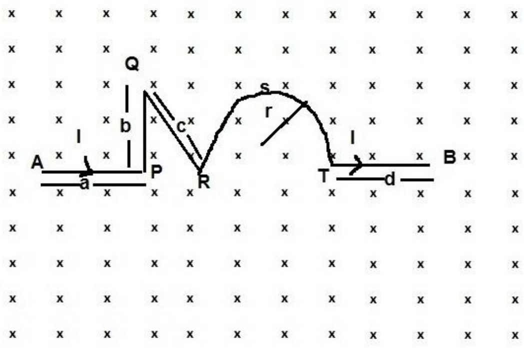
Take moment about P

$T_B = MgL$

$$\frac{q\omega B R^2}{2} = MgL$$

$\boldsymbol{M = \frac{q\omega B R^2}{2gl}}$

Q.2. Calculate the force on a current carrying conductor in a uniform magnetic field as shown.



Answer. The net force A to $B, dF = I(dL \times B)$

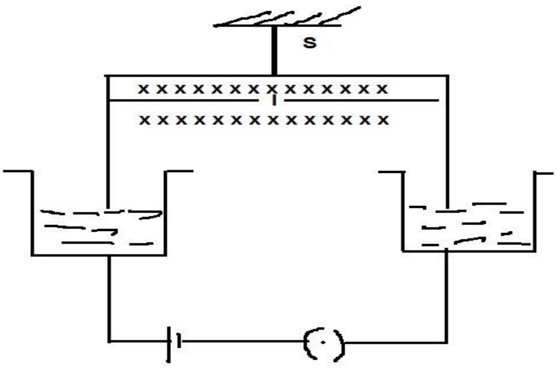
$$\int_A^B d\vec{F} = \int_A^P I[d\vec{L}_1 \times \vec{B}] + \int_P^Q I[d\vec{L}_2 \times \vec{B}] + \int_Q^R I[d\vec{L}_3 \times \vec{B}] + \int_R^T I[d\vec{L}_4 \times \vec{B}] + \int_T^B I[d\vec{L}_5 \times \vec{B}]$$

The entire path can be broken down into elemental vectors joined to each other in sequence. We know, from polygon law of addition of vectors that the vector joining the tail of the first vector to the head of the last vector is the resultant vector.

$\vec{F} = I(\vec{L} \times \vec{B})$, where $|\vec{L}| = a + \sqrt{c^2 - b^2} + 2r + d$

$F_{net} = IB(a + \sqrt{c^2 - b^2} + 2r + d)$ and direction is upwards in the plane of paper.

Q.3. A U-shaped rod of mass m and horizontal length l hangs from a rigid support by a non-conducting strings. The ends of the rod are immersed in a conducting liquid. When the key is closed at $t = 0$, a current is passed through the rod and the rod jumps up by an impulse of Ampere's force, through a height h. If the inward magnetic field is B, find the total charge passing through the rod.



Answer. Let the speed of the wire is v.

Then, $\int F dt = mv$, where

$F = Ilb$

$\because \int F dt = mv$

$$\int IlBdt = mv$$

$$lBq = mv \qquad \because Idt = q$$

$$q = \frac{mv}{lB} \text{ where } v = \sqrt{2gh}$$

Then $q = \frac{m\sqrt{2gh}}{lB} = \frac{10^{-3}\sqrt{2\times9.8\times2}}{(15\times10^{-3})(0.2)} = 2.08\ Columb$

Long Questions:

Q.1. A particle of mass 1×10^{-26} Kg and charge $+1.6 \times 10^{-19}$ coulomb travelling with a velocity of 1.28×10^{6} m/sec in the $+x$ direction enters a region in which a uniform electric field E and a uniform magnetic field of induction B are present. Such that $E_x = E_y = 0, E_Z = -102.4\frac{KV}{meter}$ and $B_x = B_z = 0, B_y = 8 \times 10^{-2}\frac{Wb}{meter^2}$. The particle enters this region at the origin at time $t = 0$. Determine the location on (x, y and z coordinates) of the particle at $t = 5 \times 10^{-6}$ second. If the electric field is switched off at this instant (with the magnetic field still present), What will be the position of the particle at $t = 7.45 \times 10^{-6}$second?

Answer. Let $\hat{\imath}, \hat{\jmath}$ and $\hat{k}$ be unit vectors along the positive directions of x, y and z axis.

Q = Charge on the particle = 1.6×10^{-19} columb

v =Velocity of the charged particle

$= (1.28 \times 10^{6})^{\hat{\imath}}\frac{meter}{sec}$

$\vec{E}$ = Electric field intensity

$= (-102.4 \times 10^{3}\ Vm^{-1})\ \hat{k}$

$\vec{B}$ = Magnetic induction of the magnetic field

$= \left(8 \times 10^{-2}\frac{Wb}{m^2}\right)\hat{\jmath}$

$\therefore\ \vec{F_e}$ = Electric force on the charge

$= q\vec{E} = [1.6 \times 10^{-19}(-102.4 \times 10^{3})N]\hat{k}$

$= 163.84 \times 10^{-16}\ Newton\ (-\hat{k})$

$\vec{F_m}$ = Magnetic force on the charge

$= q\vec{v} \times \vec{B}$

$= 1.6 \times 10^{-19}(1.28 \times 10^{6})(8 \times 10^{-2})N(\hat{\imath} \times \hat{\jmath})$

$= (163.84 \times 10^{-16}\ Newton\ )(\hat{k})$

The two forces $\vec{F_e}$ and $\vec{F_m}$ are along z axis and equal, opposite and Collinear.

The net force on the charge is zero and hence the particle does not get neglected and continues to travel along x-axis

(a) At time $t = 5 \times 10^{-6}\, second$

$X = (5 \times 10^{-6})(1.28 \times 10^{6}) = 6.4\, meter$

∴ Co-ordinators of the particle are $(6.4m, 0, 0)$

(b) When the Electric field is switched off, the particle is in the uniform magnetic field perpendicular to its velocity only has a uniform Circular motion in the X-Z plane (i.e. the plane of Velocity and magnetic force), anticlockwise as seen along +y axis.

Now $\frac{mv^2}{r} = qvB,$ Where r is the radius of the circle

$$\therefore r = \frac{mv}{qB} = \frac{(1 \times 10^{-26})(1.28 \times 10^{6})}{(1.6 \times 10^{-19})(8 \times 10^{-2})} = 1$$

The length of the arc traced by the particle in $[(7.45 - 5) \times 10^{-6}s]$

$= v(t) = (1.28 \times 10^{6})(2.45 \times 10^{-6}) = 3.136$ meter = $\pi m = \frac{1}{2}$ circumference

∴ The particle has the coordinates $(6.4m, O, 0.2m)$ as (x, y, z).

2. A particle of mass m and charge q is projected from the origin with a velocity $\vec{v} = a\hat{i} + b\hat{j} + c\hat{k}$ at $t = 0$, in an electric field $\vec{E} = E\hat{J}$ and magnetic field $\vec{B} = B\hat{J}$. Find the position vector of the particle after a time t.

Answer. The components of velocity of the particle parallel and perpendicular to $\vec{B}$ are

$v_{||} = v\cos\theta$ and $v_{\perp} = v\sin\theta$

The period of revolution of the particle is:

$$T = \frac{2\pi m}{qB}$$

Then, the angular frequency of revolution is $w = \frac{2\pi}{T} = \frac{qB}{m}$

The radius of the circular path is $r_0 = \frac{mv_{\perp}}{qB}$

After a time $t,$ (assuming $E = 0$ and $v_{||} = 0$)

the chord $OA = 2r_0 \sin\frac{wt}{2}$

and the angle β made by OA with X=axis is

$$\beta = 90^{\circ} - \left(\frac{wt}{2} + \emptyset\right),$$

Where $\emptyset = \tan^{-1}\left(\frac{v_z}{v_x}\right) = \tan^{-1}\frac{c}{a}$

Then, $v_x(=x) = OA\cos\beta,$

$r_z(=z) = OA\sin\beta$

and $r_y = v_{\parallel}t + \frac{1}{2}\frac{qE}{m}t^2$

$$\vec{r} = OA\cos\beta\,\hat{\imath} + \left(v_{\parallel}t + \frac{1}{2}\frac{qE}{m}\ t^2\right)\hat{J} + OA\sin\beta\,\hat{k},$$

Where $OA = 2r_0\sin\frac{wt}{2}$

Or $\vec{r} = 2r_0\frac{\sin wt}{2}\cos\ \beta\,\hat{\imath} + \left(v_{11}t + \frac{1}{2}\frac{qE}{m}t^2\ \right)\hat{\jmath} + 2r_0\sin\frac{\omega t}{2}\sin\beta\hat{\jmath}$

Where $w = \frac{qB}{m}, v_{\parallel} = b, r_0 = \frac{m\sqrt{a^2+c^2}}{qB}\ and\ \beta = 90^{\circ} + \frac{wt}{2} - \emptyset$

Or $\vec{r} = \frac{-2m\sqrt{a^2+c^2}}{qB}\frac{\sin qB}{2m}t\sin\left(\frac{wt}{2} - \emptyset\right)\hat{\imath} + \left(bt + \frac{qE}{2m}t^2\right)\hat{J} + \frac{2m\sqrt{a^2+c^2}}{qB}\ \frac{\sin qB}{2m}t.\cos\left(\frac{wt}{2} - \emptyset\right)\hat{k},$

Where $\emptyset = \tan^{-1}\frac{a}{c}$

Q.3. Find the pressure exerted on the wall of a long thin cylinder of radius *R* which carries a current I.

Answer. The magnetic field just outside of the tube is

$$B_{out} = \frac{\mu_0 I}{2\pi R}$$

and that inside is $Bin = 0$

Taking a thin long segment of the tube, its magnetic field B_1 is equal to magnetic field $B^{'}$ due to the other position of the tube because these two fields nullifies each other to give zero magnetic field inside.

Hence, $B^{'} = B_1,$ since $B^{'} + B_1 = \frac{\mu_0 I}{2\pi R}$ because these two magnetic fields favours outside the tube, we have $B_1 = B^{'} = \frac{\mu_0 I}{2\pi R}$. Then the force acting on the considered portion is:

$$d_F = (di)lB^1$$

$$= \left\{\left(\frac{I}{2\pi R}\right)(dx)\right\}l\left(\frac{\mu_0 I}{4\pi R}\right)$$

$$P = \frac{d_F}{d_A} = \frac{d_F}{ld_x}$$

$$\boldsymbol{P = \frac{\mu_0 I^2}{8\Pi^2 R^2}}$$

Session IX

Alternating Current

Dr. Manisha Hawaldar

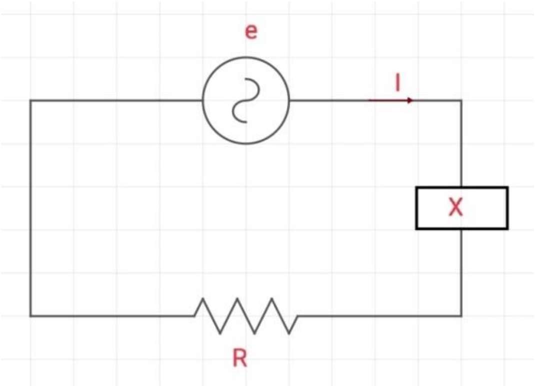
The following points were discussed by the resource person

- Concept of alternating current
- Comparison between ac and dc
- Working of Resistive circuit
- RMS voltage
- Working of Inductive circuit
- Series LCR circuit
- Working of Transformer

Alternating Current

Type of Question: MCQ

Q.1. An AC source of emf $E = E_0\ sin\ (50t)$ is connected across the circuit as shown. The current through the circuit is found as $I = I_0 \sin(50t + \pi/4)$. Identify the component in the box (x) and select the possible pair of values of the components in the circuit.



(1) R = 1 kΩ, L = 10 H

(2) R = 2 kΩ, L = 5H

(3) R = 1 kΩ, C = 20 μF

(4) R =2 kΩ, C = 5 μF

Solution: Since the current is leading the voltage, from the given equations.

The phase angle is $\pi/4$ rad = $\tan^{-1}(X_C / R)$

Therefore, $(X_C / R) = 1$, $(1 / \omega CR) = 1$

But $\omega = 50$, so $CR = 1/50 = 0.02$

Option (3) gives the component, x as capacitor and product of R and C as 0.02 is correct.

Q.2. When an alternating voltage V is supplied to R-C circuit, current leads the voltage by an angle θ. Now, when the capacitor C is replaced by an inductor L, voltage leads the current by θ'. In both the circuits, maximum power dissipated is same. Then,

(1) $\theta < \theta'$

(2) $\theta > \theta'$

(3) $\theta = \theta'$, $(\theta, \theta' > 0)$

(4) $\theta = \theta = 0$

Solution:-

Maximum power is dissipated, implies Z = R.

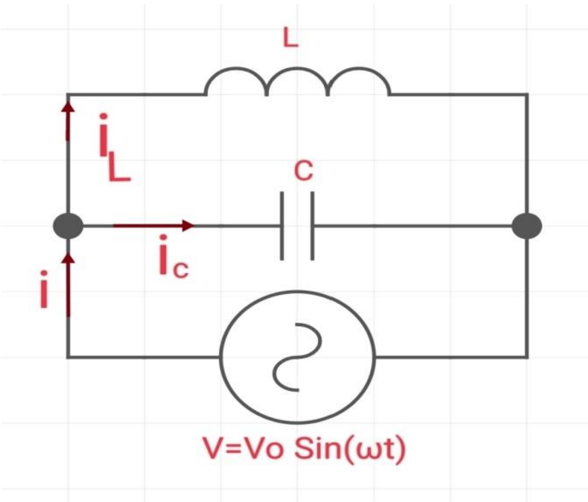
Maximum power dissipated is same, implies $X_L = X_C$. (Resonance condition)

Voltage lag and lead must be same since $(X_L / R) = (X_C / R)$

So $\theta = \theta'$.

Correct option is (3)

Q.3. An inductor L and capacitor C are connected in parallel and an alternating voltage $V = V_0 \sin(\omega t)$ is given to this combination. Find the rms current drawn from the source in the circuit.



Solution:- i_L is the current passing through the inductor L. It will lag behind the voltage by $\pi/2$, i_c is the current passing through the capacitor C. It will lead the input voltage by $\pi/2$.

$i_L = (V_0 / X_L) \sin(\omega t - \pi/2) = -(V_0 / X_L) \cos \omega t$

and $i_C = (V_0/X_C) \sin(\omega t + \pi/2) = (V_0 / X_L) \cos \omega t$

Appling KCL , $I = i_L + i_c = [(V_0/X_C) - (V_0 / X_L)] \cos \omega t$

Maximum current (Peak current) = $[(V_0/ X_C) - (V_0 / X_L)]$

Therefore, rms current drawn from the source = $I_{peak} /\sqrt{2}$

$= [(V_0/X_C) - (V_0 / X_L)] /\sqrt{2}$

$= (V_0/\sqrt{2}) [(1/X_C) - (1/X_L)]$

Q.4. A certain voltage Vp is fed to a 90% efficient transformer with transformation ratio 3:1 If the output voltage is 2700 V, find Vp.

Solution:-

η = Poutput/ Pinput = (VsIs)/ (VpIp) x 100

But Is/Ip = Np/Ns and Ns / Np = transformation Ratio (T.R)

η = (Vs/Vp) x (Np/Ns) x 100

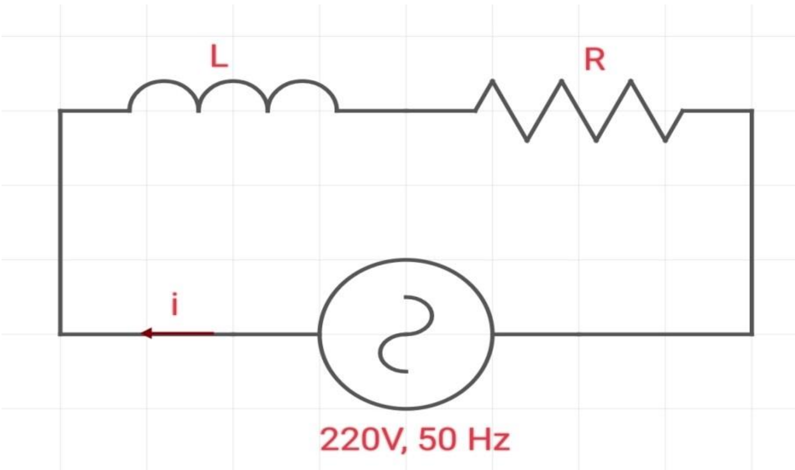
η = (Vs / Vp) x (I / T.R) x 100

Vp= (Vs / η) x (I / T.R) x 100

Vp= 2700/90 x 1/3 x 100

Vp = 1000 V

Q.5. A sinusoidal voltage of rms value 220V and frequency 50 Hz is applied to a series combination of an inductor (L) of 0.14 H and a resistance (R) of 8Ω. If the instantaneous current in the circuit is given as $i = i_m \sin(\omega t + \Phi)$, find the value of i_m, ω and Φ. Hence rewrite the equation. [i_m , ω, Φ carry usual meaning]



Ans :- The inductive reactance, $X_L = \omega L = 2\pi \times 50 \times 0.14 = 14\pi\ \Omega$

Therefore, impedance, $Z = (X_L^2 + R^2)^{1/2}$

$= [(14\pi)^2 + 8^2]^{1/2}$

$= (1936 + 64)^{1/2} = (2000)^{1/2} = 20 \times (5)^{1/2}$

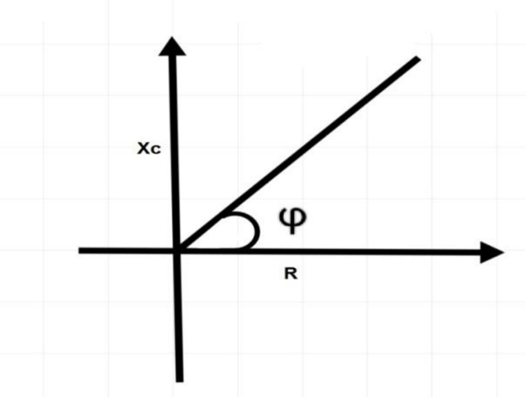
$Z = 20 \times 2.21 = 44\ \Omega$

$í_{rms} = V_{rms} / I = 220/44 = 5$ A

$í_m = (2)^{1/2} \times í_{rms} = (2)^{1/2} \times 5 = 5 \times (2)^{1/2}$ A

$\omega = 2\pi n = 2\pi \times 50 = 100\pi$

Q.6. A series combination of resistance 'R' and capacitance 'C' is supplied with alternating voltage of frequency 'ω' The student noticed that though the voltage is maintained the current gets reduced to half due to some change in frequency of the a.c. signal. He finds the phase angle (Φ) between the current and voltage as $\tan^{-1}$ (0.5). What would be change in frequency?



$\tan \Phi = Xc / R$

$\Phi = \tan^{-1} (0.5)$ - given

$\tan \Phi = 0.5 = 1/2$

$Xc/R = 1/2 \Rightarrow R = 2Xc$

Initial impedance, $Z = (R^2 + X_c^2)^{1/2}$

Final impedance $Z' = (R^2 + X'^2_c)^{1/2}$

Current gets halved, impedance is doubled Z = 2Z

$(R^2 + X'^2_c)^{1/2} = 2 \times (R^2 + X_c^2)^{1/2}$

$R^2 + X'^2_c = 4R^2 + 4X_c^2$

$X'^2_c = {}^{3R2} + 4X_c^2$

But $R = 2X_c$

$X'^2_c = 3 \times 4X_c^2 + 4X_c2$

$X'^2_c = 16\ X_c^2$

$X'_C = 4Xc$

$1/\omega'C = 4 / \omega C$

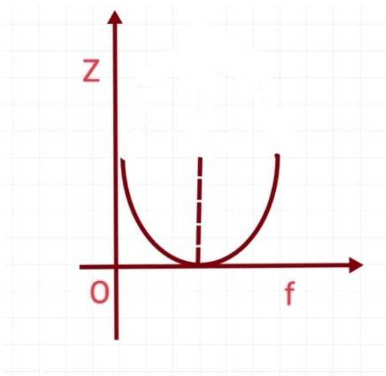
$\omega' = \omega/4$

The frequency would be ω/4

Q.7. Plot a rough graph that accurately represents the impedance Z as a function of the alternating frequency f for a series LC circuit with an AC voltage source (assume R=0). What is the minimum value of impedance possible for the circuit and at what frequency does this occur. Is it practically possible for an electrical circuit to achieve this?

Solution:- The impedance of the LC circuit is $Z = [(1/\omega C) - \omega L] = (1 - 4\pi^2 f^2 LC)/ 2\pi f C$

Therefore for extremely small values of f , Z is extremely large and Z has a local minima of 0 for $f = 1/2\pi\,(LC)^{1/2}$ and for large values of f , again Z becomes large.



The minimum value of Z is therefore 0 for a such a circuit which is practically not possible, Since any closed circuit will have non zero, finite electrical resistance R, Which will change the value of minima of Z from 0 to R.

Session X

Motion

Prof. M.N. Bapat

The following points were discussed:-

1. Moon is falling.
2. Significance of motion.
3. Conventions for motion (linear) + & -,
Anticlockwise.
4. Fluid motion Bernoulli's principle.
P1 + (1/2) ro xv2 + ro g H1 =
5. Airplane motion.
6. *A.B*
7. Position and displacement on graph.
8. Rate of change of acceleration.
9. Never ending motion.
10. whirl velocity is the tangential component of absolute velocity at the blade inlet and outlet. This component of velocity is responsible for the whirling or rotating of the turbine rotor.
11. Motion & gravity.

Direct Implementation of Concept

(Very Short Reasoning Based)

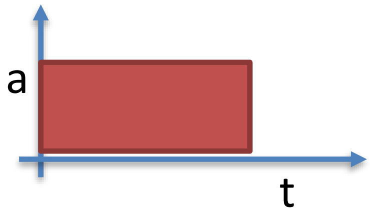
Q.1. What would you predict about the type of motion if $\vec{v}\ X\,\vec{a} = \vec{0}$. Analyse it in terms of principles of motion given than velocity and acceleration are non – zero?

Solution: It is given that the velocity and acceleration are non – zero and $\vec{v}\ X\,\vec{a} = \vec{0}$. Then by the definition of the cross product, we get that the angle between the velocity vector and the acceleration vector is zero.

Hence, the motion is a straight-line motion.

Q.2. What do we get on the taking the area under acceleration vs time graph? Analyse the quantity computed conceptually.

Solution: Acceleration is the time rate of change of velocity. So, when we compute the area under the acceleration vs time graph, we get change in velocity over the period of time.



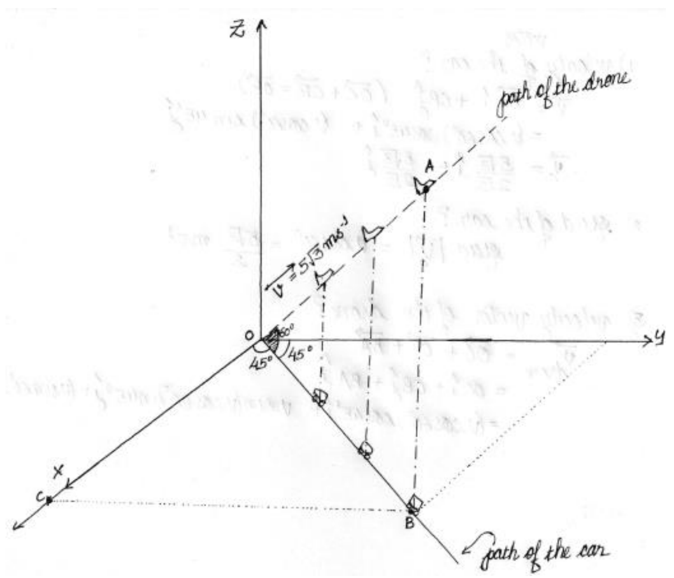
Note that, we do not get velocity which comes to our mind as a first thought, instead it is change in velocity that we get from the area under the graph.

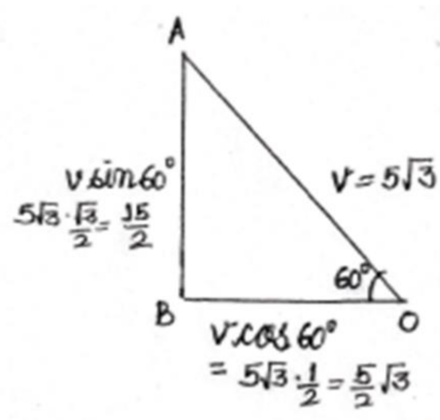
Mathematical Problem

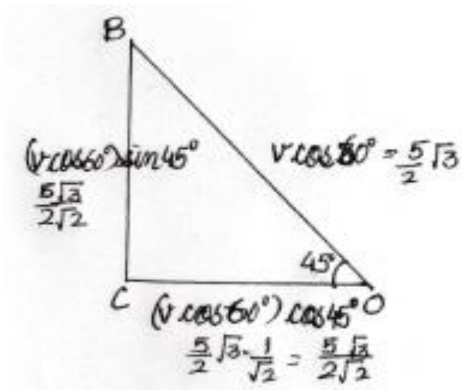
Q.3. A flight test for a Make-In-India Drone is conducted at RIE Bhopal during Amrit Mahotsav Celebrations. The Drone is launched from a point (origin) at an angle of 60° from the plane of the airstrip (X-Y Plane) in such a manner that its distance from X and Y axes always remains same. To observe the flight trajectory, a professor of RIE Bhopal starts in a car from the same point of origin as that of the Drone so that it always remains below the flying Drone at all points of time. If the speed of the Drone is 5√3 m/s, then

- **a. What is the velocity vector of the Car?**
- **b. What is the speed of the Car?**
- **c. What is the velocity vector for the Drone?**

Solution:







1) Velocity vector of the car?

$$\vec{v}_c = OC\hat{i} + CB\hat{j}\left(\overrightarrow{OC} + \overrightarrow{CB} = \overrightarrow{OB}\right)$$

$= (v\, cos\, 60^{\circ})\, cos\, 45^{\circ} \hat{\imath} + (v\, cos\, 60^{\circ})\, sin\, 45^{\circ} \hat{\jmath}$

$\vec{v}_c = \frac{5\sqrt{3}}{2\sqrt{2}} \hat{\imath} + \frac{5\sqrt{3}}{2\sqrt{2}} \hat{\jmath}$

2) Speed of the car?

$speed = |\vec{V_c}| = V\, cos\, 60^{\circ} = \frac{5\sqrt{3}}{2} ms^{-1}$

3) Velocity vector of the drone?

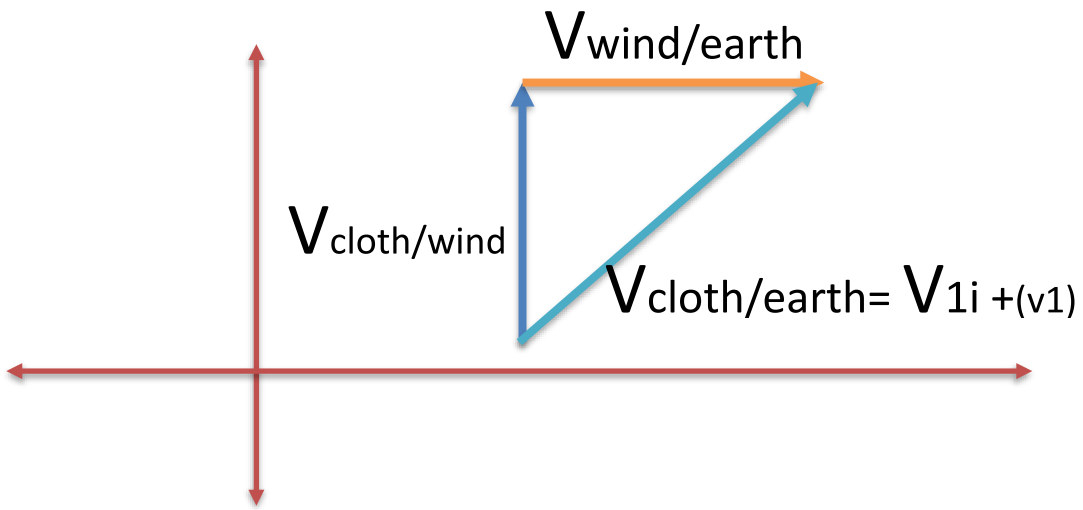
$\vec{v}_{drone} = \overrightarrow{OC} + \overrightarrow{CB} + \overrightarrow{BA}$

$= OC\, \hat{\imath} + CB\, \hat{\jmath} + BA\, \hat{k}$

$= (V\, cos\, 60^{\circ}) cos\, 45^{\circ} \hat{\imath} + (V\, cos\, 60^{\circ})\, sin\, 45^{\circ} \hat{\jmath} + (V\, cos\, 60^{\circ})\, \hat{k}$

Q.4. Mohan's mother has put clothes for drying on his roof after a day's rain. Wind is so fast that clothes are thrown in north direction with respect to the blowing wind with velocity 7ms-1. The wind is blowing in the east direction with velocity 5ms-1. What will be actual path of clothes flying in the air?

Solution:



The velocity of the clothes is: $V_{cloth/earth} = V_1^i + V_2^i$

$V_{cloth/earth} = (5i + 7j)\ m/s$

Direction of the clothes flying in air: $\frac{(5i+7j)}{\sqrt{5^2+7^2}} = \frac{(5i+7j)}{\sqrt{74}}$

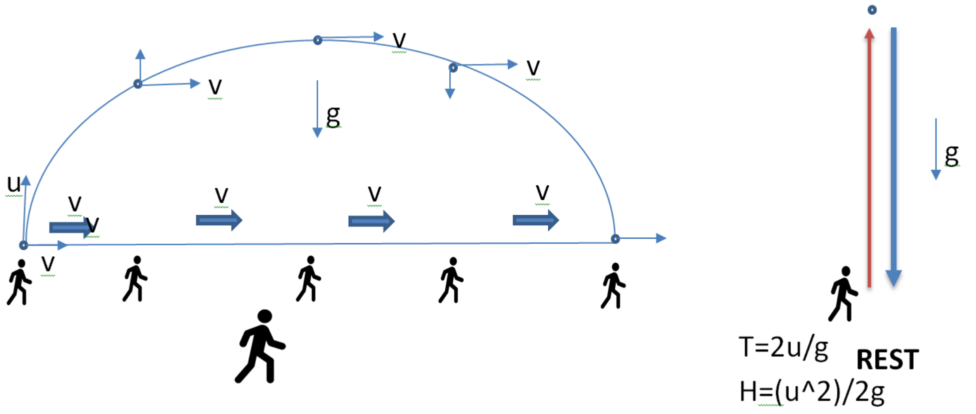
Concept Based Question

Q.5. Imagine you are sitting in a moving train. You throw a coin in the air; how would you throw it that the coin falls into your hands again. Describe the process mathematically with reference to an observer seeing you from platform and yourself.

Solution: For a passenger sitting in the train the, trajectory of the coin is a vertical uniformly acceleration motion. The figure and the equations are given to the right.

For an onlooker from the platform, the trajectory of the coin is a parabolic path. The figure is given below to the left.

The interpretation of acceleration due to gravity is also mentioned below.



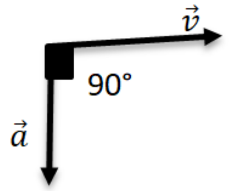
$$g = A\frac{particle}{earth} = A\frac{particle}{train}$$

Reasoning Based MCQ

Q.6. For a moving object, if the velocity is perpendicular to the acceleration vector, then what can be inferred amongst the following choices:

a) Rate of change of distance is zero.
b) Rate of change of displacement is zero.
c) Rate of change of speed is zero.
d) Rate of change of velocity is zero.

Solution:



c) Rate of change of speed is zero.

Speed is constant.

The condition of the question that velocity of the object is perpendicular to the acceleration vector can be put mathematically as: $\vec{a} \cdot \vec{v} = 0$

Applying the definition of acceleration$(\vec{a} = \frac{d\vec{v}}{dt})$, we rephrase the above dot product as:

$$\frac{d\vec{v}}{dt} \cdot \vec{v} = 0$$

$$\frac{1}{2}\frac{d(\vec{v} \cdot \vec{v})}{dt} = 0$$

$$\vec{v} \cdot \vec{v} = k\ (Constant)$$

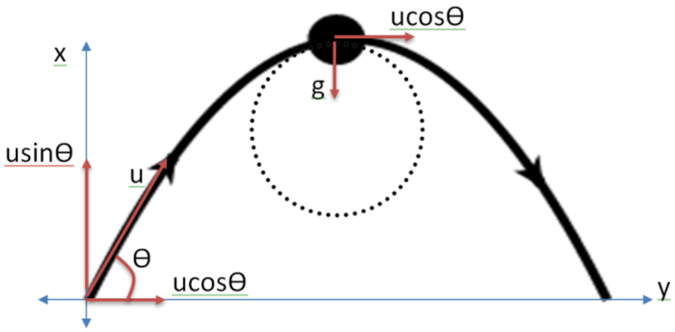
$$|\vec{v}| = k\ (Constant)$$

Q.7. Will a particle moving on a curve (non-circular) possess a Centripetal acceleration?

This only implies speed is constant. Nothing can be inferred that the motion of the will be circular.

Solution: (Centripetal acceleration: Due to change in the direction of the velocity vector and in the direction perpendicular to it and is directed towards the centre of the circle.

Consider the following representative diagram from the projectile motion:



At the highest point, $g \perp u\cos\theta$

So, at the highest point of the projectile curve, 'g' can be termed as centripetal acceleration.

Session XI

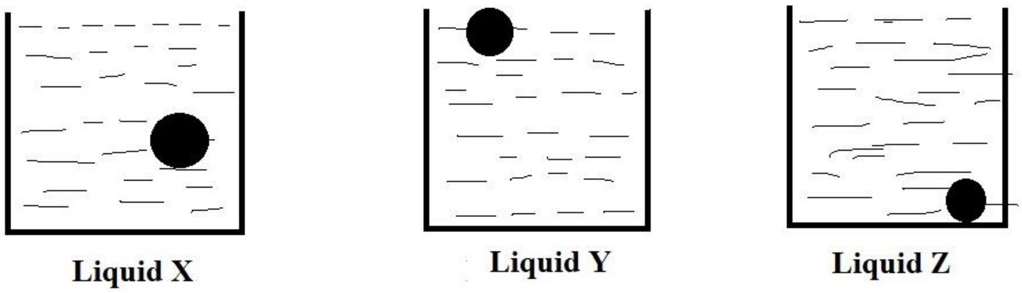
Mechanical Properties of Fluids

Dr. Akash Yadav

The following points were discussed by the resource person

- Phases of Matter
- Density and Specific Gravity
- Pressure in Fluids
- Atmospheric Pressure and Gauge Pressure
- Pascal's Principle
- Measurement of Pressure; Gauges and the Barometer
- Buoyancy and Archimedes' Principle
- Fluids in Motion; Flow Rate and the Equation of
- Continuity
- Bernoulli's Equation
- Applications of Bernoulli's Principle: Torricelli,
- Airplanes, Baseballs, Blood Flow
- Viscosity
- Flow in Tubes: Poiseuille's Equation, Blood Flow
- Surface Tension and Capillarity
- Pumps, and the Heart

Q.1. In the following diagrams three different liquids have been taken in three beakers and a ball made of a material of specific gravity D remain in these three liquids as shown in figure. If the three liquids X, Y, Z have specific gravities $D_x, D_y, and\ D_z$ respectively, which of the following statement is correct?

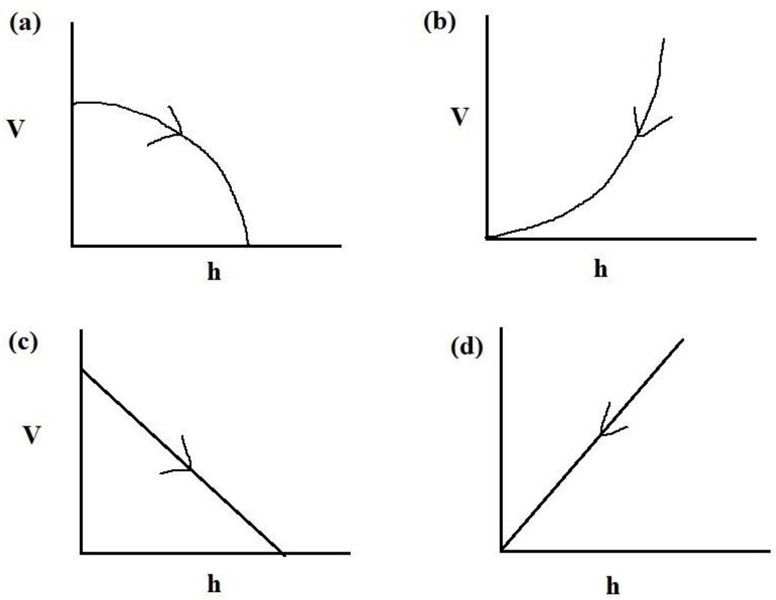


(a) $D_x > D_y > D_z$ (b) $D_z < D_y > D_x$

(c) $D_y > D_x > D_z$ (d) $D_z > D_x > D_y$

Answer: (d)

Q.2.A rectangular tank is filled completely with water. A hole at its bottom is unplugged. The graph between the velocity of efflux V (through a small hole) vs depth of water h from the top of the tank will be.



Answer: (a)

Q.3. Five equal drops of water are falling through air with terminal velocity of 10 cm/sec. If the drops coalesce, then the terminal velocity of the large drop is:

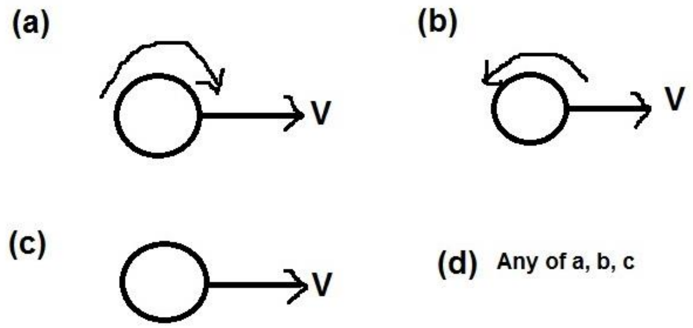
(a) 10 cm/sec (b) 20 cm/sec

(c) 10 x $(5)^{2/3}$ cm/sec (d) 5 cm/sec

Hint: $V_T = \frac{2}{9} r^2 \left[\frac{\rho - \delta}{n}\right] g$

Answer: (c)

Q.4. To get the maximum flight, a ball must be thrown as:



Answer: (b)

Very Short Questions:

Q.1. A cube of wood supporting 200 g mass just floats in water. When the mass is removed, the cube rises by 2 cm. What is the size of the cube?

Answer: If a is the side of the cube and as cube rises 2 cm on removing the mass, the weight of body must be equal to the thrust providing by 2 cm height of cube of base area $(a \times a)$, i.e.

$mg = v'\sigma g$

Where v' = rises volume of cube from the water and σ is the density of water

$200 \times g = (2 \times a^2) \times 1 \times g$

$a = 10\ cm$

the size of the cube is 10 cm.

Q.2. Air is streaming past a horizontal aeroplane wing such that its speed is 120 m/sec over the upper surface and 90 m/s at the lower surface. If the density of air is 1.3 Kg/m³, find the difference in pressure between the top and the bottom of the wing. If the wing is 10 m long and has an average width 2 m, calculate the gross lift of the wing.

Answer: According to Bernoulli's equation for a horizontal plane,

$$P_1 + \frac{1}{2} d\, v_1^2 = P_2 + \frac{1}{2} d v_2^2$$

$$P_1 - P_2 = \frac{1}{2} d(v_2^2 - v_1^2)$$

$$P_1 - P_2 = \frac{1}{2} \times 1.3 \times (120^2 - 90^2)$$

$$= 4.1 \times 10^3\ N/m^2$$

Now as Gross lift = $(P_1 - P_2) \times A$

$= 4.1 \times 10^3 \times (10 \times 2)$

$= 8.2 \times 10^4 Newton$

Q.3. Calculate the force (F) needed to punch 1.46 cm diameter hole in a steel plate 1.27 cm thick. The ultimate shear strength of steel is $\mathbf{3.45 \times 10^8\ Newton/m^2}$.

Answer: As in punching shear elasticity is involved, the hole will be punched if

$\left[\frac{F_{11}}{A}\right] >$ Ultimate shear stress

i.e. F_{11} >(Shear stress) x (Area)

$(F_{11})_{min} = (3.45 \times 10^8) \times (2\pi r L)$ [as here $A = 2\pi r L$]

$(F_{11})_{min} = (3.45 \times 10^8) \times (2 \times 3.14) \times (0.73 \times 10^{-2}) \times (1.27 \times 10^{-2})$

$= \sim 200\ KN$

Short Questions

Q.1. A cubical water tank is completely filled the water of mass $M = 1000\ kg$. The force exerted by the water on the side wall of the tank is?

Answer: The cubical tank contains water of $Mass\ M = 1000\ kg$

Volume of water $V = \frac{M}{d_w}$ where d_w is the density of water

$$= \frac{1000\ kg}{1000\ kg/m^3} = 1m^3$$

∴ Volume of the tank

$V = 1m^3$

Therefore side of the tank $b = 1\ meter$

The pressure at $A = P_A = P_{atm}$

The pressure at $B = P_B = P_{atm} + dgh$

∴ The pressure at C, mid point of the face, $P_C = \frac{P_A + P_B}{2}$

$= A$verage pressure over the side wall

$$= \frac{2P_{atm} + dgh}{2} = P_{atm} + \frac{dgh}{2}$$

The force exerted on the side wall is:

$$F = \left(P_{atm} + \frac{dgh}{2}\right) \times b^2 = \left(1.013 \times 10^5 + \frac{10^3 \times 9.8 \times 1}{2}\right)\ N$$

$F = 1.062\ \times 10^5$ Newton

Q.2. A glass beaker having mass 390 gm and an interior volume of 500 cm^3 floats on water when it is less than half filled with water. What is the density of the material of the beaker?

Answer. As the beaker floats in water when less than half filled with water, it will float just fully submerged when half filled.

In this situation, mass of beaker + mass of water in it $= v_\sigma$

$390 + \frac{500 \times 1}{2} = v \times 1$

i.e. Outer volume of beaker

$v = 640\ cm^3$

Now as inner volume of beaker is given to be $500cm^3$, so the volume of the mateiral of beaker $= 640 - 500 = 140\ cm^3$

But as mass of beaker is 390gm, so density of material of beaker

$$e = \frac{m}{v} = \frac{390}{140} = 2.79\frac{g}{cm^3}$$

Q.3. An open U-tube of uniform cross-section contains mercury. When 27.2 cm of water is poured into one limb of the tube

(a) How high does the mercury rise in the other limb from its initial level?

(b) What is the difference in levels of liquids of the two sides? (dw = 1 and $d_{Hg} = 13.6\ units$)

Answer. (a) If water depresses the mercury by y, the mercury in the other limb will rise by y above its initial level.

(As fluids are incompressible), so that

$AA' = BB' = y$

Also $h_2 = B'B + AC$

i.e. $h_2 = B'B + AA^1$ [as $BC = AA'$]

or $h_2 = 2y$ [as $AA' = BB' = y$]

Now If h_1 is the height of water column above A', then as in a liquid, pressure is same at all points in the same level.

$PA' = PC$

$P_0 + h_1 d_1 g = P_0 + h_2 d_2 g$

$h_1 d_1 = h_2 d_2$

$27.2 \times 1 = 2y \times 13.6 \Rightarrow y = 1\ cm$

So mercury rises by 1cm from its initial level.

(b) The difference of level on two sides

$Z = h_1 - h_2 = 27.2 - 2 \times 1 = 25.2\ cm$

i.e., the water level will stand 25.2 cm higher than the mercury level in the other limb.

Long Questions

Q.1. A block of wood weights 12 kg and has a relative density 0.6. It is to be in water 0.9 of its volume immersed. What weight of a metal is needed?

(a) If the metal is on the top of wood.

(b) If the metal is attached below the wood?

(Relative density of metal = 14)

Answer: (a) When the metal is on the top of wood,

$$M + m_1 = 0.9\, V_W \sigma = 0.9 \frac{M}{d_W} \sigma$$

$$\left[a_s\, V_W = \frac{M}{d_W}\right]$$

$$m_1 = M\left[0.9\frac{\sigma}{d_W} - 1\right] = 12\left[\frac{0.9}{0.6} - 1\right] = 6\ kg$$

(b) When the metal is attached at the bottom of Wood,

$$(M + m_2) = (0.9\ V_W + V_M)\sigma$$

$$M + m_2 = \left[0.9\frac{M}{d_W} + \frac{m_2}{d_M}\right]\sigma$$

$$m_2\left[1 - \frac{\sigma}{d_W}\right] = M\left[0.9\frac{\sigma}{d_M} - 1\right]$$

$$m_2\left[1 - \frac{1}{14}\right] = 12\left[\frac{0.9}{0.6} - 1\right] = 6\ kg$$

$$m_2 = \frac{14 \times 6}{13} \cong 6.5\ kg$$

Q.2. A light rod of length 200 cm is suspended from the ceiling horizontally by means of two vertical wires of equal length tied to its ends. One of the wires is made of steel and is of cross-Section 0.1 cm^2 and the other is made of brass of cross-section 0.2 cm^2. Along the rod at which distance may a weight be hung to produce:

(a) Equal stresses in both the wires.

(b) Equal strains in both the wires.

Young modulus (Y) for brass and steel are 10×10^{11} and 20×10^{11} dyne/cm^2 respectively.

Answer. (a) As stresses are equal,

$$\frac{T_1}{A_1} = \frac{T_2}{A_2}$$

$$\frac{T_1}{T_2} = \frac{A_1}{A_2} = \frac{0.1}{0.2}$$

$T_2 = 2T_1$ … … (1)

Now for translatory Equilibrium of the rod,

$$T_1 + T_2 = W$$

Which in the light of Equation (1)

gives $T_1 = \frac{W}{3}$

$$T_2 = \frac{2W}{3} \ldots\ldots\ldots (2)$$

Now, If x is the distance of weight W from steel wire, for rotational Equilibrium of rod,

$$T_1 x = T_2(2 - x)$$

$$\frac{W}{3}x = \frac{2W}{3}(2 - x)$$

$x = \frac{4}{3}$meter

(b) As strains are equal,

$$\frac{T_1}{A_1Y_1} = \frac{T_2}{A_2Y_2} \qquad [as\ Strain = \frac{stress}{Y}]$$

So $\frac{T_1}{T_2} = \frac{A_1Y_1}{A_2Y_2} = \frac{0.1\times20\times10^{11}}{0.2\times10\times10^{11}} = 1$

$T_1 = T_2 \dots\dots\dots (2)$

So for translatory equilibrium of rod, $T_1 + T_2 = W$ in the light of Equation (3) yields

$$T_1 = T_2 = \frac{W}{2}$$

And for rotational Equilibrium of rod

$T_1x = T_2(2 - x)$

$$\frac{W}{3}x = \frac{2W}{3}(2 - x)$$

$x = 1\ meter$

Q.3. A copper wire of negligible mass, 1 meter length and cross-sectional area 10^{-6} meter^2 is kept on a smooth horizontal table with one end fixed. A ball of mass 1 kg is attached to the other end. The wire and the ball are rotating with an angular velocity of 20 rad/s. If the elongation in the wire is 10^{-3} meter, obtain the Young's modulus. If on increasing the angular velocity to 100 rad/sec, the wire breaks down, obtain the breaking stress.

Answer: According to given problem, for vertical Equilibrium of ball.

$R = mg \dots\dots (1)$

And for motion of mass m in a circle of radius r at angular frequency w in a horizontal plane, the centripetal force required.

$F = m\omega^2 r \dots\dots (2)$

Here this force is provided by the Elasticity of the wire.

$$F = T = \frac{YA.\Delta L}{L} \dots\dots\dots (3)$$

So equating F from Equations (2) and (3)

$Y = \frac{m\omega^2 rL}{A.\Delta L} = \frac{m\omega^2 L^2}{A.\Delta L}$ [as $r = L + \Delta L \approx L$]

So $Y = \frac{1\times(1)^2\times(20)^2}{(10^{-6})\times(10^{-3})} = 4 \times 10^{11} N/m^2$

Further as wire breaks at $\omega_{max} = 100\ rad/sec,$

Breaking force $= m\omega_{max}^2\ r = 1 \times 1 \times (100)^2 = 10^4 Newton$

And as Cross-Section of wire is $10^{-6}\ meter^2$

Breaking Stress $= \frac{Breaking\ Force}{Area}$

$$= \frac{10^4}{10^{-6}} = 10^{10}\ N/m^2$$

Q.4. A conical glass capillary tube of length 0.1 meter has diameters 10^{-3} and 5×10^{-4} meter at the ends. When it is just immersed in a liquid at $0^{\circ}C$ with larger diameter in contact with it, the liquid rises to 8×10^{-2} meter in the tube. If another cylindrical glass capillary tube B is immersed in the same liquid at $0^{\circ}C$, the liquid rises to 6×10^{-2} meter up. The rise of liquid in the tube B is only 5.5×10^{-2} meter. When the liquid is at $50^{\circ}C$. Find the rate of which the surface tension changes with temperature considering the change to be linear. The density of the liquid is $\frac{1}{14} \times 10^4$ kg/m³ and angle of contact is zero. Effect of temperature on density of liquid and glass is negligible.

Answer. If r is the radius of the meniscus in the conical tube, then

$$\tan\theta = \frac{r - r_1}{L - h} = \frac{r_2 - r_1}{L}$$

$$\frac{r - 2.5 \times 10^{-4}}{(0.1\ -\ 0.08)} = \frac{(5 - 2.5) \times 10^{-4}}{0.1}$$

$$r \times 10^4 - 2.5 = 0.2 \times 2.5$$

$$r = 3 \times 10^{-4}\ meter$$

Now as Capillarity is independent of the shape of tube so at same temperature $\theta = 0^{\circ}C$

$$h_A r_A = h_B r_B = \frac{2T}{dg} = Constant$$

So $r_B = \frac{(0.08 \times 3 \times 10^{-4})}{(6 \times 10^{-2})} = 4 \times 10^{-4}\ m$

Now as from $h = \frac{2T}{rdg}$ for cylindrical tube.

$$T = \frac{h_{\circ} dgr}{2} = \frac{1}{2}\left[6 \times 10^{-2} \times \frac{1}{14} \times 10^4 \times 9.8 \times 4 \times 10^{-4}\right]$$

$$= 8.4 \times 10^{-2}\ Newton/Meter$$

Now as for a given tube and liquid $T \propto h$ (as $T = \frac{hrdg}{2}$)

$$\frac{T_{50}}{T_0} = \frac{h_{50}}{h_0}$$

So $T_{50} = \frac{5.5 \times 10^{-2}}{6 \times 10^{-2}} \times 8.4 \times 10^{-2} = 7.7 \times 10^{-2}\ N/meter$

So rate of change of surface tension with temperature assuming linearity $\frac{\Delta T}{\Delta\theta} = \frac{T_{50} - T_0}{50 - 0} = \frac{(7.7 - 8.4) \times 10^{-2}}{50} = -1.4 \times 10^{-2}\ N/m^{\circ}C$

Negative sign shows that with rise in temperature surface tension decreases.

Session XI

Current Electricity

Dr. Mita Chourasia

The following points were discussed by the resource person

- Ohm's Law Experiment
- Deviation from Ohm's Law
- Temperature Coefficient
- Concept of Resistance in Ohm's Law, Resistivity
- Combination of resistance in various ways
- Wheatstone bridge
- Kirchhoff's Law
- Constructing meter bridge its use and applications

Current Electricity

MCQ Type

Q.1. The masses of three copper wires are in the ratio 5:3:1 and their lengths are in the ratio 1:3:5. The ratio of their electrical resistance is:

(a) 1:3:5 (b) 5:3:1

(c) 1:15:125 (d) 125:15:1

Answer: (c) 1:15:125

$R = s\frac{l}{A}$; Now $m = A\,ld \Rightarrow A = \frac{m}{ld} \Rightarrow R \propto \frac{l^2}{m}$

$R_1 : R_2 : R_3 = \frac{1}{5} : \frac{9}{3} : \frac{25}{1} = \frac{1}{5} : 3 : 25$

$\Rightarrow R_1 : R_2 : R_3 = 1 : 15 : 125$

Learning Outcomes: To establish relation between physical quantity.

Q.2. Assertion - Reason type Questions:

The following question consists of two statements, each as Assertion and Reason.

You are required to choose any one of the following four responses.

(A) If both, Assertion and reason are true and the Reason is the correct explanation of the Assertion.

(B) If both, Assertion and reason are true but reason is not a correct explanation of the Assertion.
(C) If Assertion is true but the reason is false.
(D) If both Assertion and Reason are false.

Assertion: The end of the driver cell in the potentiometer experiment should be greater than the emf. of the cell to be determined.

Reason: The fall of potential across the potentiometer wire should not be less than the emf. of the cell to be determined.

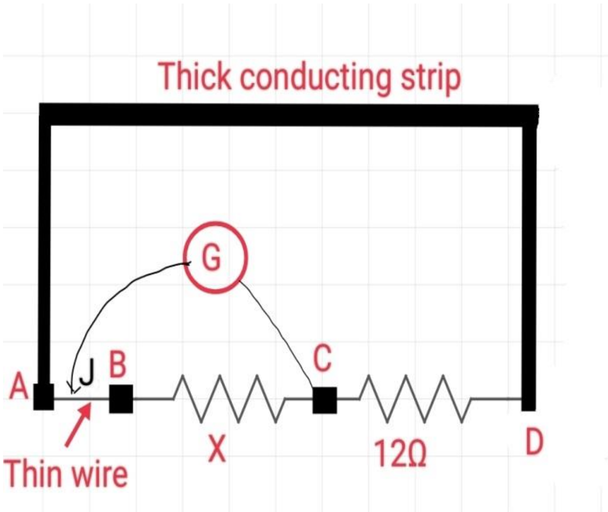
(a) A (b) B (c) C (d) D

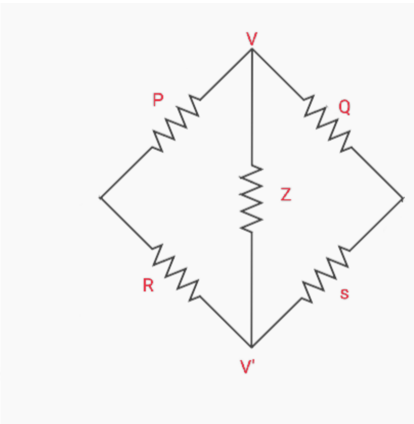
Answer: A

Learning Outcomes: Applying logical reasoning.

Q.3. Case based MCQ.

A thin uniform wire AB of length 1m, an unknown resistance X and a resistance of 12□ are connected by thick conducting strips, as shown in the figure.

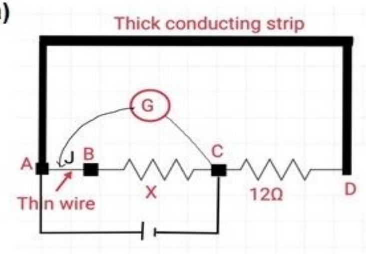




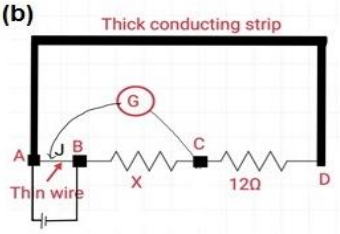
Solution: A battery and a galvanometer (with a sliding jockey connected to it) are also available. Connections are to be made to measure the unknown resistance X using the principle of Wheatstone bridge. For balanced Wheatstone bridge as shown in the figure we have $\frac{P}{Q} = \frac{R}{S}$.

Q.I. The correct figure showing the battery and the galvanometer (with jockey) connected at appropriate point is:

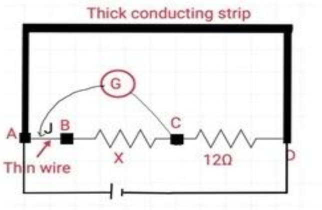
(a)



(b)



(c)



(d) None of these

Answer: (b)

Learning Outcomes: Identification of correct diagram.

Short answer questions:

Q.4. What may be the causes process of short circuiting.

Answer:

a) Shorting happens when two points which have a potential difference, is connected by a wire, which has zero or negligible resistance. Under such a situation, the amount of current flowing into the wire will be infinite and hence heat generated will also be very high (I^2/R).

Because of this all wires leading to this wire from the battery or emf source also will have very high current. Heat generated melts the wire & we get sparks.

b) Short circuiting can also happen when two wires having reverse polarity (i.e. there is a pd between the wires) comes in contact. This is equivalent to connecting two points with finite pd with a wire of zero resistance.

Learning Outcomes: Connect learning with day to day life.

Q.5. What is the purpose of a capacitor in an electrical circuit? Why can't we use a capacitor as a battery?

Answer:

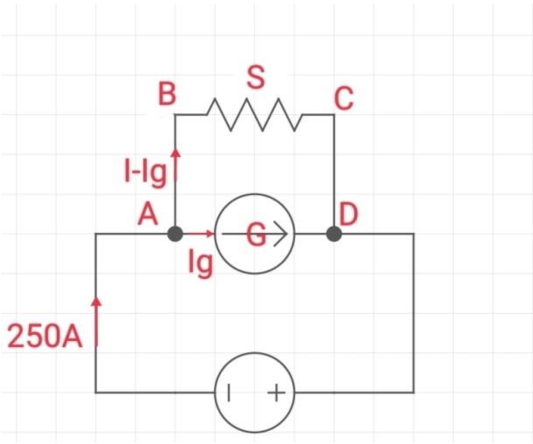
a) Capacitors act as temporary reservoirs of electrical energy. They are used in electrical fillers, rectifiers, amplifiers etc. One of the main uses of capacitors is to feed a particular wave form and phase difference of current to various appliances. This also filters the potential and changes the wave forms.

b) We cannot use a capacitor as a battery, because the discharge time of a capacitor is very short. In various circuit we need a particular type of current. Sometimes we need a constant source of emf for the circuit. But when the capacitor discharges emf is not constant.

Learning Outcomes: Connect learning with practical experience.

Q.6. An ammeter has an internal resistance of 1 ohm. What should be the shunt resistance so that the ammeter with a range of 5 amperes, can measure. 250 amperes in a circuit?

Answer: As 'G' and 'S' are parallel, pd across $BC = pd\ across\ AD$



$V_{BC} = V_{AD}$

$I_g G = (I - I_g)S$

$S = \frac{I_g G}{I - I_g} = \frac{5N}{250\ S} = \frac{5}{245}$

$S = \frac{1}{49} = 0.02\ \Omega$

Learning Outcomes: Concept of even measuring device and its use in circuit.

Short Answer:

Q.7. At 0^oC the electric resistance of a conductor C_1 is 'n' times that of conductor C_2. The temperature coefficient of resistance for conductors C_1 and C_2 are $\propto_1$ and $\propto_2$ respectively. What will be the temperature coefficient of resistance of a circuit segment containing C_1 and C_2 in series?

Solution: Let r_1 and r_2 be the resistance of C_1& C_2 at 0^oC and $r_1'\ and\ r_2'$ be the resistance of C_1 and C_2 at t^oC. then**.**

$r_2 = nr_1\ and\ r_1' = r_1(1 + \propto_1 t)\ and\ r_2' = r_2(1 + \propto_2 t)$

When resistances are in series, then

$r_s' = r_1' + r_2'[(1+n) + (\propto_1 + n \propto_2)t]$.............(1)

If $\propto_s$= Temperature coefficient of series combination, then

$r_s' = (r_1 + r_2)(1 + \propto_s t) = (r_1 + nr_1)(1 + \propto_s t)$

$= r_1(1+n)(1 + \propto_s t)$

$r_s' = r_1[(1+n) + (1+n) \propto_s t]$............(2)

Comparing (1) and (2)

$(\propto_1 + n \propto_2) = (1+n)\ \propto_s$ or $\propto_s = \frac{\propto_1 + n\propto_2}{1+n}$

Learning Outcomes: Concept of temperature coefficient and its application.

Q.8. In series combination of electrical incandescent bulbs, the bulb of lower power emits more light than that of higher power bulb.

Solution: Power = Voltage x Current

Voltage supply is constant, so according to Ohm's law

$Current(I) = \frac{Voltage\ (V)}{Resistance\ (R)} ie \quad I \propto \frac{I}{R}$

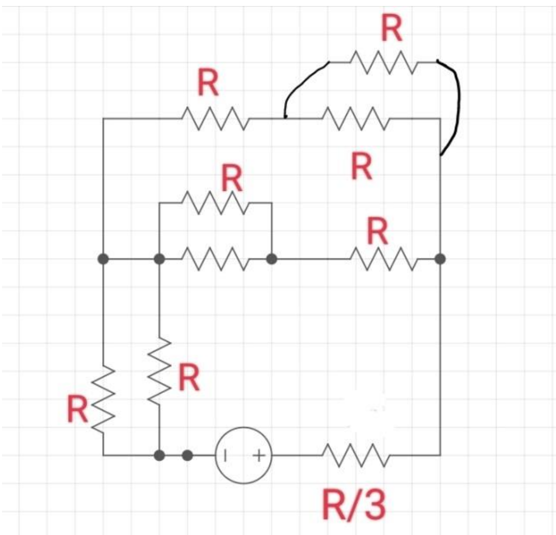
As resistance goes down, current increases, hence more heat dissipation or power, so bulb of lower power has higher resistance in series and glows brighter.

Learning Outcomes: Understanding the flow of current in series and parallel circuit.

Long Answer:

Q.9. (a) Find current flowing through all resistors? Assume that the battery has an internal resistance of R/3

(b) Redraw the circuit with different current magnitudes.

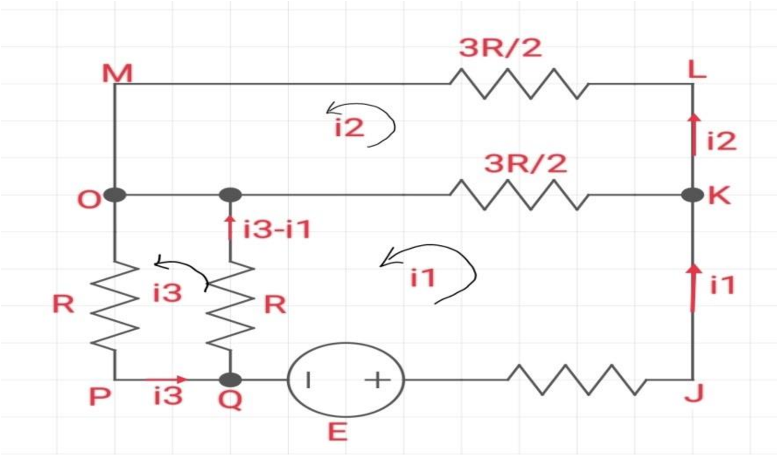


Solution: a) Rearranging the resistance wrt voltages:

Applying Kirchhoff's second law in closed loop E J K R Q E

$$E - \left[i_1 \frac{R}{3} + (i_1 + i_2)\frac{3R}{2} + (i_1 + i_3)R\right] = 0$$

$\Rightarrow \frac{E}{R} = \frac{17}{6}\, i_1 - \frac{3}{2}\, i_2 - i_3$ ....(1)



Equation for closed loop E J K R O P Q E

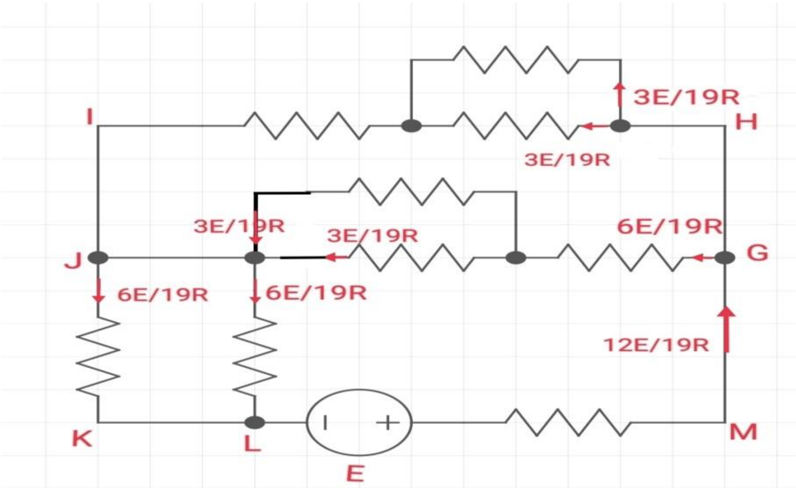
$$E - \left[i_1 \frac{R}{3} + \frac{3}{2}(i_1 + i_2)\, R + i_3\, R\right] = 0 \Rightarrow \frac{E}{R} = \frac{11}{6}\, i_1 - \frac{3}{2}\, i_2 - i_3 \quad \text{.............(2)}$$

Equation for closed loop E J K L M O P Q E

$$E - \left[i_1 \frac{R}{3} + \frac{3}{2}\, i_2\, R + i_1\, R\right] = 0 \Rightarrow \frac{E}{R} = \frac{i_1}{3} + \frac{3}{2}\, i_2 - i_3 \quad \text{............(3)}$$

Solving (1), (2), (3)

$i_1 = \frac{12E}{19R}$ $\quad i_2 = \frac{6E}{14R}$ $\quad i_3 = \frac{6E}{19R}$

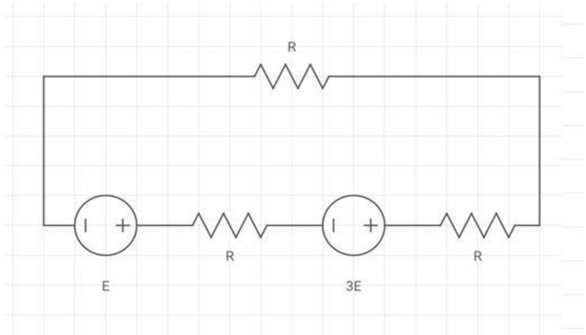


Learning Outcomes: Understanding arrangement of resistances in a circuit enhanced current distribution around it.

Q.10 Two batteries of emf "E" and "3E" are connected to a resistance 'R'. The internal resistance of both the batteries is R. What will be the current flowing through the resistance?

Solution: Based on effective emf in different modes, there can be 04 arrangements.

Both batteries connected +vely in series	**Both batteries connected -vely in series**

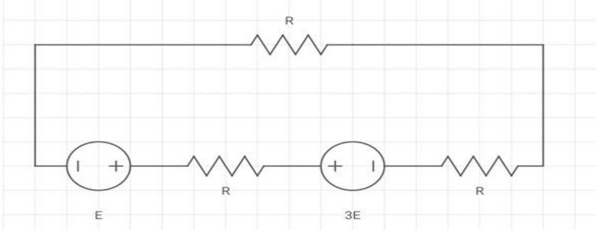


$E_{eff} = E + 3E = 4E$

$r_{eff} = R + R = 2R$

Applying Kirchoff's voltage law

$$i = \frac{E_{eff}}{R + r_{eff}} = \frac{4E}{3R}$$

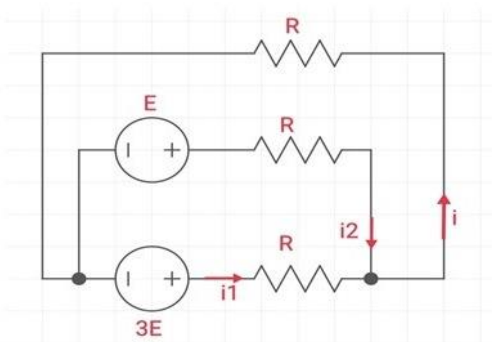


$E_{eff} = 3E - E = 2E$

$r_{eff} = R + R = 2R$

$$i = \frac{E_{eff}}{R + r_{eff}} = \frac{2E}{3R}$$

<u>Batteries connected +vely in parallel</u>



$E = (i_1 R + i_1 + i_2)R \rightarrow (1)$

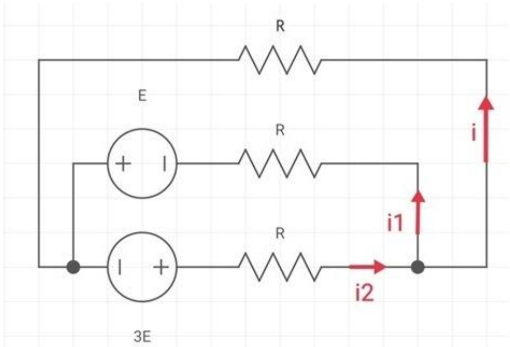
$3E = i_2 R + (i_1 + i_2)R \rightarrow (2)$

Solving (1) & (2)

$$i_1 = -\frac{E}{3R}, i_2 = \frac{5E}{3R}$$

$$I = i_1 + i_2 = \frac{4E}{3R}$$

<u>Batteries connected in parallel</u>



$-E = i_1 R + (i_1 + i_2)R \rightarrow (3)$

$3E = i_2 R + (i_1 + i_2)R \rightarrow (4)$

$$I = i_1 + i_2 = \frac{2E}{3R}$$

Session XI

Wave Optics

Dr. Deepak Sondhiya

The following points were discussed by the resource person

- Background of Wave Optics
- A very brief history of light
- Theories of light
- Young's Double Slit Experiment
- Single Slit Diffraction
- Limits of Resolution: The Rayleigh Criterion
- Thin Film Interference
- Polarization
- Polarization by Reflection

Wave Optics

1. Consider a friend of yours performing Young's Double Slit Experiment. What would be his observations if instead of splitting a light beam into two sources what is used are:
    a. the headlights of a distant car.
    b. two different sodium lamps emitting light of the same wavelength.
    c. two separate beams from one red and one green.
    d. Two coherent sources separated by long distance.

Solution: No interference pattern is observed.

Concept involved: Young's Double Slit Experiment conditions of Interference

- They are the two independent soures of light.
- No interference pattern will be observed on the screen.
- In YDSE, we use a single source (like a sodium lamp) and then pass the waves through the slits to obtain coherent waves which are in phase to each other.
- Two independent light sources do not have coherent phase.

- Consider 2 lasers (blue and green) shining on a wall (rough surface) on the same spot. You basically will see 2 interferene patterns (called laser speckle) overlapping but they do not interefere with each other. You can shine one laser at time and add the 2 pictures separetely to get the same pattern as you would with shining both lasers.
- Take a double slit and the same is true, you will see 2 patterns that are just an over lap of each other.
- Even if you have two different lasers with the same nominal waelength, they're likely to differ in frequency by at least a few ppm. Then they will not noticeably interfere unless you are very carefully tuning them to produce interference.

- As the distane between two sources increases, the fringe width decreases. So when the sources are far apart then, the fringe width becomes practically zero and hence no interference pattern is pratically detected. Remember, finge width: $\beta = \frac{D\lambda}{d}$

2. During Young's Double slit experiment, what is the separation between two slits for which 589-nm light from a Sodium vapour lamp gives its first maximum at an angle of 45°? Is the separation between the slits same when the sodium light is replaced by red light of 650nm? Prove the similarity or difference by calculated results.

   Solution:

   $$n\lambda = d\sin\theta$$
   $$d = \frac{n\lambda}{\sin\theta}$$

   Here it is first maximum, it implies, n=1

   $\lambda = 589 \times 10^{-9}m$

   $\theta = 45°$

   d = $1 \times \frac{(589\times10^{-9}m)}{sin45°} = 832.9717 \times 10^{-9}m$

When the light is replaced by red light of 650 nm, the wavelength changes, and everything else remais same in the formula

Hence, new $d_{red} = 919.2388 \times 10^{-9}m$

Concept involved: Young's Double Slit Experiment & Interference: The solution involves the Formula Calculation and the question tests the analytical ability & interpretation skills of the students.

3. Discuss the interference pattern in Young's Double slit experiment if the monochromatic light is replaced by the white light from a single source. How will the fringe patterns be observed on the screen?

Solution: ***Concept involved: Young's Double Slit Experiment & Interference***

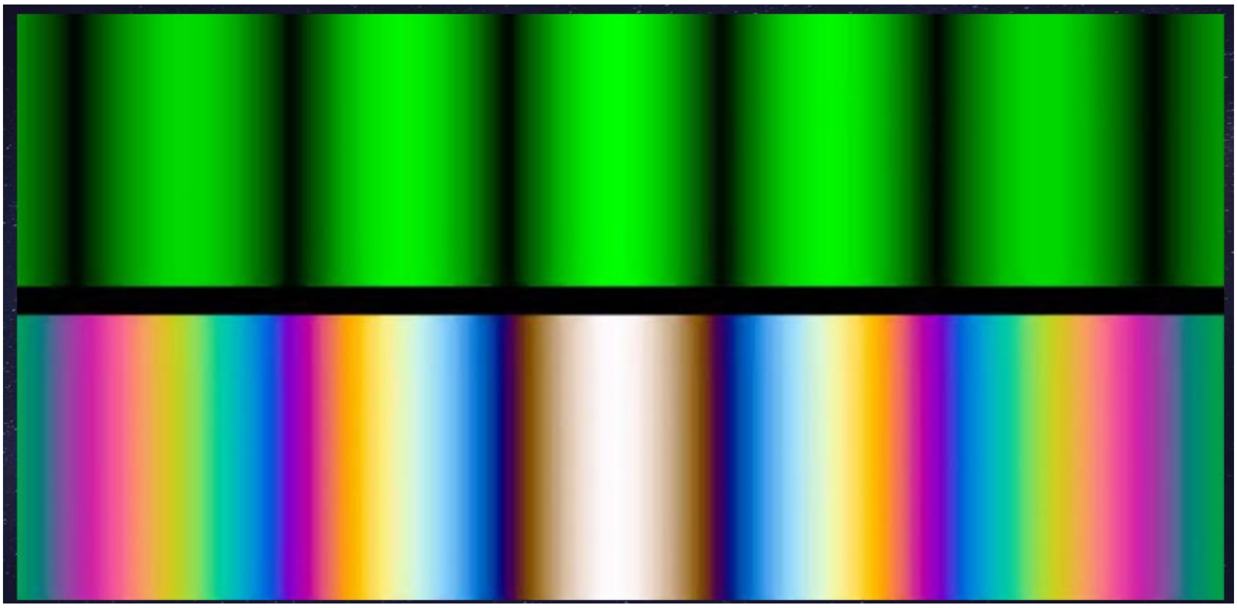
- If monochromatic light in Young's interference experiment is replaced by white light, then the waves of each wavelength form their separate interference patterns. The resultant effect of all these patterns is obtained on the screen.
- In Young's Double Slit Experiment, using white coherent light leads to observing the coloured fringes on the screen.
- All colours give maxima at the centre, so maxima is white.
- Red light has maximum wavelength, so its first maxima is at maximum distance from the central line and it has also have maximum fringe width
- Violet light has minimum wavelength, so its first maxima is at minimum distance from the central line and it has also minimum fringe width.
- Other colours are too are present at the maximum of a particular colour.

After this the fringes of many colours overlap at each point on the screen and the screen appears uniformly illuminated.

(A) Bright white fringes are formed at the centre of the screen.

(B) fringes of different colours are observed clearly only in first order.

(C) the first order violet fringes are closer to the centre of the screen than the first order red fringes.



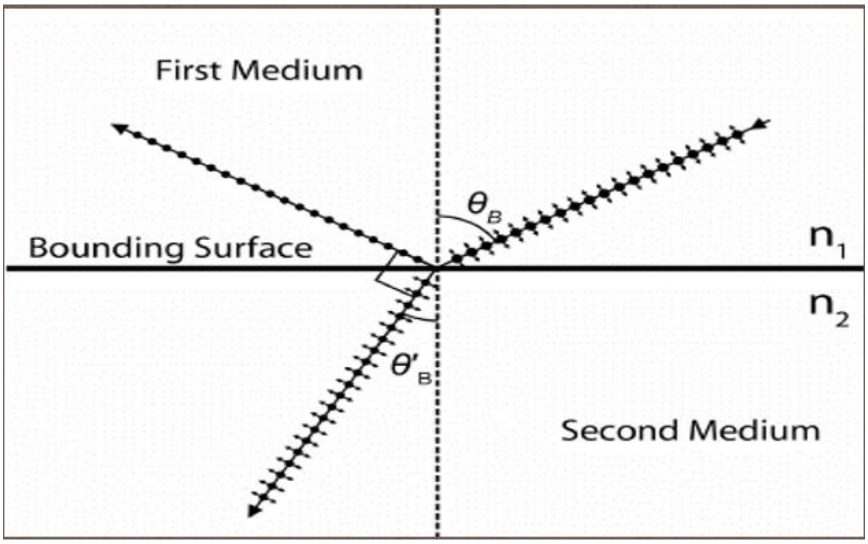
(Image source: Internet only for discussion with panelists)

4. A treasure hunter is about to jump into ocean for finding some hidden artifact. He observes the light reflected from the water's surface. At what angle relative to the surface of the water this observed light will be completely polarized?

Solution:

Concept involved: Brewster's Laws & Polarization

(Image Source: Internet)



We can find the refractive index of refracting medium.

Thus we have

$n2 = 1.333$

and $n1\ (air) = 1.000293$

$n1(air) = 1.000293$

and we know that

$\tan\theta = n2/n1$

$\theta = 53.115^{\circ}$

5. **Statement:** While there is seen a fall in intensity of the secondary maxima in comparison to the central maximum for a single slit diffraction, on the contrary all the bright fringes are of the same intensity in Young's Double Slit Experiment.

   Choose with proper justification from the following options:

   Option A: Statement is completely True.
   Option B: Statement is completely False.
   Option C: Statement is Partially correct with single slit part true and double slit part false.
   Option D: Statement is Partially correct with single slit part false and double slit part true.

   Solution:
   Option A
   For a single slit diffraction, the intensity of light for the secondary maxima decreases with the order of the maximum as the intensity of the central maximum is due to wavelets from all parts of the slit and the first secondary maximum is due to wavelets from one third part of the slit only (first two parts send wavelets in opposite phase), the second secondary maximum is due to the wavelets from the fifth part only (as first four parts shall send wavelets in opposite phase) and so on.
   Hence, the intensity of secondary maxima becomes less as compared to central maximum.
   In Young's Double Slit Experiment, the fringes are of equal width $y = \frac{\lambda D}{d}$ and equal intensities $I = (a + a)^2 = 4a^2$.

   Concept involved: Diffraction

   Discussion
   This is a direct paraphrasing of the conceptual definitions to check the ability of the student to grasp the concept if presented in terms of conditional statements or when two concepts simultaneously need to be interpreted.

6. Visible Hydrogen spectrum displays four wavelengths. In an experiment, the with second and third line of Hydrogen spectrum in visible band, viz, 434nm and 486nm wavelengths they are made to fall upon a single slit of width 5μm. Calculate the angle between the first minima for the two mentioned Hydrogen spectrum lines when they fall upon a slit.
   Solution:

   $n\lambda_1 = d\sin\theta_1$

$\lambda_1 = 434 \times 10^{-9} m$
d = $5\mu m$
Hence, $\theta_1 = \sin^{-1}\left(\frac{n\lambda_1}{d}\right)$

Substituting the values, we get $\theta_1 = 4.9795°$

$n\lambda_2 = d \sin\theta_2$
$\lambda_2 = 486 \times 10^{-9} m$
d = $5\mu m$
Hence, $\theta_2 = \sin^{-1}\left(\frac{n\lambda_2}{d}\right)$

Putting in the values, we get $\theta_2 = 5.5779°$

Hence, the angle between the first minima for the two mentioned Hydrogen spectrum lines

when they fall upon a slit.= $\theta_2 - \theta_1 = 0.5984°$

Concept involved: Diffraction: This question is a calculative question

Session XI

Higher Order Thinking Skills and Electromagnetic Induction

Dr. Deepak Sondhiya

- Developing thinking and learning
- What is the purpose of education?
- Why teach for thinking?
- Thinking to Learn (Highland Council)
- What are thinking skills?
- Dimensions of thinking
- What is higher order thinking?
- Activities that promote higher order skills

Electromagnetic Induction

Very Short

Q.1. If the coefficient of coupling between the two coils is 0.75, what does it indicate?

Solution: If the coefficient of coupling between two coils is 0.75, it means that 75% of the flux set up in one coil links the other.

Q.2. Consider that an artificial satellite that has a metal surface is orbiting the earth around the equator. Will the earth's magnetic field induce current in it?

Solution: No, magnetic field will not induce a current in this case. It is because a satellite can cut only the vertical component of earth's field which is zero at the equator. Therefore, no e.m.f. (and hence no current) is induced in the satellite.

Q.3. Can you suggest a method by which one may detect the presence of magnetic field on a planet?

Solution: We may connect a coil to a sensitive galvanometer and rotate the coil. If the galvanometer shows deflection, magnetic field is present on the planet, otherwise not.

Short Answers

Q.1. A truck is being driven with a velocity of 20m/sec. Assuming the length of the axle to be 2 metres and the vertical component of the earth's magnetic field to be 40 µwb/sec^2 determine the e.m.f. in the axle that is generated.

Solution:

Given:

Velocity of the truck **v = 20 m/sec**

Area of Magnetic field swept by axle, **A = axle length × car velocity = 2 × 20 = 40 m^2**

Now the flux cut **dφ = B.A = 1600 x 10^{-6} Wb**

Time Taken **dt=1 sec**

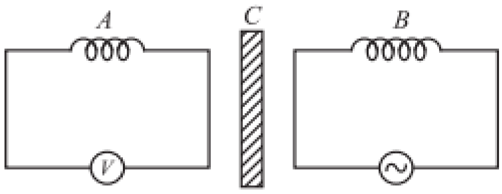
Therefore e=N (dφ/dt) = 1.6 mV

Ans: 1.6mV

Q.2. It is normally observed that small resistor (say a lamp) in general is put in parallel to the current carrying coil of a large electromagnet. What is the purpose of this resistor?

Solution: When current in the coil of a large electromagnet is switched off, there is a sudden break in the circuit. As a result, magnetic flux linking the coil decreases to zero at a very high rate and a large e.m.f. i.e. **e = – N(dφ/dt)** is induced in the coil. This large e.m.f. appears across the open contacts of the switch and may cause sparking, resulting in damage to the insulation. The small resistor placed in parallel provides a conducting path to the induced current. Thus the risk of sparking is avoided.

Q.3. Let us consider a case as in figure below where a coil A is connected to a voltmeter V and the other coil B to an alternating current source. If a large copper sheet C is placed between the two coils, how does the induced e.m.f. in the coil A get affected due to current in coil B?



Solution: In this case the induced e.m.f. in coil A will get reduced. It is so because when the copper sheet is placed between the two coils, then the eddy currents are induced in it which will oppose the magnetic flux due to coil B. As a result, the magnetic flux linking the coil A decreases.

Long Answer

Q.1. Can the effect of mutual inductance on the two coils between which it exists, be explained?

Solution: Mutual inductance comes into picture when two coils are placed close together in such a way that flux produced by one coil links the other. Each coil has its own inductance but in addition there is further inductance M due to coupling between the coils. If the fluxes of the two coils aid each other, the inductance of each coil will increase by M. If the fluxes of the two coils oppose each other, the inductance of each coil will decrease by M.

Q.2. Describe two important real time applications of Eddy currents.

Solution:

a. As Energy Meters: Eddy current braking is employed in energy meters. The aluminum disc of the energy meter rotates between the poles of two permanent horse shoe magnets. As the disc rotates and cuts across the magnetic fields of the magnets, eddy currents are produced in the disc. These eddy currents oppose the motion of the disc. As a result of this braking effect, the speed of the disc is directly proportional to the energy consumed.

b. As Electromagnetic Brakes. Eddy current braking can be used to control the speed of electric trains. In order to reduce the speed of the train, an electromagnet is turned on that applies its field to the wheels. Large eddy currents are set up which produce the retarding effect.

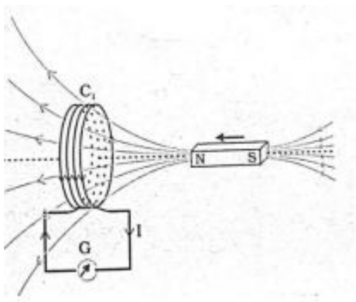
Q.3. What could be the reason for the coils of a resistance box being normally made up of double insulated wire?

Solution: This is done to minimize the inductance of coils. The wire is doubled back on itself. As a result, there are equal and opposite currents in each section of the coil. Therefore, the coil has no net magnetic field and no net induced e.m.f. Such coils are called no inductive coils and have the following advantages:

(i) The current attains the final value quickly at the time of make or break.
(ii) When used with a.c., the current through such coils is not dependent n frequency.

Q.4. How does the coil and magnet experiment justify the law of Electromagnetic Induction?

Solution: This phenomena can be justified on the basis of the figure given below. When the North-pole of a magnet is moved towards a coil connected to a galvanometer, the galvanometer in the circuit shows a deflection indicating a current (and hence an emf) in the circuit. The deflection continues as long as the magnet is in motion. A deflection can be observed if and only if the coil and the magnet are in relative motion. When the magnet is moved away from the coil, the galvanometer shows a deflection in the opposite direction. Bringing the South-pole towards the coil produces the opposite deflection as bringing the North-pole. Faster the magnet or the coil is moved, larger is the deflection produced. By this experiment we can conclude that: the relative motion between the coil and the magnet generates an emf (current) in the coil.



Multiple Choice Question-MCQ

Q.1. In an experiment, A conductor 0.4m long moves with a velocity of 0.2m/s in a magnetic field of 5T, calculate the emf induced if magnetic field, velocity and length of conductor are mutually perpendicular to each other.
a) 0.4V
b) 0.04V
c) 40V
d) 4V

Ans: a) 0.4 V

The formula for induced emf is: emf=Blv if B,l,v are mutually perpendicular to each other. Substituting the values of B, l and v from the question, we get emf=0.4V.

Q.2. Suppose two identically coaxial circular loops carry a current ***i*** each circulating in the same direction. If the loops approach each other then which will hold true?

a) Current in each will increase
b) Current in each will decrease
c) Current in each will remain same
d) Current in one will increase and in the other will decrease

Ans: b) Current in each will decrease

Q.3. Let us consider that two coils are placed close to each other. Then the mutual inductance of the pair of coils will depend upon:

a) the rates at which currents are changing in the two coils
b) relative position and orientation of the two coils
c) the materials of the wires of the coils
d) the currents in the two coils

Ans: d) The coils are placed close to each other; the mutual inductance of the pair of coils depends upon the current in two coils.

Session XI

Newton’s Laws of Motion

Dr. Mita Chaurasia

Galileo’s Experiment and Inertia of Rest/Motion- Day to day applications

Concept of Momentum

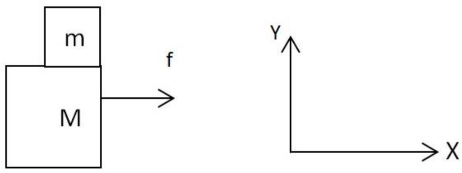
Concept of Force

Concept of Newton’s Laws

Laws of Motion

MCQ Type

Q.1. Mass "m" is placed on a body of mass "M". It is assumed that there is no friction. Force "F" is applied on "M" and is moved with acceleration "a". Then the force along x-axis on the top of the body is:

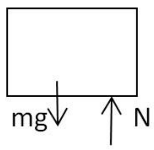


(a) F itself
(b) F - ma
(c) $\frac{F}{2}$
(d) No force.

Ans. (d)

Solution: There exists no force along horizontal direction on mass "m"

[The free body diagram on "m" is]



Learning Outcomes: Understanding a "system" and analyzing the force acting on a Mass.

Q.3. Assertion - Reason type questions:

The following question consists of two statements, each as Assertion and Reason.

You are required to choose any one of the following four responses.

Assertion: A body dropped from a given height and another body projected horizontally from the same height strike the ground simultaneously.

Reason: Because horizontal velocity has no effect in the vertical direction.

- **(A) If both, Assertion and reason are true and the Reason is the correct explanation of the Assertion.**
- **(B) If both, Assertion and reason are true but reason is not a correct explanation of the Assertion.**
- **(C) If Assertion is true but the reason is false.**
- **(D) If both Assertion and Reason are false.**

(a) A (b) B (c) C (d) D

Solution: Component of horizontal velocity (u) along the vertical = $u\cos 90^{\circ} = 0$. Therefore, vertical motion is not affected. Time taken by the two bodies to strike the ground is the same.

Answer: (a) A

Learning Outcomes: Apply logical reasoning

Q.4. Case based MCQ.

Newton stated second law as rate of change of momentum is equal to the force applied. To produce an acceleration "a" on mass "m", a force F = ma is required If a = 0, then F = 0 means no external force is required to move a body uniformly along a straight line. If a force "F" acts on a body for a very small instant of time "t" seconds, then this effect of the force is called Impulse.

(i) A cricket ball of mass 120 g is moving with a velocity 10 m/s and is hit by a bat so that the ball is turned back with a velocity of 20 m/s. If duration of contact between the ball and the bat is 0.01 sec. The impulse of the force is:

(a) 4.8 N-S (b) 3.6 N-S (c) 1.2 N-S (d) 6.3 N-S

Solution:

m=120g $= 120 \times 10^{-3}$ kg

u =10 m/s, V = 20m/s, t = 0.01 Sec.

Impulse = change in linear momentum

$= m(v - u)$

$= 120 \times 10^{-3}[20 - (-10)]$ = 3.6 N-S.

Answer (b)

(ii) Average force exerted by the bat is:

(a) 360 N (b) 120 N (c) 1200 N (d) 630 N

Solution: F $= \frac{I}{t} = \frac{3.6}{.01} = 360\ N$

Answer (a)

Learning Outcomes: Correlated physical quantities with their mathematics statements.

Short answer questions:

Q.5. The distance travelled by a body is directly proportional to time. Is any external force acting on it?

Solution:

$s \propto t \Rightarrow s = kt,$ where k is constant

$\upsilon = \frac{ds}{dt} = k \Rightarrow a = \frac{\nu}{dt} = 0$

External force, $F = m \times a =$ zero

Learning Outcomes: Analyze relation between physical quantity.

Q.6. Is large brake on a bicycle wheel more effective than a small one? Justify. Assume that there is no slipping.

Solution:

Small brake is effective as force of friction is ideally independent of surface area of constant. However, the chances of brake fail decreases when area of contact is large. Therefore large brakes are preferred.

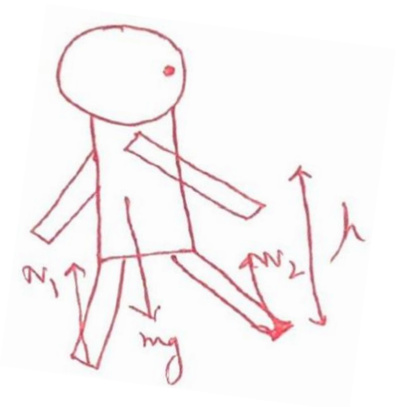
Learning Outcomes: Concept of force v/s Area of contact.

Short Answer

Q.7. A man is walking and slips on a frictionless surface. Describe the motion. If he manages to stand on such a surface, is his weight equally distributed on both legs?

Solution:

Free Body Diagram



Stability condition:

Net torque about center of mass (CM) of man = 0

Foot length = $2l$

Torque about CM, $\tau = (N_1 - N_2)\, l = 0$ ... ... (i)

Hence $N_1 = N_2$

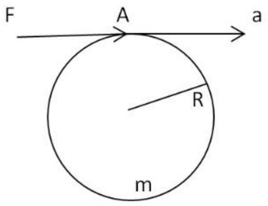
Case I: If man's initial position is as shown in the diagram, then when he lifts his back leg for forward movement, from equation........(1)

$I = N_2 l \Rightarrow$ So he falls, his back facing ground.

Case II: If initially his legs are together and he tries to move forward, then as there is no external HORIZONTAL FORCE, his CM does not move horizontally. So as he propels forward his leg slips backward to keep cm at the same position, hence he falls forward.

Learning Outcomes: Balancing of forces.

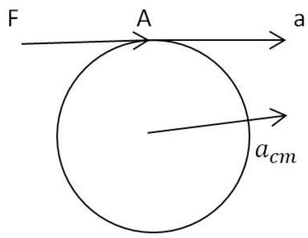
Q.8. A force "F" is acting on a disc of mass "m" and radius R as shown. The acceleration at point A is "a", hence F = ma. Is it.



(i) True or (ii) False

Justify.

Solution:



According to Newton's 2nd law.

$F = ma_{CM}$, (CM=centre of disc itself)

The acceleration of point A,

$\mathrm{a} = \mathrm{a_{cm}} + \propto \mathrm{R}$, ($\propto$ is angular accleration about CM),

both a_{cm} & $\propto \times \mathrm{R}$ are in the same direction, so additive.

$\tau = I \propto$, here $\tau = \mathrm{FR}$. and moment of inertia $\mathrm{I} = \frac{1}{2}\mathrm{mR}^2$

$$\propto = \frac{\tau}{I} = \frac{2F}{mR}$$

$MR = 2F$

$$\therefore \mathrm{a} = \mathrm{a_{cm}} + \propto \mathrm{R} = \frac{3\mathrm{F}}{\mathrm{m}}$$

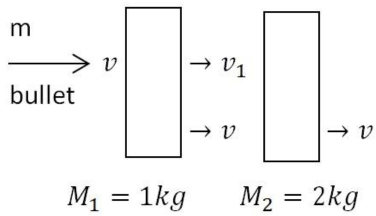
Answer: False

Learning Outcomes: Torque is force for rotational motion.

Q.9. Two husk solid blocks of masses 1kg and 2kg are kept 50 cm apart. A bullet 0.02 kg fired from a gun passes through 1kg block and then stopped in the second block. After the impact of the bullet, assume that both blocks start moving with the same speed. Calculate the percentage loss in the initial velocity of the bullet, when it is in between the two blocks.

Solution:

M1=1kg, M2=2 kg, m=.02 kg



Let v =initial velocity of the bullet

v_1 = Velocity of bullet after piercing through the first block.

V = Velocity of each block after hitting by the bullet.

Applying Principle of conservation of linear momentum

When bullet penetrates I block

$mv = M_1 V + m v_1 \ldots\ldots..(1)$

When bullet penetrates II block

$mv_1 = (M_2 + m)V$

$$v_1 = \left(\frac{M_2 + m}{m}\right) V$$

$$= \left(\frac{2 + 0.02}{0.02}\right) V$$

$v_1 = 101V$

From (1), $0.02v = 1V + 0.02v_1$

$= V + (0.02)(101)V$

$v = \frac{3.02}{0.02}V = 151V$

% Loss in initial velocity of bullet $= \frac{(v - v_1) \times 100}{v}$

$= \frac{151V - 101V}{151V} \times 100$

$= 33.11\%$

Learning Outcomes: Conversation of linear momentum.

Long Answer:

Q.10. Two block of mass $m_1 = 10\ kg\ and\ m_2 = 5\ kg$ are connected to each other by a massless inextensible string of length 0.3 m are placed along a diameter of the turn table. The coefficient of friction between the table and m_1 is 0.5 while there is no friction between m_2 and the table. The table is rotating with an angular velocity of 10 rad/s about a vertical axis passing through its entre O. The masses are placed along the diameter of the table on either side of the center O such that the mass m_1 is at a distance of 0.124 m from O. The masses are observed to be at rest with respect to an observer on the turn table. (g=9.8 m/s^2)

(i) Calculate the frictional force on m_1.

(ii) What should be the minimum angular speed of the turn table so that the masses will slip from this position?

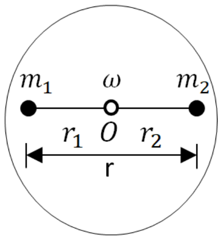
(iii) How should the masses be placed with the string remaining taut so that there is no frictional force acting on the mass m_1?

Solution: Given $m_1 = 10\ kg, m_2 = 5\ kg, \omega = 10$ rad/s

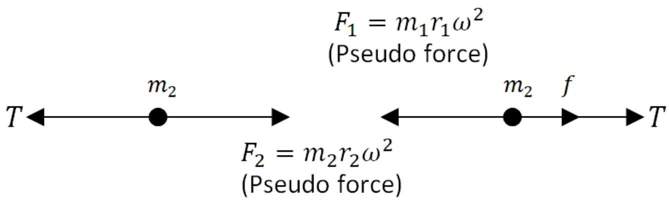
$r = 0.3$ m, $r_1 = 0.124$ m

$\therefore r_2 = r - r_1 = 0.176$ m

(i) m_1 and m_2 are at rest with respect to rotating table. Let f be the friction between mass m_1 and table.



Free body diagram of m_1 and m_2 with respect to table (non inertial frame of reference are shown in figure).



$F_2 = m_2 r_2 \omega^2$ ....(1)

Since, $m_2 r_2 \omega^2 < m_1 r_1 \omega^2$ $(m_2 r_2 < m_1 r_1)$

Therefore, $m_1 r_1 \omega^2 > F_2$

And friction on m_1 will be inwards (towards centre)

Equilibrium of m_1 gives

$$f = T = m_1 r_1 \omega^2 \quad ..(2)$$

From Eqs. (1) and (2), we get

$$F_1\text{-}F_2 = f = m_1 r_1 \omega^2 - m_2 r_2 \omega^2$$

$$= (m_1 r_1 - m_2 r_2)\omega^2 \quad ...(3)$$

$$= (10 \times 0.124 - 5 \times 0.176)^2 \text{ newton}$$

$$\boldsymbol{f = 36N}$$

Therefore, frictional force on m_1 is 36 N (inwards).

Eq. (2) from Eq. (3)

$$f = (m_1 r_1 - m_2 r_2)\omega^2$$

Masses will start slipping when this force is greater than f_{max} or

$$(m_1 r_1 - m_2 r_2)\omega^2 > f_{max} > \mu m_1 g$$

∴ Minimum value of ω is

$$\omega_{min} = \sqrt{\frac{\mu m_1 g}{m_1 r_1 - m_2 r_2}} = \sqrt{\frac{0.5 \times 10 \times 9.8}{10 \times 0.124 - 5 \times 0.176}}$$

$$\omega_{min} = 11.67 \text{ rad/s}$$

(iii) From eq. (3), frictional force $f = 0$ when $m_1 r_1 = m_2 r_2$

or $\frac{r_1}{r_2} = \frac{m_2}{m_1} = \frac{5}{2} = \frac{1}{2}$

and $r = r_1 + r_2 = 0.3m$

∴ $r_1 = 0.1m \text{ and } r_2 = 0.2m$

$\mathbf{i.e.,\ mass\ m_2\ should\ be\ placed\ at\ 0.2\ m\ and\ m_1\ at\ 0.1\ from\ the\ centre\ O.}$

Learning Outcomes: Concept of friction, angular velocity and rotational motion.

Session XII

Magnetism

Prof. M.N. Bapat

- Analysis: Analyze the effects of magnetic fields on different materials and how it affects their behavior.
- Evaluation: Evaluate the effectiveness of different methods for measuring the strength of magnetic fields.
- Synthesis: Create a design for a device that uses magnetism to solve a particular problem or achieve a specific goal.
- Application: Apply the principles of magnetism to real-world situations, such as designing motors or generators.
- Comparison: Compare and contrast different types of magnets and their properties.
- Interpretation: Interpret and analyze data from experiments involving magnetism to draw conclusions and make predictions.
- Problem-Solving: Develop strategies for solving problems related to magnetism, such as how to increase the strength of a magnetic field or how to shield against magnetic interference.
- Prediction: Predict the behavior of magnetic fields in different situations, such as how the field will change when a magnet is moved or when a current is applied to a wire.
- Generalization: Generalize the principles of magnetism to other areas of physics, such as electricity or electromagnetism.
- Creativity: Use imagination and creativity to design novel applications or uses for magnetism that have not been explored before.

Objective Type Questions:

Q.1. The magnetic moment of an electron orbiting in a circular orbit of radius r with a speed v is equal to:

(a) $\frac{evr}{2}$ (b) evr (c) $\frac{er}{2v}$ (d) None of these

Answer: (a)

Solution: Magnetic movement $\mu = nIA$

Where $n =$ number of turns of the current loop, and $I =$ current

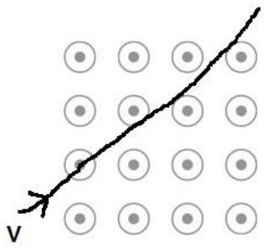
Since the Orbiting electron behaves as a current loop of current I,

So $I = \frac{e}{T} = \frac{e}{2\pi r/v} = \frac{ev}{2\pi r}$

$A =$ Area of the loop $= \pi r^2$

$\mu = (1)\left(\frac{ev}{2\pi r}\right)(\pi r^2) = \frac{evr}{2}$ **Answer.**

Q.2. A particle enters the region of a uniform magnetic field as shown in figure. The path of the particle inside the field is shown by a dark line. The particle is:



(a) Electrically neutral

(b) Positively charged

(c) Negatively charged

(d) Nothing definite can be said about the nature of the charge as the information given is inadequate.

Answer: (c)

Q.3. An electron moves straight inside a charged parallel plate capacitor of uniform surface charge density σ. The space between the plates is filled with constant magnetic field of induction $\vec{B}$ as shown in figure, Neglecting gravity, the time of straight line motion of the electron in the capacitor is:

(a) $\frac{\sigma}{\varepsilon_0 l_B}$ (b) $\frac{\varepsilon_0 l_B}{\sigma}$ (c) $\frac{\sigma}{\varepsilon_0 B}$ (d) $\frac{\varepsilon_0 B}{\sigma}$

Answer: (b)

Solution: The net electric field

$\vec{E} = \vec{E}_1 + \vec{E}_2$

$$E = \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0} = \frac{\sigma}{\varepsilon_0}$$

The net force acting on the electron is zero because it moves with constant velocity

$\vec{F}_{net} = \vec{F}_e + \vec{F}_m = 0$

$|\vec{F}_e| = |\vec{F}_m|$

$e_E = evB$

$$v = \frac{E}{B} = \frac{\sigma}{\varepsilon_0 B}$$

∴ The time of motion inside the capacitor

$t = \frac{l}{v} = \frac{\varepsilon_0 lB}{\sigma}$ **Answer**

Q.4. Two wires wrapped over a conical frame form coils 1 and 2. If they produce no net magnetic field at the apex P, the value of $\frac{I_1}{I_2} =$

(a) $\sqrt{\frac{r2}{r_1}}$ (b) $\frac{r_1}{r_2}$ (c) $\left(\frac{r_1}{r_2}\right)^2$ (d) $\sqrt{\frac{r_1}{r_2}}$

Hint B = $\frac{\mu_0 I}{2r}$

Answer: (b)

Solution:

For loop 1

$$B_1 = \frac{\mu_0 I_1}{2r_1}(+\hat{j})$$

For loop 2

$$B_2 = \frac{\mu_0 I_2}{2r_2}(-\hat{j})$$

∵Net Magnetic field at P is zero

So

$$\vec{B}_1 + \vec{B}_2 = 0$$

$$B_1 = B_2$$

$$\frac{\mu_0 I_1}{2r_1} = \frac{\mu_0 I_2}{2r_2}$$

$\frac{I_1}{I_2} = \frac{r_1}{r_2}$ **Answer**

Very Short Answer

Q.1. The magnetic field at Q, where Q is the centre of the circular loop lying in $y - z$ plane is:

$$\vec{B}_1 = \frac{\mu_0 I}{2a}(-\hat{\imath})$$

Magnetic field due to the Z-axis at Q point

$$\vec{B}_2 = \frac{\mu_0}{4\pi a}2I(+\hat{\imath})$$

Magnetic field due to the X-axis at Q point

$$\vec{B}_3 = \frac{\mu_0}{4\pi a}2I\left(+\hat{k}\right)$$

Resultant Magnetic field of B_1 and B_2

$$B^1 = B_1 - B_2$$

$$B^1 = \frac{\mu_0 I}{2a}\left(1 - \frac{1}{\pi}\right)(-\hat{\imath})$$

Resultant Magnetic field of B_1 and B_3

$$B = \sqrt{B_3^2 + B_1^2 + 2B_3.B^1\cos 90^\circ}$$

$$= \sqrt{B_3^2 + B_1^2}$$

$$= \sqrt{\left(\frac{\pi_0}{4\pi a}2I\right)^2 + \left[\frac{\mu_0 I}{2a}\left(1-\frac{1}{\pi}\right)\right]^2}$$

$= \frac{\mu_0 I}{2a}\sqrt{\left(\frac{1}{2\pi}\right)^2 + \left(1-\frac{1}{\pi}\right)^2} = \frac{\mu_0 I}{2a}\left(\frac{1}{\pi}-1\right)$ Answer

Magnetic field at O point due to Circular loop (radius a)

$$\vec{B}_1 = \frac{\mu_0 I}{2a}(+\hat{K})$$

Magnetic field at O point due to Circular loop (radius b)

$$\vec{B}_2 = \frac{\mu_0 I}{2b}(-\hat{K})$$

Magnetic field at O point due to the linear

$$\vec{B}_3 = \frac{\mu_0}{4\pi b}2I(-\hat{K})$$

Because not magnetic field at O point is Zero

So $\vec{B}_1 + \vec{B}_2 + \vec{B}_3 = 0$

$B_1 - B_2 - B_3 = 0$

$$\frac{\mu_0 I}{2a} - \frac{\mu_0 I}{2b} - \frac{\mu_0 2I}{4\pi b} = 0$$

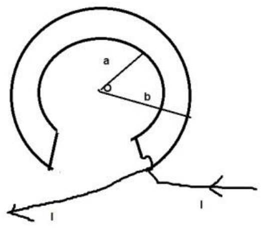
$$\frac{\mu_0 I}{2a} = \frac{\mu_0 I}{2b}\left(1+\frac{1}{\pi}\right)$$

$$\frac{1}{a} = \frac{1}{b}\left(1+\frac{1}{\pi}\right)$$

$$\frac{1}{a} = \frac{1}{b}\left(\frac{\pi+1}{\pi}\right)$$

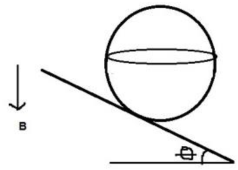
$\frac{a}{b} = \left(\frac{\pi}{\pi+1}\right)$ **Answer**

Q.2. The value of $\frac{a}{b}$ so as to get a zero magnetic field at O is:



Answer. $\frac{\pi}{(\pi+1)}$

Q.3. In the figure shown, a coil of single turn is would on a sphere of radius r and mass m. The plane of the coil is parallel to the inclined plane and lies in the equatorial plane of the sphere. If the sphere is in rotational equilibrium, the value of B is (current in the coil is I)



Answer. The gravitational torque must be counter balanced by the magnetic torque about O, for equilibrium of the sphere. The gravitational torque:

$\tau_{gr} = mg \times r \sin\theta$

$\tau_{gr} = mgr \sin\theta$ ... ... (1)

The magnetic torque, $\tau_m = \vec{\mu} \times \vec{B}$

Where the magnetic moment of the coil = $\mu = I\pi r^2$

$\tau_m = \pi I r^2 B \sin\theta$ ... ... (2)

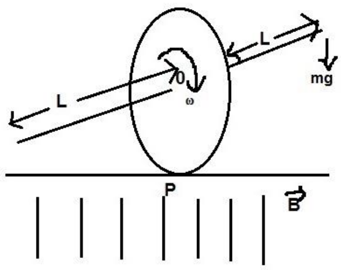
By equation (1) and (2)

$\pi I r^2 B \sin\theta = mgr \sin\theta$

$\boldsymbol{B = \frac{mg}{\pi I r}}$

Short Questions:

Q.1. A wheel of mass M and radius r having charge Q, uniformly distributed over its rim is rolling on rough horizontal ground without slipping about a light rod of length $2L$. A uniform magnetic field B, directed opposite to the gravitational field, is switched on in the space. Find the value of mass m that should be placed at the end of rod to prevent the toppling of wheel.



Answer. Torque acting on the wheel due to magnetic field,

$$T_B = \frac{q}{\frac{2\pi}{\omega}} \times \pi R^2 \times B = \frac{q\omega B R^2}{2}$$

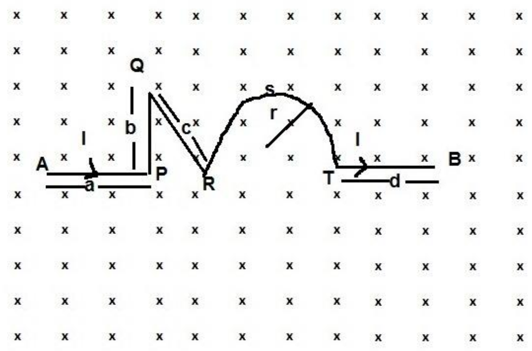
Take moment about P

$T_B = MgL$

$$\frac{q\omega B R^2}{2} = MgL$$

$\boldsymbol{M = \frac{q\omega BR^2}{2gl}}$

Q.2. Calculate the force on a current carrying conductor in a uniform magnetic field as shown.



Answer. The net force A to $B, dF = I(dL \times B)$

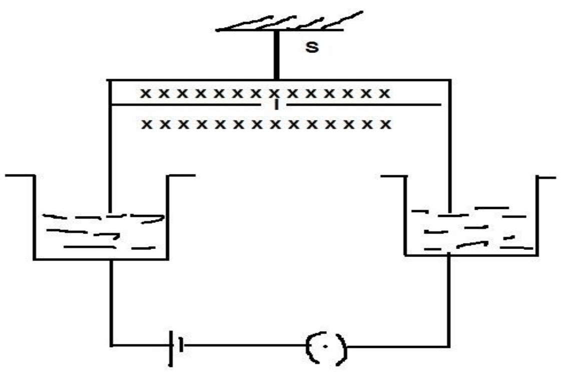
$$\int_A^B d\vec{F} = \int_A^P I[d\vec{L}_1 \times \vec{B}] + \int_P^Q I[d\vec{L}_2 \times \vec{B}] + \int_Q^R I[d\vec{L}_3 \times \vec{B}] + \int_R^T I[d\vec{L}_4 \times \vec{B}] + \int_T^B I[d\vec{L}_5 \times \vec{B}]$$

The entire path can be broken down into elemental vectors joined to each other in sequence. We know, from polygon law of addition of vectors that the vector joining the tail of the first vector to the head of the last vector is the resultant vector.

$\vec{F} = I(\vec{L} \times \vec{B})$, where $|\vec{L}| = a + \sqrt{c^2 - b^2} + 2r + d$

$F_{net} = IB(a + \sqrt{c^2 - b^2} + 2r + d)$ and direction is upwards in the plane of paper.

Q.3. A U-shaped rod of mass m and horizontal length l hangs from a rigid support by a non-conducting strings. The ends of the rod are immersed in a conducting liquid. When the key is closed at $t = 0$, a current is passed through the rod and the rod jumps up by an impulse of Ampere's force, through a height h. If the inward magnetic field is B, find the total charge passing through the rod.



Answer. Let the speed of the wire is v.

Then, $\int Fdt = mv$, where

$F = Ilb$

$\because \int Fdt = mv$

$$\int IlBdt = mv$$

$$lBq = mv \qquad \because Idt = q$$

$$q = \frac{mv}{lB} \text{ where } v = \sqrt{2gh}$$

Then $q = \frac{m\sqrt{2gh}}{lB} = \frac{10^{-3}\sqrt{2\times9.8\times2}}{(15\times10^{-3})(0.2)} = 2.08\ Columb$

Long Questions:

Q.1. A particle of mass 1×10^{-26} Kg and charge $+1.6 \times 10^{-19}$ coulomb travelling with a velocity of 1.28×10^{6} m/sec in the $+x$ direction enters a region in which a uniform electric field E and a uniform magnetic field of induction B are present. Such that $E_x = E_y = 0, E_Z = -102.4 \frac{KV}{meter}$ and $B_x = B_z = 0, B_y = 8 \times 10^{-2} \frac{Wb}{meter^2}$. The particle enters this region at the origin at time $t = 0$. Determine the location on (x, y and z coordinates) of the particle at $t = 5 \times 10^{-6}$ second. If the electric field is switched off at this instant (with the magnetic field still present), What will be the position of the particle at $t = 7.45 \times 10^{-6}$second?

Answer. Let $\hat{\imath}, \hat{\jmath}\ and\ \hat{k}$ be unit vectors along the positive directions of x, y and z axis.

Q = Charge on the particle = 1.6×10^{-19} columb

v =Velocity of the charged particle

$= (1.28 \times 10^{6})\hat{\imath}\,\frac{meter}{sec}$

$\vec{E}$ = Electric field intensity

$= (-102.4 \times 10^{3}\ Vm^{-1})\ \hat{k}$

$\vec{B}$ = Magnetic induction of the magnetic field

$= \left(8 \times 10^{-2}\frac{Wb}{m^2}\right)\hat{\jmath}$

$\therefore\ \vec{F_e}$ = Electric force on the charge

$$= q\vec{E} = [1.6 \times 10^{-19}(-102.4 \times 10^{3})N]\hat{k}$$

$$= 163.84 \times 10^{-16}\ Newton\ (-\hat{k})$$

$\vec{F_m}$ = Magnetic force on the charge

$= q\vec{v} \times \vec{B}$

$= 1.6 \times 10^{-19}(1.28 \times 10^{6})(8 \times 10^{-2})N(\hat{\imath} \times \hat{\jmath})$

$= (163.84 \times 10^{-16}\ Newton\ )(\hat{k})$

The two forces $\vec{F_e}$ and $\vec{F_m}$ are along z axis and equal, opposite and Collinear.

The net force on the charge is zero and hence the particle does not get neglected and continues to travel along x-axis

(a) At time $t = 5 \times 10^{-6}\ second$

$X = (5 \times 10^{-6})(1.28 \times 10^{6}) = 6.4\ meter$

∴ Co-ordinators of the particle are $(6.4m, 0, 0)$

(b) When the Electric field is switched off, the particle is in the uniform magnetic field perpendicular to its velocity only has a uniform Circular motion in the X-Z plane (i.e. the plane of Velocity and magnetic force), anticlockwise as seen along +y axis.

Now $\frac{mv^2}{r} = qvB$, Where r is the radius of the circle

$$\therefore r = \frac{mv}{qB} = \frac{(1 \times 10^{-26})(1.28 \times 10^{6})}{(1.6 \times 10^{-19})(8 \times 10^{-2})} = 1$$

The length of the arc traced by the particle in $[(7.45 - 5) \times 10^{-6}s]$

$= v(t) = (1.28 \times 10^{6})(2.45 \times 10^{-6}) = 3.136$ meter = $\pi m = \frac{1}{2}$ circumference

∴ The particle has the coordinates $(6.4m, O, 0.2m)$ as (x, y, z).

2. A particle of mass m and charge q is projected from the origin with a velocity $\vec{v} = a\hat{\imath} + b\hat{\jmath} + c\hat{k}$ at $t = 0$, in an electric field $\vec{E} = E\hat{\jmath}$ and magnetic field $\vec{B} = B\hat{\jmath}$. Find the position vector of the particle after a time t.

Answer. The components of velocity of the particle parallel and perpendicular to $\vec{B}$ are

$v_{||} = v\cos\theta$ and $v_{\perp} = v\sin\theta$

The period of revolution of the particle is:

$$T = \frac{2\pi m}{qB}$$

Then, the angular frequency of revolution is $w = \frac{2\pi}{T} = \frac{qB}{m}$

The radius of the circular path is $r_0 = \frac{mv_{\perp}}{qB}$

After a time t, (assuming $E = 0$ and $v_{\|} = 0$)

the chord $OA = 2r_0 \sin\frac{wt}{2}$

and the angle β made by OA with X=axis is

$$\beta = 90^{\circ} - \left(\frac{wt}{2} + \emptyset\right),$$

Where $\emptyset = \tan^{-1}\left(\frac{v_z}{v_x}\right) = \tan^{-1}\frac{c}{a}$

Then, $v_x(= x) = OA\cos\beta,$

$r_z(= z) = OA\sin\beta$

and $r_y = v_{\parallel}t + \frac{1}{2}\frac{qE}{m}t^2$

$$\vec{r} = OA\cos\beta\,\hat{\imath} + \left(v_{\parallel}t + \frac{1}{2}\frac{qE}{m}\ t^2\right)\hat{\jmath} + OA\sin\beta\,\hat{k},$$

Where $OA = 2r_0\sin\frac{wt}{2}$

Or $\vec{r} = 2r_0\frac{\sin wt}{2}\cos\ \beta\,\hat{\imath} + \left(v_{11}t + \frac{1}{2}\frac{qE}{m}t^2\ \right)\hat{\jmath} + 2r_0\sin\frac{\omega t}{2}\sin\beta\hat{\jmath}$

Where $w = \frac{qB}{m}, v_{\parallel} = b, r_0 = \frac{m\sqrt{a^2+c^2}}{qB}\ and\ \beta = 90^{\circ} + \frac{wt}{2} - \emptyset$

Or $\vec{r} = \frac{-2m\sqrt{a^2+c^2}}{qB}\frac{\sin qB}{2m}t\sin\left(\frac{wt}{2} - \emptyset\right)\hat{\imath} + \left(bt + \frac{qE}{2m}t^2\right)\hat{\jmath} + \frac{2m\sqrt{a^2+c^2}}{qB}\ \frac{\sin qB}{2m}t.\cos\left(\frac{wt}{2} - \emptyset\right)\hat{k},$

Where $\emptyset = \tan^{-1}\frac{a}{c}$

Q.3. Find the pressure exerted on the wall of a long thin cylinder of radius *R* which carries a current I.

Answer. The magnetic field just outside of the tube is

$$B_{out} = \frac{\mu_0 I}{2\pi R}$$

and that inside is $Bin = 0$

Taking a thin long segment of the tube, its magnetic field B_1 is equal to magnetic field $B^{'}$ due to the other position of the tube because these two fields nullifies each other to give zero magnetic field inside.

Hence, $B^{'} = B_1,$ since $B^{'} + B_1 = \frac{\mu_0 I}{2\pi R}$ because these two magnetic fields favours outside the tube, we have $B_1 = B^{'} = \frac{\mu_0 I}{2\pi R}$. Then the force acting on the considered portion is:

$$d_F = (di)lB^1$$

$$= \left\{\left(\frac{I}{2\pi R}\right)(dx)\right\}l\left(\frac{\mu_0 I}{4\pi R}\right)$$

$$P = \frac{d_F}{d_A} = \frac{d_F}{ld_x}$$

$$\boldsymbol{P = \frac{\mu_0 I^2}{8\Pi^2 R^2}}$$

Session XII

Electromagnetic Induction

Dr. Shivalika Sarkar

- Analysis: Analyze the relationship between magnetic flux and induced EMF in a coil. Derive an expression for the induced EMF and evaluate the factors that affect its magnitude.
- Evaluation: Evaluate the effectiveness of different methods for increasing the induced EMF in a coil, such as increasing the number of turns or changing the magnetic field strength. Compare and contrast their advantages and disadvantages.
- Synthesis: Design an electromagnetic generator that can produce a desired amount of electrical power. Calculate the required number of coils, magnetic field strength, and rotation speed of the generator.
- Application: Develop a system that uses electromagnetic induction to wirelessly charge a mobile device. Evaluate the efficiency of the system and compare it to other wireless charging methods.
- Comparison: Compare and contrast different types of transformers, such as step-up and step-down transformers. Evaluate their effectiveness in different situations.
- Interpretation: Interpret and analyze experimental data related to electromagnetic induction, such as voltage and current measurements, to make predictions and draw conclusions.
- Problem-Solving: Develop strategies for solving complex problems in electromagnetic induction, such as calculating the induced EMF in a coil with changing magnetic fields or determining the effect of eddy currents on a transformer.
- Prediction: Predict the behavior of electromagnetic systems under different conditions, such as changes in magnetic field strength or frequency.
- Generalization: Generalize the principles of electromagnetic induction to other areas of physics, such as Maxwell's equations or electromagnetic waves.
- Creativity: Use imagination and creativity to design new applications for electromagnetic induction, such as wireless power transfer for electric vehicles or induction heating systems for industrial processes.

Very Short

Q.1. If the coefficient of coupling between the two coils is 0.75, what does it indicate?

Solution: If the coefficient of coupling between two coils is 0.75, it means that 75% of the flux set up in one coil links the other.

Q.2. Consider that an artificial satellite that has a metal surface is orbiting the earth around the equator. Will the earth's magnetic field induce current in it?

Solution: No, magnetic field will not induce a current in this case. It is because a satellite can cut only the vertical component of earth's field which is zero at the equator. Therefore, no e.m.f. (and hence no current) is induced in the satellite.

Q.3. Can you suggest a method by which one may detect the presence of magnetic field on a planet?

Solution: We may connect a coil to a sensitive galvanometer and rotate the coil. If the galvanometer shows deflection, magnetic field is present on the planet, otherwise not.

Short Answers

Q.1. A truck is being driven with a velocity of 20m/sec. Assuming the length of the axle to be 2 metres and the vertical component of the earth's magnetic field to be 40 μwb/sec^2 determine the e.m.f. in the axle that is generated.

Solution:

Given:

Velocity of the truck **v = 20 m/sec**

Area of Magnetic field swept by axle, **A = axle length × car velocity = 2 × 20 = 40 m^2**

Now the flux cut **$d\varphi = B.A = 1600 \times 10^{-6}$ Wb**

Time Taken **dt=1 sec**

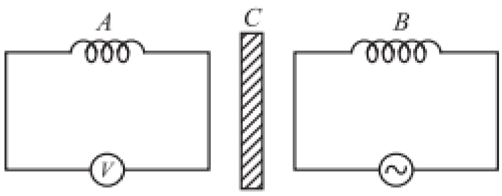
Therefore $e=N (d\varphi/dt) = 1.6$ mV

Ans: 1.6mV

Q.2. It is normally observed that small resistor (say a lamp) in general is put in parallel to the current carrying coil of a large electromagnet. What is the purpose of this resistor?

Solution: When current in the coil of a large electromagnet is switched off, there is a sudden break in the circuit. As a result, magnetic flux linking the coil decreases to zero at a very high rate and a large e.m.f. i.e. **$e = - N(d\varphi/dt)$** is induced in the coil. This large e.m.f. appears across the open contacts of the switch and may cause sparking, resulting in damage to the insulation. The small resistor placed in parallel provides a conducting path to the induced current. Thus the risk of sparking is avoided.

Q.3. Let us consider a case as in figure below where a coil A is connected to a voltmeter V and the other coil B to an alternating current source. If a large copper sheet C is placed between the two coils, how does the induced e.m.f. in the coil A get affected due to current in coil B?



Solution: In this case the induced e.m.f. in coil A will get reduced. It is so because when the copper sheet is placed between the two coils, then the eddy currents are induced in it which will oppose the magnetic flux due to coil B. As a result, the magnetic flux linking the coil A decreases.

Long Answer

Q.1. Can the effect of mutual inductance on the two coils between which it exists, be explained?

Solution: Mutual inductance comes into picture when two coils are placed close together in such a way that flux produced by one coil links the other. Each coil has its own inductance but in addition there is further inductance M due to coupling between the coils. If the fluxes of the two coils aid each other, the inductance of each coil will increase by M. If the fluxes of the two coils oppose each other, the inductance of each coil will decrease by M.

Q.2. Describe two important real time applications of Eddy currents.

Solution:

c. As Energy Meters: Eddy current braking is employed in energy meters. The aluminum disc of the energy meter rotates between the poles of two permanent horse shoe magnets. As the disc rotates and cuts across the magnetic fields of the magnets, eddy currents are produced in the disc. These eddy currents oppose the motion of the disc. As a result of this braking effect, the speed of the disc is directly proportional to the energy consumed.
d. As Electromagnetic Brakes. Eddy current braking can be used to control the speed of electric trains. In order to reduce the speed of the train, an electromagnet is turned on that applies its field to the wheels. Large eddy currents are set up which produce the retarding effect.

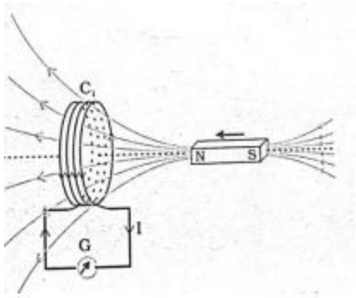
Q.3. What could be the reason for the coils of a resistance box being normally made up of double insulated wire?

Solution: This is done to minimize the inductance of coils. The wire is doubled back on itself. As a result, there are equal and opposite currents in each section of the coil. Therefore, the coil has no net magnetic field and no net induced e.m.f. Such coils are called no inductive coils and have the following advantages:

(iii) The current attains the final value quickly at the time of make or break.
(iv) When used with a.c., the current through such coils is not dependent n frequency.

Q.4. How does the coil and magnet experiment justify the law of Electromagnetic Induction?

Solution: This phenomena can be justified on the basis of the figure given below. When the North-pole of a magnet is moved towards a coil connected to a galvanometer, the galvanometer in the circuit shows a deflection indicating a current (and hence an emf) in the circuit. The deflection continues as long as the magnet is in motion. A deflection can be observed if and only if the coil and the magnet are in relative motion. When the magnet is moved away from the coil, the galvanometer shows a deflection in the opposite direction. Bringing the South-pole towards the coil produces the opposite deflection as bringing the North-pole. Faster the magnet or the coil is moved, larger is the deflection produced. By this experiment we can conclude that: the relative motion between the coil and the magnet generates an emf (current) in the coil.



Multiple Choice Question-MCQ

Q.1. In an experiment, A conductor 0.4m long moves with a velocity of 0.2m/s in a magnetic field of 5T, calculate the emf induced if magnetic field, velocity and length of conductor are mutually perpendicular to each other.
a) 0.4V
b) 0.04V
c) 40V
d) 4V

Ans: a) 0.4 V

The formula for induced emf is: emf=Blv if B,l,v are mutually perpendicular to each other. Substituting the values of B, l and v from the question, we get emf=0.4V.

Q.2. Suppose two identically coaxial circular loops carry a current ***i*** each circulating in the same direction. If the loops approach each other then which will hold true?

e) Current in each will increase
f) Current in each will decrease
g) Current in each will remain same
h) Current in one will increase and in the other will decrease

Ans: b) Current in each will decrease

Q.3. Let us consider that two coils are placed close to each other. Then the mutual inductance of the pair of coils will depend upon:

e) the rates at which currents are changing in the two coils
f) relative position and orientation of the two coils
g) the materials of the wires of the coils
h) the currents in the two coils

Ans: d) The coils are placed close to each other; the mutual inductance of the pair of coils depends upon the current in two coils.

Session XIII

Dual nature of Radiation and Matter

Dr. Shivalika Sarkar

- Analysis: Analyze the wave-particle duality of matter and radiation. Evaluate the different experimental observations that led to the development of the theory and its implications for modern physics.

- Evaluation: Evaluate the effectiveness of different methods for measuring the properties of matter and radiation, such as wavelength or momentum. Compare and contrast their accuracy and usefulness in different situations.

- Synthesis: Design an experiment to demonstrate the wave-particle duality of matter, such as the double-slit experiment with electrons. Calculate the expected results and compare them to the experimental observations.

- Application: Develop a system that uses the principles of wave-particle duality to image small objects or particles, such as in electron microscopy or atomic force microscopy.

- Comparison: Compare and contrast the properties of particles and waves in the context of the wave-particle duality, such as their behavior in diffraction or interference phenomena.

- Interpretation: Interpret and analyze experimental data related to the dual nature of matter and radiation, such as photoelectric effect measurements or electron diffraction patterns, to make predictions and draw conclusions.

- Problem-Solving: Develop strategies for solving complex problems related to the dual nature of matter and radiation, such as calculating the energy and momentum of a photon or the de Broglie wavelength of a particle.

- Prediction: Predict the behavior of matter and radiation under different conditions, such as changes in energy or momentum.

- Generalization: Generalize the principles of wave-particle duality to other areas of physics, such as quantum mechanics or particle physics.

- Creativity: Use imagination and creativity to design new applications for the dual nature of matter and radiation, such as quantum computing or novel materials with unique electronic properties.

Very Short

1. **Photoelectric emission is not possible at all frequencies. Why?**
   Solution:
   Photoelectric emission is possible only if the energy of the incident photon is equal to or greater than the work function of the metal. Now work function, $W_0 = h.f_0$ where f_0 is the threshold frequency. Therefore, frequency of radiation should be equal to or greater than f_0.

2. **Given, the work function of a metal is 4.2 eV. Suppose two photons, that have energy 2.5 eV, are incident on its surface, will they cause the emission of electrons to take place?**
   Solution:
   No. The emission will not occur in this case. It is because for emission of photoelectron, the energy of a single photon must be equal to or greater than the work function of the metal.

3. **Light of frequency 2.5 f_0 is incident on a metal surface of threshold frequency $2f_0$. If its frequency is halved and intensity is made two times, what will be the photoelectric current?**

Solution : The answer is Zero. It is because when the frequency is halved (i.e. $1.25f_0$), it will become less than the given threshold frequency $2f_0$. Therefore, no electron emission occurs, no matter how great is the intensity

Short Answer Type Questions

1. **How would you justify why the number of ejected photoelectrons increases with the increase in intensity of light but not with the increase in frequency of light.**

Solution: If the intensity of incident light is increased, it means that the number of photons falling on the photosensitive surface increases. Therefore, the number of ejected photoelectrons increases with the increase in intensity of light and vice-versa. On increasing the frequency of the incident light, the energy of the incident photons increases but their number remains the same. Since one photon may eject only one or none photoelectron, the number of emitted photoelectrons does not increase.

2. **The wave nature of matter is not apparent in our daily life observations? What could be the reason behind it?**
   Solution:
   If we examine the equation of de-Broglie wavelength, $\lambda = h/mv$. This means, for ordinary objects, m is large and λ is extremely small and can be accounted as negligible as m becomes bigger. Therefore, the waves associated with ordinary moving objects cannot be detected.

3. **A source of light of frequency greater than the threshold frequency is placed at a distance of 1m from the cathode of a photocell. If the distance of the light source from the cathode is reduced, what changes you will observe in the**
   (i) photoelectric current?
   (ii) stopping potential?

Solution:

(i) When the distance between source of light and cathode is reduced, the intensity of incident light on cathode increases. This means greater number of incident photons on cathode surface. Therefore, number of photoelectrons and hence photoelectric current increases.

(ii) The stopping potential V_0 remains the same because it does not depend upon the intensity of incident radiation. Note that V_0 depends on the frequency of incident

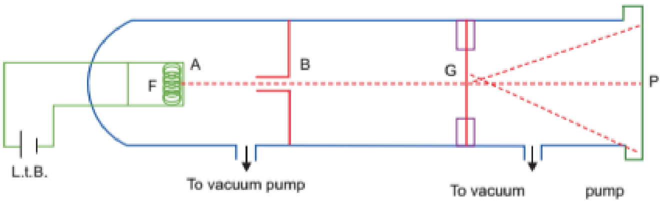
LONG Answers

1. **How will you validate de-Broglie hypothesis experimentally.**

Solution: G.P. Thomson's experiment proved that the diffraction pattern observed was due to electrons but not due to electro magnetic radiation produced by the fast moving charged particles.

The experimental arrangement consists six parts as shown in diagram, they are:

i. Filament (F)
ii. Cathode (C)
iii. Anode (A)
vi. A fine hole metal block (B)
v. Gold foil (G)
vi. Photographic plate(P)



The whole apparatus is kept in highly evacuated chamber. Using a suitable battery the filament F (Thoriated tungsten) can be heated, so that electrons will be emitted and pass through a high positive potential given to the anode A then the electron beam passes through a fine holed metal block B and incidents on the gold foil G of thickness 10^{-8} m. The electrons passing through the gold foil G are recorded on a photographic plate P. Since the gold foil consists a large number of microscopic crystals orientated at random, the electrons striking the gold foil diffracts according to Bragg's law 2d sin q = nl. After developing the plate asymmetrical pattern consisting of concentric rings about a central spot is obtained. This pattern is similar as produced by X-rays generated by the electrons in their pattern is due to the electrons in their passage through the foil, the cathode rays in the discharge tube should be deflected by magnetic field .It was observed that the beam shifts correspondingly, showing thereby that the pattern is produced by electrons (X- rays pattern is not effected by electric and magnetic fields). The observed rings can only be considered as the diffraction pattern of the incoming beam is due to the diffraction of electrons by the gold foil. As the diffraction pattern can only be produced by waves and not by the particles. So Thomson concluded that electrons behave like waves hence justifying the existence of matter waves.

2. **A researcher in lab is required to select a sample substance for a designing a photocell operable with visible light. Which of the following sample out of three given samples should be chosen with given work functions of respective samples and why?**

Element	**Work Function**
Sample A	**4.2 eV**
Sample B	**2.3 eV**
Sample C	**2.5 eV**

Solution:

The photocell operates with visible light.
The visible light range is 4000 Å – 7000 Å

Work function $W_0 = h\nu_0 = (hc)/\lambda_0$

$= 12400(eV)/\lambda_0$(**Å)**

Now energy of incident light = $h\nu = (hc)/\lambda$

Hence in terms of work function the range is

12400 (eV)/4000 Å to 12400(eV)/7000 Å
i.e.,

3.1 eV to 1.77 eV

Hence Sample B (2.3 eV) and Sample C (2.5 eV) can be used while sample A (4.2) cannot be used for the above purpose.

3. **Explain, why an electron cannot reside in the nucleus?**

Solution: The radiation emitted by radioactive nuclei consists of alpha, beta and gamma rays, out of which beta rays are identified to be electrons. We apply uncertainty principle to find whether electrons are coming out of the nucleus. The radius of the nucleus is of the order of 10^{-15} m. Therefore, if electrons were to be in the nucleus, the maximum uncertainty Δx in the position of the electron is equal to the diameter of the nucleus.

$\Delta x.\Delta p >= h/4\pi$
$= 6.626 \times 10^{-34} / (4 \times 3.14 \times 10^{-15} \times 9.1 \times 10^{-31})$
$= 5.79 \times 10^{10}$m/s

Hence the uncertainty in its velocity will be 5.79×10^{10}m/s which is very much greater than even the speed of light.

MCQ

1. **The de Broglie wave associated with a moving particle is :**
   a. **an infinite monochromatic wave**
   b. **a finite monochromatic wave train**
   c. **a wave packet having a group velocity equal to that of the moving particle**
   d. **polychromatic infinite waves**

Answer: C: a wave packet having a group velocity equal to that of the moving particle

2. **Davisson and Germer experiment is related to**
   a. **interference**
   b. **polarization**
   c. **electron diffraction**
   d. **verification of Bohr's theory**

Answer: C: electron diffraction

3. Can you determine the relation between the interaction parameter, 'b', and atomic radius, R, for the Photoelectric effect to take place?
   a) b > R
   b) b ≈ R
   c) b < R
   d) no relation between b and R

Answer: A: b > R

Very Short

4. **Photoelectric emission is not possible at all frequencies. Why?**
   Solution:
   Photoelectric emission is possible only if the energy of the incident photon is equal to or greater than the work function of the metal. Now work function, $W_0 = h.f_0$ where f_0 is the threshold frequency. Therefore, frequency of radiation should be equal to or greater than f_0.

Short Answer

5. Can you justify why the number of ejected photoelectrons increases with the increase in intensity of light but not with the increase in frequency of light.

Solution: If the intensity of incident light is increased, it means that the number of photons falling on the photosensitive surface increases. Therefore, the number of ejected photoelectrons increases with the increase in intensity of light and vice-versa. On increasing the frequency of the incident light, the energy of the incident photons increases but their number remains the same. Since a photon can eject only one photoelectron, the number of emitted photoelectrons does not increase.

6. The wave nature of matter is not apparent in our daily life observations? What could be the reason behind it?

Solution: If we examine the equation of de-Broglie wavelength, $\lambda = h/mv$. This means, for ordinary objects, m is large and λ is extremely small and can be accounted as negligible as m becomes bigger. Therefore, the waves associated with ordinary moving objects cannot be detected

Session XIV

Semiconductor Electronics

Dr. Shivalika Sarkar

- Analysis: Analyze the behavior of semiconductor devices, such as diodes and transistors, in different circuit configurations. Evaluate the relationship between the device's physical properties and its electrical behavior.

- Evaluation: Evaluate the effectiveness of different methods for improving the performance of semiconductor devices, such as optimizing the doping profile or changing the device structure. Compare and contrast their advantages and disadvantages.

- Synthesis: Design a semiconductor device that can perform a specific function, such as amplification or switching. Calculate the required parameters, such as doping concentrations and dimensions, and evaluate the device's expected performance.

- Application: Develop a system that uses semiconductor electronics to perform a specific task, such as a digital logic circuit or an audio amplifier. Evaluate the system's efficiency and compare it to alternative technologies.

- Comparison: Compare and contrast different types of semiconductor devices, such as diodes and transistors, and evaluate their effectiveness in different applications.

- Interpretation: Interpret and analyze experimental data related to semiconductor electronics, such as current-voltage characteristics or frequency response measurements, to make predictions and draw conclusions.

- Problem-Solving: Develop strategies for solving complex problems related to semiconductor electronics, such as calculating the voltage drop across a diode or the gain of a transistor amplifier.

- Prediction: Predict the behavior of semiconductor devices under different conditions, such as changes in temperature or voltage.

- Generalization: Generalize the principles of semiconductor electronics to other areas of physics and engineering, such as optoelectronics or power electronics.

- Creativity: Use imagination and creativity to design new applications for semiconductor electronics, such as wearable electronics or sensors for environmental monitoring.

Very Short

1. **If we add a trivalent impurity to a Silicon wafer in lab experimentally, how is it expected affect the electron-hole pairing?**
   Solution:
   At room temperature, electron-hole pairs are created in a pure semiconductor; there being as many holes as the number of electrons. However, with the addition of trivalent impurity, the holes far outnumber the electrons.

2. **The movement of the valence electrons from one covalent bond to another are responsible for generating the hole current. Then why do we use the term 'Hole Current' here?**
   Solution:
   The main reason for current flow is the presence of holes in the covalent bonds. Therefore, it is more appropriate to consider the current as due to the movement of holes and hence the term hole current is used her**e.**

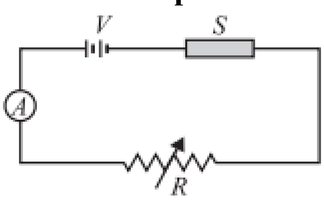
3. **A photo-diode is exposed to light with an illumination of 2.5 mW/cm^2. If the sensitivity of the photo-diode for the given conditions is 37.4 μA/mW/cm^2. What should be the reverse current through the device.**
   Solution:

$$\text{Reverse current} = \text{Sensitivity} \times \text{Illumination}$$
$$I_R = m \times E = 37.4 \times 2.5 = \mathbf{93.5\ \mu A}$$

Short

4. **Ram was trying to measure the V-I characteristics in a semi conductor. By mistake, he passed a heavy amount of current through the circuit and found that the semi conductor was damaged. What could be the reason for this?**
   Solution:
   When a heavy current is made to flow through the semiconductor, it gets heated up. This heat would break many covalent bonds, liberating a large number of free electrons. The semiconductor now becomes a conductor or gets damaged and becomes non conductor.

5. **In the figure given below, a pure semiconductor (S) is connected in series with a variable resistance R and a battery of V volts. Logically, would you increase or decrease the value of R to keep the reading of ammeter A constant when semiconductor is heated? Explain.**



   Solution:
   For the ammeter reading to remain the same, the circuit resistance should not change. Now, when semiconductor is heated, its resistance and hence the total circuit resistance decreases. Therefore, value of R should be increased so that circuit resistance becomes equal to the original value.

6. **You are required to design a Voltage Regulator in the lab. You are given a PN diode and a Zener diode. Which one would you prefer and why?**
   Solution:
   A PN diode will not be able to serve as a Voltage Regulator. A zener diode constitutes as a special type of PN diode that is designed to operate in the reverse breakdown region. An ordinary PN diode operated in this region will usually be destroyed due to excessive current. This is not the case for the zener diode. A zener diode is heavily doped to reduce the reverse breakdown voltage. This causes a very thin depletion layer. As a result, a zener diode has a sharp reverse breakdown voltage VZ. Hence we will choose a Zener diode.

   A Light emitting diode was manufactured and found to radiate at 300 nm. If the forward current in the LED is 20 mA, calculate the power output, assuming an internal quantum efficiency of 2%

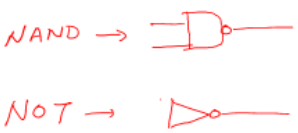
Short

1. Can you convert the following number into decimal? [1100]

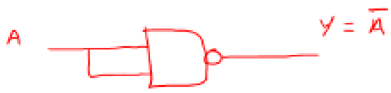
2. **A Logic gate is also referred as a Combinational circuit. Why?**

   Solution
   In a combinational circuit, the output depends upon present input(s) only i.e, not dependant on the previous input(s). The combinational circuit has no memory element. The logic gate also works on the same principle and hence is also called a Combinational Circuit.

3. A NAND gate is a Universal Block Builder. How will you constitute a NOT gate from a NAND gate?



Solution:



Truth table

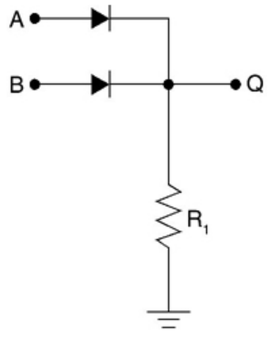
A	Y
0	1
1	0

LONG

1. Illustrate the working of an ordinary PN diode as an OR Gate

Solution

- **Inputs at logic 1:** In the circuit, if both the inputs are connected to +5 V or logic high input logic 1 then the diodes are forward biased and are closed. The current passes across the diode and causes high voltage drop across the resistor R_1. The output is at high or logic 1. If one input is high and the other input is low, then the diode connected to the high input acts as closed switch and the output is still high.
- **Inputs at logic 0:** When both the inputs are connected to zero volts or ground, then the inputs are at logic 0. Both the diodes are reverse biased and switches are open and do not conduct. Therefore, the output across the resistor will also be zero volts.



To assess the achievement of physics teachers in developing HOTS based physics questions

The main aim of the training program was to make the teachers competent enough to compile HOTS questions in physics themselves. HOTS questions need to be based on the learning outcomes and they can encourage students to think broadly and deeply about the material lesson.

Besides, in this century's learning, students must master 21-st century skills that consist of critical thinking, creativity and innovation, collaboration, communication and learning to learn (usually called 4Cs). These skills are essential for students to face in the post-school world.

Based on these facts, NCERT has made an effort to train teachers of different states on preparing HOTS-based question in Physics. However, more efforts are still needed to train the skills of teachers in composing HOTS-based Physics questions. The steps taken by NCERT in overcoming these obstacles are to empower teachers who have more ability to prepare questions to teach their peers.

Another step is to invite conduct training programs with a team of expert resource persons to assist the physics teachers in compiling HOTS questions. The purpose of providing training and mentoring is to improve the insights and skills of higher secondary physics teachers of different states in compiling HOTS-based physics questions.

Method

The research determined the extent to which physics teachers of Chhattisgarh state have compiled HOTS based physics questions by using a one-shot case study of pre-experimental design. There were 18 participants who participated in the training program for development of HOTS questions.

The resource persons who participate in the workshop understood HOTS characteristics and trained on how to make HOTS questions to the physics teachers, starting from fundamental competency analysis in the curriculum into creating HOTS questions for physics. All this was done through a workshop for the development of HOTS questions.

In the first stage, the resource persons reviewed the training participants' knowledge of HOTS-based test instruments, either in the form of direct question-answer or in a questionnaire. Furthermore, an appropriate approach carried out to provide insight into physics teachers regarding the preparation of HOTS-based test instruments and the importance of HOTS-based assessments in 21-st century learning. After being given insights on 21st-century learning, HOTS-based assessments, and criteria for good test item preparation, the lecturers provided training to prepare HOTS-based test instruments. Resource persons provided examples of HOTS-based question stem and explain why the test item is called HOTS-based test item. Resource persons also offer directions on how to arrange useful HOTS-based test items and can measure students' HOTS. After providing training on the preparation of HOTS-based physics questions, the resource persons assisted the training participants in compiling HOTS-based physics questions. Service carried out during the training and after the training so that a product produced in HOTS-based physics questions. Post-training assistance carried out through the WhatsApp Group. The mentoring activity is an assignment for making HOTS questions with the final result in the form of HOTS questions that have been developed by the training participants.

The final stage is assessing the achievement of physics teachers in developing HOTS-based physics questions. In this stage, the resource persons checked the results in compiling HOTS based physics questions.

Result and Discussion

In the workshop's implementation, the lecturer provides material following the stages described in the method section. The first steps to train the skills of making HOTS-based physics questions to physics teacher are reviewing physics teachers' insights on the preparation of HOTS-based physics questions. Based on the workshop's interview, most of the physics teacher participating in the seminar could not distinguish between HOTS questions and challenging questions. More than 50% of the participants thought that HOTS was a difficult question and requires many physics formula applications. Whereas, HOTS-based physics questions are very different from difficult questions. The cognitive processes reflect high-level thinking when they are independent, have social origins, and are accessible to their self-awareness. HOTS are closely related to the thinking process. HOTS's several aspects are conceptual understanding, systematic thinking, problem-solving, and critical thinking. This understanding is a significant concern that must give to teachers. The HOTS question is not only challenging but has the characteristics of a high-level thinking process. Leaders and teachers must also learn how to view the goals of thinking to be essential and tangible as content goals.

The results of completing the task are sent to the lead researcher e-mail to evaluate whether the questions include the HOTS category or not. After two months, the participants were the physics teachers who sent three groups of e-mails. It means that only 60% of participants completed and submitted their assignment. Other groups have been in progress. The compilation of questions sent by the participants is then analyzed to determine the percentage of achievement of the physics teacher in the preparation of HOTS questions for high school physics subjects. Based on all the physics questions received, 80% composed of HOTS questions while the rest were not HOTS questions. It shows an increase in the understanding of physics teachers from those who were not understanding HOTS questions to experience and producing HOTS questions for physics material, even though not all physics teachers submitted assignments according to the agreement. Based on the physics teachers' interview that has not completed the task, they find it challenging to determine appropriate contextual phenomena in the preparation of HOTS questions. Besides, they not accustomed to using multiple representations in presenting one question item.

As for the workshop participants' response, after participating in the presentation of material about skills in making HOTS-based physics questions, most of them gave positive responses. 46 % of participants felt this training provided many benefits, 50% agreed with the same statement, while 4% strongly disagreed with this statement. After checking in the open questions section, 4% of these participants wanted laboratory equipment training. 54% of the participants strongly agree and 46% of the participant agree that they get a clear understanding of the preparation of HOTS-based physics questions. 54% of the participants strongly agree and 46% agree that the training materials help them develop the skills in composing HOTS-based physics questions.

During the training activities, lecturers provide modules containing HOTS material, preparation of HOTS questions, question grid instruments, and several examples of HOTS questions. Based on the workshop participants' questionnaire, 35% strongly agreed, and 65% agreed that the training module was well structured. The hope is that, through this training module, participants can learn independently during the mentoring activities and assist participants in completing assignments as a follow-up to providing material on preparing HOTS questions to workshop participants. The workshop participants' strongly agree that the presenters master the training materials well (62%) and the remaining 38% agree with the same statement. Although some participants felt that they lacked the time and thought that the training was ineffective because it was too short, more than 50% of participants strongly agreed that the material's delivery was communicative, the rest agreed with the same statement. All the participants also felt that the material's delivery was impressive, 50% of the participants strongly agreed, and the rest of 50% agreed with this statement. Based on the discussion above, it can conclude that they need more effort to improve a physics teacher's skills in compiling HOTS-based physics questions. Some of the difficulties experienced by physics teachers include not accustomed to using multiple representations in composing problems and challenges in finding phenomena in everyday life that match the material tested topic.

Conclusion

Efforts have made to train skills in making HOTS-based physics questions for physics teachers of Chhattisgarh state. It found that 60% of physics teachers as training participants had completed and submitted assignments, while the rest were in the process of compiling HOTS-based physics questions. About 40% of the physics teachers have difficulty collecting HOTS-based physics questions because not accustomed to using multiple representations simultaneously in items and problems in determining real-life phenomena that are following the topic to test. More effort is needed to familiarize physics teachers to implement learning strategies that teach HOTS and get used to composing HOTS-based physics questions. Physics teachers as training participants gave a positive response to the HOTS-based physics questions preparation training at RIE Bhopal. They also benefited from this training.

Appendix

Some Information / Tasks / Thinking

A_1 Plasma exerts more pressure than light.

Light cotton based oil lamp. Light/plasma pushes up it flame which otherwise should have flipped of if it were not lighted.

A_2 Cartesian Coordinate System

Take X – axis parallel to lower edge of book.
Take plane in X – Y axis.
Right handed coordinate system is that: If a screw is rotated in anticlockwise direction from X – towards Y – axis then movement of the tip of screw is Z direction. We in India use RH coordinate system.

A_3 Unit representation and measurement

1) Write symbols with capital letters like (if associated with name of scientists) N for Newton, J for Joule, K for Kelvin etc. But if unit is written in full form, first letter also is written in lower case: say 6 newton, 418 joule, 78 kelvin etc.
2) If difference in temperature is to be written it, should be $30C^o$ and not 30^oC. In absolute scale it is not so. You need to write difference in temperature is 30 K. Ponder over it.
3) Earth rotates about sun in elliptical orbit. It has to have two foci. Find the distance between two foci. Also find eccentricity of the elliptical path. Ponder over it. Would you like to say that the orbit is almost circular? Take distance in seconds.
4) While writing in mobile phone, you find it difficult to write 10^{-3}, so use 10^{-3}. Try to write E_o or H_2.
5) In rotating scale of measurement there is always a backlash error and you have a solution. Is it so in vernier also. There is latch in micrometer say in screw gauge. Use only that while length measurement.
6) After measurement / calculations, verify it with logic if those do not match discard or redo.


हिन्दी पखवाड़ा-2022
क्षेत्रीय शिक्षा संस्थान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क्षेत्रीय शिक्षा संस्थान


हिन्दी पखवाड़ा-2022
(14 सितंबर, 2022 से 28 सितंबर, 2022 तक)
एन सी ई आर टी
NCERT

Training on development of HOTS questions in Chemistry for KRPs of Chhattisgarh and Maharashtra State

Introduction:

One aim of education for the 21st Century Skills is to cultivate the problem solving, critical thinking and higher order thinking skills (HOTS). Higher order thinking skill basically means a thinking that is taking place in the higher levels of the hierarchy of cognitive processing. The most widely accepted hierarchical arrangement of this sort in education is the Bloom Taxonomy, viewing a continuum of thinking skills starting with knowledge-level thinking to evaluation-level of thinking. Higher order thinking skills are the ability to think not just recall, restate, or recite but it reaches several dimensions of knowledge, including meta cognitive dimensions. Students who have higher order thinking skills will be have the ability of connect different concepts, interpret, problem solving, communication, reasoning, and make the right decisions. The National Educational Policy also envisages the development of higher-order thinking capacities, problem-solving abilities. It further stresses on the fact that, aim of assessment in the culture of our schooling system should be testing the higher order skills. Hence through this program development of items based on higher order skills in Chemistry will be done and the items will be tested also.

Generally, there still many teachers who have not been able yet to design learning model and giving assessment by using Higher Order Thinking based-question Even though, they have to be aware that learning and assessment using Higher Order Thinking must be applied in learning process to prepare the students' ability in facing competition in 21st century. Based on this fact, teachers should have an ability to design and develop the Higher Order Thinking level question. On the other hand, it means that if their ability is on low level in designing Higher Order Thinking level question, it will give a bad impact on the quality of students' learning process and question made. Finally, it shows that how important the teachers' action related to developing students' scientific ideas and their reflective thinking.

However, implementing and developing Higher Order Thinking level question can be said so difficult enough, but it doesn't mean cannot be learnt. Teachers are required to have skill in construct the test in Higher Order Thinking level or at least there should be guidance for them related to learning and assessment model which can be used in developing students' Higher Order Thinking skill. Based on the result study and analysis above, this article is focused on; what is Higher Order Thinking Skill concept of Chemistry for Senior high School students.

Objectives:

- To review Chemistry' teachers insight on the preparation of HOTS based questions
- To train KRPs in developing HOTS questions
- To assess the achievement of Chemistry teachers in developing HOTS based Chemistry questions

Methodology:

- In house meeting to plan the overall program
- Five days training of KRPs of Chhattisgarh state on development of HOTs questions In Chemistry.
- Five days training of KRPs of Maharashtra state on development of HOTs questions in Chemistry.

HOTS questions were developed for all the chapters in chemistry at Secondary level (Class XI and XII) mentioned below is exemplar questions on **HOTS for the chapter "Structure of Atom"**

Learning Outcomes

The learner-

1. **Takes initiative to know about scientific discoveries/ inventions, such as,** fundamental particles in an atom; discovery of various atomic models; electron, proton and neutron and their characteristics;
2. **Verify the facts/ principles/ phenomena** or to seek answers to queries on their own, such as, describe Thomson, Rutherford and Bohr atomic models;
3. **Understand** the important features of the quantum mechanical model of atom; understand nature of electromagnetic radiation and Planck's quantum theory;
4. **Explains scientific terms/ factors / laws / theories governing processes and phenomena such as** explain the photoelectric effect and describe features of atomic spectra;
5. **Derives Equations**, such as state the de Broglie relation and Heisenberg uncertainty principle; define an atomic orbital in terms of quantum numbers;
6. **Draws diagrams/ flow charts/ concept map/graphs, such as**, shapes of orbitals (s,p,d), aufbau principle, Pauli exclusion principle and Hund's rule of maximum multiplicity;
7. **Exhibits values of honesty/ objectivity/ rational thinking/ freedom from myth/superstitious beliefs while taking decisions, respect for life, etc., such as**, write the electronic configurations of atoms.
8. **Communicates the findings** and conclusions effectively, such as, those of experiment/ activity/ project orally and in written form using appropriate figures/ tables/ graphs/ digital forms, etc.

Multiple Choice Questions:

1. Which of the following set of quantum numbers is not valid?
   A. $n = 3, l = 2, m = 2, s = +1/2$
   B. $n = 3, l = 0, m = 0, s = -1/2$

C. n = 4, l = 2, m = -1, s = +1/2

D. n = 4, l = 3, m = 4, s = -1/2

2. De-Broglie wavelength of electron in second orbit of Li^{2+} ion will be equal to de-Broglie of wavelength of electron in

A. n = 3 of H^{-}atom

B. n = 4 of C^{5+} ion

C. n = 6 of Be^{3+} ion

D. n = 3 of He^{+} ion

3. Order of wavelength in Electromagnetic spectrum

A. Cosmic rays <γ . rays<Visible < Infrared < Micro waves < Radio waves< X-rays < Ultraviolet rays

B. Cosmic rays <γ . rays < X-rays < Ultraviolet rays < Visible < Infrared < Micro waves < Radio waves

C. γ . rays < X-rays < Ultraviolet rays < Visible < Infrared < Micro waves < Radio waves <Cosmic rays

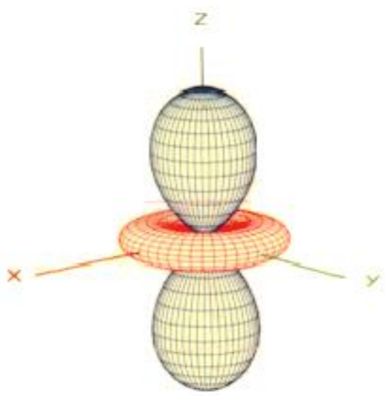
D. Cosmic rays < X-rays < Ultraviolet rays < Visible<γ . rays < Infrared < Micro waves < Radio waves

Very Short Answer Type:

4. Find orbital angular momentum of an electron in (a) 4s subshell and (b) 3p subshell
5. In all, how many nodal planes are there in the atomic orbital's for the principal quantum number n = 3.
6. If the nitrogen atom had electric configuration $1s^7$, it would have energy lower than that of the normal ground state configuration $1s^2\ 2s^2\ 2p^3$, because the electrons would be closer to the nucleus. Yet $1s^7$ is not observed because it violates.

Short Answer Type:

7. Predict the orbital given and mention its combinations



8. How many protons, electrons and neutrons are there in the following nuclei ?

(i) ${}^{17}_{8}O^{2-}$ (ii) ${}^{25}_{12}Mg^{2+}$

9. The atomic number of an element M is 26. How many electrons are present in the M-shell of the element in its M^{3+} state?

10. Criticize the statement. An element is a substance made up of atoms all of which are alike.
11. (a) What is the charge on a chloride ion?
    (b) What is the charge on a chlorine nucleus?
    (c) What is the charge on a chlorine atom?

Long Answer Type:

12. On the basis of Heisenberg's uncertainty principle, show that the electron cannot exist within the nucleus

Assertion Reason Type:

In each of the following questions a statement of assertion followed by a statement of reason is given. Choose the correct option out of the following given below.

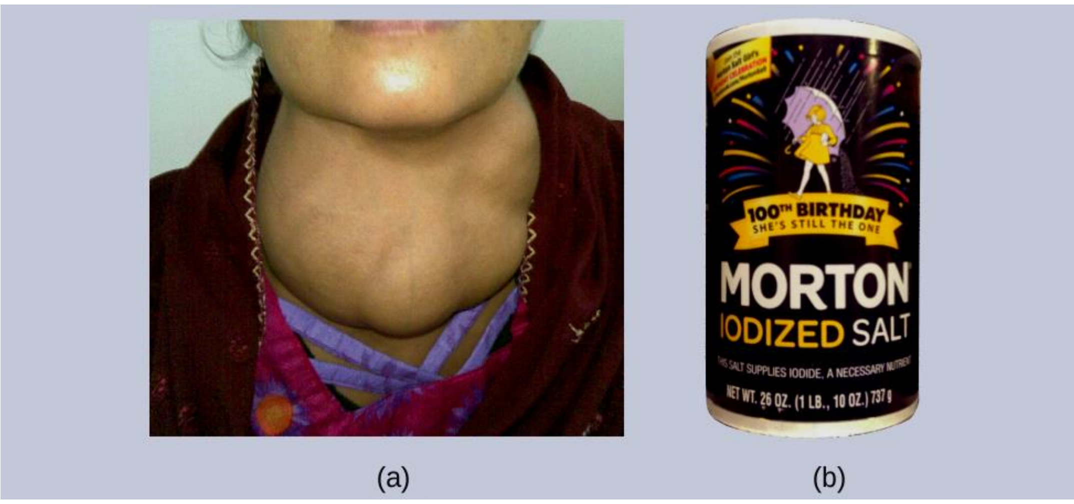
a) Assertion and reason both are correct statements and reason is correct explanation for assertion.
b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.
c) Assertion is correct statement but reason is wrong statement.
d) Assertion is wrong statement but reason is correct statement.

13. Assertion: A spectral line will not be seen for a $2p_x$-$2p_y$ transition.
    Reason: Energy is not released when the electron drops from $2p_x$ to $2p_y$ orbital as both have same energy
14. Assertion : Electronic configuration of Cr3+ (containing 21 electrons) is same as that of Sc (Z = 21) i.e. isoelectronic species have the same electronic configuration.
    Reason: Orbitals are filled in order of increasing energy and also this filling follows Pauli's exclusion principle and Hund's rule.
15. Assertion: The number of spectral lines emitted out during jump of electron from V to II orbit is six.
    Reason: The number of spectral lines given out during a jump are given by $\Sigma\Delta n$.

Case Based Question:

Composition of an Atom

Iodine is an essential trace element in our diet; it is needed to produce thyroid hormone. Insufficient iodine in the diet can lead to the development of a goiter, an enlargement of the thyroid gland



(a) Insufficient iodine in the diet can cause an enlargement of the thyroid gland called a goiter.

(b) The addition of small amounts of iodine to salt, which prevents the formation of goiters, has helped eliminate this concern in the US where salt consumption is high.

The addition of small amounts of iodine to table salt (iodized salt) has essentially eliminated this health concern, but as much as 40% of the world's population is still at risk of iodine deficiency. The iodine atoms are added as anions, and each has a 1− charge and a mass number of 127.

16. Determine the numbers of protons, neutrons, and electrons in one of these iodine anions.
17. Determine the number of protons, neutrons and electrons in atomic number 53, mass number 127, charge of 1+
18. Average atomic masses listed by IUPAC are based on a study of experimental results. Iodine has three isotopes ^{127}I, ^{126}I and ^{128}I whose abundances (80%, 17% and 3% respectively) were determined in experiments. Calculate the average atomic mass of Iodine based on these experiments.

Answers:

1. D. (m > l is not possible)

2. B λ=h/mv & vα (z/n)
   $\therefore \lambda \; \alpha$ (n/z)
   For Li^{2+} $\lambda \; \alpha$ (2/3)
   for n = 4 of C^{5+} ion, $\lambda \; \alpha$ 4/6
   =2/3
   Hence the result
3. B

4. (a) 0 (b) $\sqrt{2}$ h/2Π

5. Shell with n = 3 has 1 ‘s’ (3s), 3 ‘p’ (p_x, p_y, p_z) and 5 ‘d’ (dxy, dxz, dyz, d(x^2 y^2) and dz^2 orbitals.
   - ‘s’ has no nodal plane.
   - Each of p_x, p_y, p_z has one nodal plane, which means a total of 3 nodal planes.
   - d^2z has no nodal plane.
   - Each of d_{xy}, d_{xz}, d_{yz}, d(x^2 y^2) has 2 nodal planes, which means a total of 8 nodal planes.

   Hence for n = 3, a total of 11 nodal planes are there.
6. Pauli exclusion principle

7. dz^2 , dz^2 is combination of (dz^2-dx^2 + dz^2-dy^2)

8. (i) Atomic number , Z = 8, Mass number, A = 17
   No. of protons = 8
   No. of electrons= 10 (because 2- charge)
   No. of neutrons + No. of protons = A
   No. of neutrons + 8 = 17
   Or No. of neutrons = 17 – 8 = 9
   (ii) Atomic number, Z = 12, Mass number, A = 25
   No. of protons = 12
   No. of electrons = 10 (because 2+ charge)
   No. of neutrons = A – No. of protons.
   = 25 – 12 = 13.

9.

	K	L	M	N
M (26)	$1s^2$,	$2s^2 2p^6$,	$3s^2 3p^6 3d^6$	$4s^2$
M^{3+}	$1s^2$,	$2s^2 2p^6$,	$3s^2 3p^6 3d^5$	$4s^0$

Hence, 13 electrons are present in the M-shell of M^{3+} state.

10. All matter is composed of atoms, and atoms are indivisible and indestructible. Elements are composed of identical atoms, but the atoms of each element are different and distinguishable from each other.

11. (a) The charge on a chloride ion = -1
    (b) The charge on a chlorine nucleus= +17 (17 protons will show +ve charge)
    (c) The charge on a chlorine atom= 0 (neutal atom)

12. Radius of the nucleus is of the order of 10^{-13} cm and thus uncertainty in position of electron i.e. (Δx), if it is within the nucleus will be 10^{-13} cm.
    Now, Δx. Δu >h/4πm

$$\Delta u = \frac{6.626 \times 10^{-27}}{4 \times 3.14 \times 9.108 \times 10^{-28} \times 10^{-13}} = 5.79 \times 10^{12} \text{ cm/sec}$$

i.e., order of velocity of electron will be 100 times greater than the velocity of light which is impossible.

Thus possibility of electron to exist is nucleus is zero. i.e., The value of uncertainty in velocity, Δv is much higher than the velocity of light (3.0×10^8 ms−1) and hence an electron cannot be found within atomic nucleus.

13. [A] (No energy is released when electron drop from $2p_x$ to $2p_y$ (because they are degenerated orbitals)

14. [A]Electronic configuration of [Cr^{3+}] = [Ar] $3d^3$ (obtained from electronic configuration of Cr by removing 3 electrons) whereas that of Sc is [Ar] $3d^1$ $4s^2$

15. [A]

16. The number of neutrons is 74 (127 − 53 = 74). Since the iodine is added as a 1− anion, the number of electrons is 54 [53 – (1–) = 54]

17. The atomic number of iodine (53) tells us that iodine atom contains 53 protons in its nucleus and 52 electrons outside its nucleus(since 1+ charge is given). Because the sum of the numbers of protons and neutrons equals the mass number, 127, the number of neutrons is 74 (127 − 53 = 74).

18. 126.86 amu (.80 x 127 = 101.6
.17 x 126 = 21.42
.03 x 128 = 3.84
Total = 126.86 amu)

Various methodology was taken into consideration during the training process, the questions which were developed for all the chapters of chemistry at secondary level (classes XI and XII like MCQs, very short answers type, long answers type , Assertion-reason type and case based questions.
Play way Method, with the help of TARSIA, CHEMBOLA, RATIBOLA,
Questions given to the participants, following the sequence of difficulty level in the order of very low order, low order, medium , high level.

Coordination Chemistry

Dr. R. K. Sharma
RIE, Ajmer

Werner synthesized a purple colored compound $CoCl_3$ .5NH_3 by the reaction of $CoCl_3$ and NH_3. If the aqueous solution of the compound is treated with aqueous solution of AgNO3 the number of AgCl moles precipitate is

(a) Optical isomers (b) Linkage isomers
© Geometrical isomers (d) Coordination isomers

Werner synthesized a purple colored compound $CoCl_3$ .5NH_3 by the reaction of $CoCl_3$ and NH_3. If the aqueous solution of the compound is treated with aqueous solution of AgNO3 one mole of AgCl precipitates. The primary and secondary valencies of the metal in the complex are, respectively

(a) 1, 6 (b) 2, 6

© 3, 6 (d) 3, 8

According to Valence Bond Theory, the metal atom or ion under the influence of ligands can use its valence orbitals for 125ybridization to yield a set of equivalent orbitals of definite geometry. The hybridization state required for square planar geometry of a complex is

(a) dsp2 (b) dsp3

© d2sp3 (d) sp3d2

According to Valence Bond Theory, the metal atom or ion under the influence of ligands can use its valence orbitals for 125ybridization to yield a set of equivalent orbitals of definite geometry. The type and hybridization of the diamagnetic $K_4[Fe(CN)_6]$ complex is

(a) outer sphere, sp3d2 (b) inner sphere,d2sp3

© outer sphere, d2sp3 (d) inner sphere, sp3d2

According to CFT if we assign electrons in the d orbitals of metal ion in octahedral coordination entities, for d 4 ions, two possible patterns of electron distribution arise. The high spin complex will be formed if

(a) $\Delta o < P$ (b) $\Delta o > P$

© $\Delta o = 2P$ (d) $\Delta o = P$

According to CFT if we assign electrons in the d orbitals of metal ion in octahedral coordination entities, for d 4 ions, two possible patterns of electron distribution arise. The high spin complex will be formed if

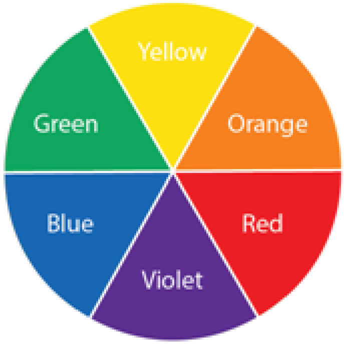
(a) Endothermic process w.r.t. to P is favorable

(b) Endothermic process w.r.t. to Δo is favorable

(c) Exothermic process w.r.t. to P is favorable

(d) Exothermic process w.r.t. to Δo is favorable

The colour of the complex is complementary to that which is absorbed and it can be assigned from the color wheel given below-

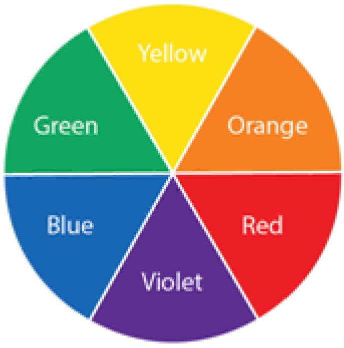


If a complex absorbs green light then its color would be

(a) red (b) orange

© violet (d) blue

The colour of the complex is complementary to that which is absorbed and it can be assigned from the color wheel given below-



A particular complex absorbs orange light when Cl- ligands are attached to metal. If the Cl- ligands are replaced by OH- and complex still absorbs visible light then expected color of the complex is

(a) red (b) orange

© violet (d) blue

Ruby is aluminium oxide (Al_2O_3) containing about 0.5-1% Cr^{3+} ions (d^3) and has a shining color due to presence of

(a) Cr^{3+} ions (b) Al^{3+}ions (c) O^{2-} ions (d) Al^{3+} and O^{2-} ions

Ruby is aluminium oxide (Al_2O_3) containing about 0.5-1% Cr^{3+} ions (d^3) and has a shining color due to

(a) d-d transitions of Cr^{3+} octahedral complexes

(b) d-d transitions of Cr^{3+} tetrahedral complexes

© d-d transitions of Al^{3+} octahedral complexes

(d) d-d transitions of Al^{3+} tetrahedral complexes

Case Study:

The degeneracy of the d orbitals has been removed due to ligand electron-metal electron repulsions in the octahedral complex to yield three orbitals of lower energy, t_{2g} set and two orbitals of higher energy, e_g set. This splitting of the degenerate levels due to the presence of ligands in a definite geometry is termed as crystal field splitting and the energy separation is denoted by Δo (the subscript o is for octahedral). Thus, the energy of the two eg orbitals will increase by (3/5) Δo and that of the three t_{2g} will decrease by (2/5)Δ

1. The net energy change in the process is---

(a) Zero (b) $0.6\Delta o$

© $1.2\Delta o$ (d) $0.4\Delta o$

2. The energy of the two eg. orbitals increases because these orbitals are

(a) Non-directional (b) directional with lobes along the axis

© directional with lobes between the axis (d) none

Although the participants were not aware of case based questions, but during the training period they could learn, understand and frame the case based questions also.

Rati Round

I have named this game as RR or RATI (shortcut of my name) ROUND

In this game all the participants or the students forms a round

1. The teacher allot serial number or can use role number of the student
2. Teacher or the resource person initiates the game by asking a question to randomly one serial number which is already been allotted to the student-the student has to reply in 30 seconds
3. If the student replies the answer he/she takes the next number and the person with that number will raise the hand after that the student will frame a question and asked to the other student
4. In case the first student is not able to answer the question then he leaves the game just taking one number now the initiator or the teacher will again ask a question to the next student who is this number has been called.
5. In this way the game will be continued gradually students or the participants will leave the game and at the end there will be two students left
6. It is up to the discretion of the teacher that she may ask question to decide the winner or the Students can continue in the same manner
7. Finally the participant of the student with profound knowledge will be the winner

This game can be used for the recapitulation of the of the concepts of any particular chapter also the student will come across kind of questions which they should focus on depending upon the capability of the teacher or the resource person the same condition can be developed from low to higher order thinking skill

Chembola Tickets

Player name:____________________ Ticket No..: chem01

			$Fe(CO)_5$		

	W	MnF_7	Ze	MnO_2	+4
	S				

Player name:________________________ Ticket No..: chem02

W		Ir			
MnO_4^-	$Fe(CO)_5$		Fe^{3+}		
$FeCl_2$			Mn_2O_7		

Player name:______________________________________Ticket No..: chem03

			Os		
Zr	W	S	+7		
		Pm			$FeCl_2$

Player name:________________________ Ticket No..: chem04

	Cu				TiC
$Fe(CO)_5$		Ti + Al	Mn_3O_4		
V^{2+}		W			

Player name:________________________ Ticket No..: chem05

	Sc	V^{2+}			

	Zr	Cr^{3+}	Os		
	$FeCl_2$	Gd			

Player name:_________________________ Ticket No..: chem06

					CO^{2+}
Sc	Ir	Gd	Mn_2O_7	Mn^{2+}	
Os					

Player name:_________________________ Ticket No..: chem07

		MnO_4^-			
	La	S	MnO_2		MoO_3
		Zr			Os

Player name:_________________________ Ticket No..: chem08

	Ir				
	Mn_3O_4	MnO_2	F to d		
W	V^{2+}		CO^{2+}		

Player name:_________________________ Ticket No..: chem09

Cu + Ni		Mn^{2+}			

Ni^{2+}	V	+7			Zr
			$FeCl_2$		

Player name:________________________ Ticket No..: chem10

La	Mn_2O_7	Mn_3O_4			
MnO_2			W		
				$FeCl_2$	Gd

Player name:________________________ Ticket No..: chem11

Pm	Cr^{3+}	Mn_3O_4			
		+4	Mn^{2+}		
	Cu + Ge	V			

Player name:________________________ Ticket No..: chem12

			Zr		
F to d		Cu + Ge			S
	MoO_3	Mn_3O_4	Cu		

Player name:________________________ Ticket No..: chem13

	CO^{2+}				Mn_3O_4

Ni^{2+}		$FeCl_2$			
S	TiC		Cu + Ge		

Player name:________________________ Ticket No..: chem14

			Mn^{2+}		V^{2+}
		V	Pm		
Cu	CO^{2+}			Sc	

Player name:________________________ Ticket No..: chem15

					W
MnO_4^-	V		Mn_2O_7		
V^{2+}	Zr			$Fe(CO)_5$	

Player name:________________________ Ticket No..: chem16

		Gd			
	Os	MnO_2	Ir	$Fe(CO)_5$	
Ni^{2+}			TiC		

Player name:________________________ Ticket No..: chem17

		MnO_2			

Mn^{2+}			La	$FeCl_2$	
Pm	Fe^{3+}				Zr

Player name:________________________ Ticket No..: chem18

			Pm		Mn_3O_4
Ni^{2+}	W	Mn^{2+}		Ti + Al	
	Os				

Player name:________________________ Ticket No..: chem19

			MnF_7		
	Mn_2O_7		S	+7	MnO_2
		MnO_4^-		La	

Player name:________________________ Ticket No..: chem20

		Mn^{2+}			$FeCl_2$
TiC	MoO_3	Cu + Ni		Ir	
		Ti + Al			

Player name:________________________ Ticket No..: chem21

	V^{2+}				
Gd		La	MoO_3		Mn_2O_7
	F to d	MnO_4^-			

Player name:________________________ Ticket No..: chem22

	MnO_4^-				
			CO^{2+}	Sc	F to d
V	Cu	+7			

Player name:________________________ Ticket No..: chem23

		V			
MnO_4^-	Fe^{3+}	Gd	$FeCl_2$		
		CO^{2+}			Ni^{2+}

Player name:________________________ Ticket No..: chem24

W					Gd
	Sc	Cu + Ni	+7		
			Ti + Al	Mn^{2+}	

Player name:________________________ Ticket No..: chem25

	+4			MnO_2	
V		Cr^{3+}	$Fe(CO)_5$		Sc
	Mn^{2+}				

Player name:________________________ Ticket No..: chem26

				$Fe(CO)_5$	
CO^{2+}	F to d	Zr	W		S
		Mn^{2+}			

Player name:________________________ Ticket No..: chem27

$FeCl_2$					
	Cu	La	Zr	Cu + Ge	
			MnO_2		Fe^{3+}

Player name:________________________ Ticket No..: chem28

					MnO_2
Ir		V	CO^{2+}	F to d	
		Cu + Ge			Mn_3O_4

Player name:________________________ Ticket No..: chem29

		$Fe(CO)_5$			
Mn_3O_4			MnO_2	Ir	
		Os	$FeCl_2$		Sc

Player name:________________________ Ticket No..: chem30

$Fe(CO)_5$	MnF_7		S	Os	
		Mn_3O_4		V^{2+}	
				Zr	

Player name:________________________ Ticket No..: chem31

					V^{2+}
Pm	Cu + Ni	Gd	Mn_3O_4		
	Cr^{3+}	Cu + Ge			

Player name:________________________ Ticket No..: chem32

	MnF_7				
	La	Mn^{2+}	Cr^{3+}	F to d	$FeCl_2$
MnO_2					

Player name:________________________ Ticket No..: chem33

		Cu	$Fe(CO)_5$		
Fe^{3+}	MnO_2	V		F to d	
		Cu + Ni			

Player name:________________________ Ticket No..: chem34

	TiC				
Cu + Ge	Fe^{3+}	F to d	Sc		
MnO_4^-					Ir

Player name:________________________ Ticket No..: chem35

					$FeCl_2$
MnO_2	V	Os	La	Cr^{3+}	
				Mn_2O_7	

Player name:________________________ Ticket No..: chem36

	Ni^{2+}				
MoO_3		Os		Ti + Al	Sc
	Ir		Cr^{3+}		

Player name:________________________ Ticket No..: chem37

MoO_3					V^{2+}
	Ir	TiC	Os		
Sc		S			

Player name:________________________ Ticket No..: chem38

Ti + Al	+7		Pm	Gd	
		Sc			
			Ir		MoO_3

Player name:________________________ Ticket No..: chem39

S		Mn^{2+}			
			$FeCl_2$	W	Cu + Ni
		La		Zr	

Player name:________________________ Ticket No..: chem40

Cu			$FeCl_2$		
		Mn_3O_4	+7		
Gd	Mn^{2+}			F to d	

Player name:_______________________ Ticket No..: chem41

	V		MoO_3		
CO^{2+}		TiC		Os	
	Ti + Al		Pm		

Player name:_______________________ Ticket No..: chem42

		CO^{2+}			
TiC	V	Sc	$Fe(CO)_5$	Ni^{2+}	
					MnO_4^-

Player name:__________________________ Ticket No..: chem43

	Cr^{3+}		Pm		S
Fe^{3+}		Ir		W	
	MnF_7				

CHEMBOLA

1. Which element though f block has no election in f orbital. - La
2. In 5d series it has comparable I.E like Gold. - Iridium (Ir)
3. Lanthanide used in MRI. - Gd
4. Which non metal other than C is present in Misch Metal. - S
5. Which transition occurs in UV region. - F to d
6. Only lanthanide which is radioactive. - Pm
7. This constitutes silver UK coins. - Cu + Ni
8. These are main elements in Zeigler Natta Catalyst. - Ti + Al.
9. These are present in Sterling Silver. - Cu + Ge
10. Neither typically ionic or covalent - TiC

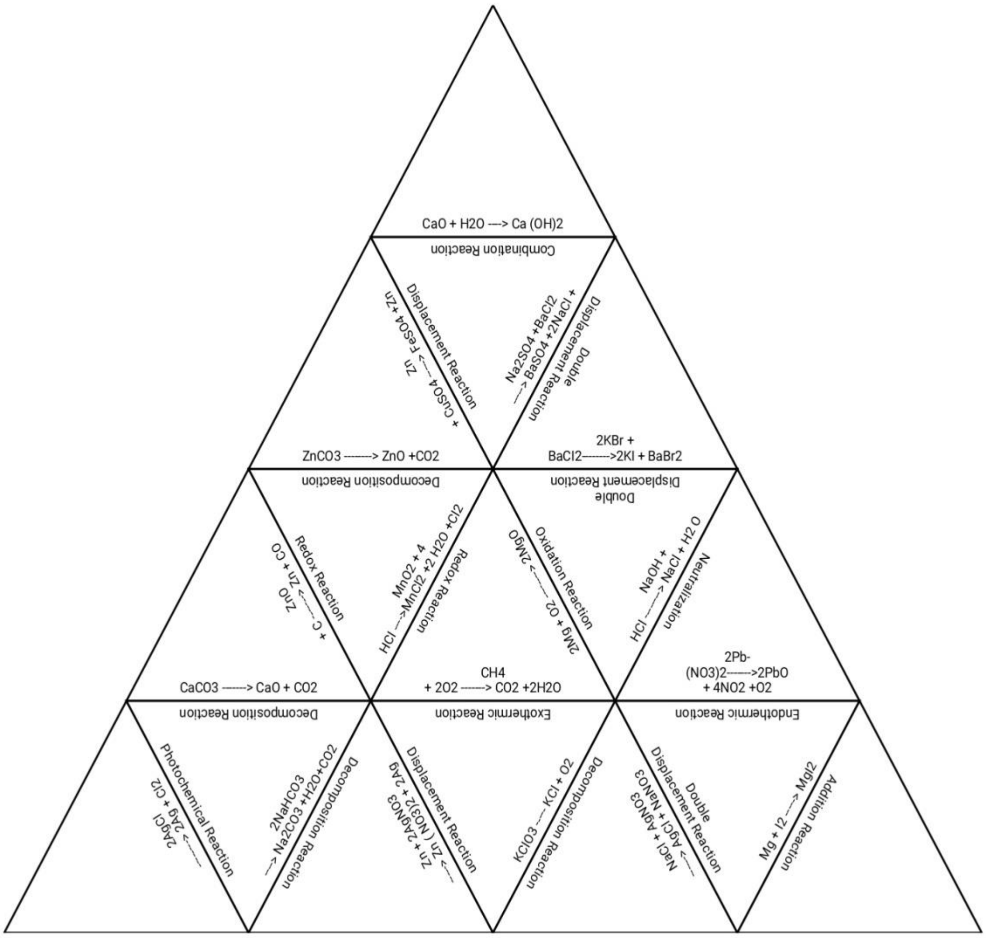
11. It has stable t2g level.	-	V^{2+}
12. Its anhydride of permanganic acid	-	Mn_2O_7
13. It exists as dimer in vapour phase.	-	$FeCl_2$
14. In this metal is not getting oxidized	-	$(Co)_5$
15. Metal in 3d with the E^o value (M^{2+}/M)	-	Cu
16. In neutral medium this is formed by MnO_4	-	MnO_2
17. In acidic medium, this is formed by MnO_4^-	-	Mn^{2+}
18. $^{9+5}$BM value is 3.87	-	Cr^{3+}
19. $^{9+5}$BM value is 4.87	-	Co^{2+}
20. It is having more –ve E^o value than expected due to highest -ve enthalpy of hydration	-	Ni^{2+}
21. It cannot act as ox agent	-	MoO_3
22. What is the ox-state you can show?	-	+7
23. Ce is more stable in the ox-state	-	+4
24. It has highest enthalpy of atomization in 3d series	-	V
25. Highest M.P	-	W
26. Considered as TM but does not form color ion	-	Sc
27. It is colored due to charge transfer.	-	MnO_4^-
28. It shows +8 ox-state	-	Os
29. This will not form due to more steric effect & repulsion	-	MnF_7
30. It is a mixed oxide	-	Mn_3O_4
31. This catalyzes the in between Iodide & Persulphate ions	-	Fe^{3+}
32. Its atomic radii is similar to Hf	-	Zr

Tarsi

अवतल दर्पण	विद्युत मोटर	212	साइटोकाइनिन	-273
NH4Cl	H2Co3	धमनी	अपसारी	Br
उत्तल दर्पण	भर्जन	Ca	Mg	अभिसारी

अवतल दर्पण	विद्युत मोटर	212	पेप्सिन	-273	
NH4Cl	HCHO	डायप्टर	अपसारी	Br	
उत्तल दर्पण	भर्जन	Ca	Mg	अभिसारी	

Solution:



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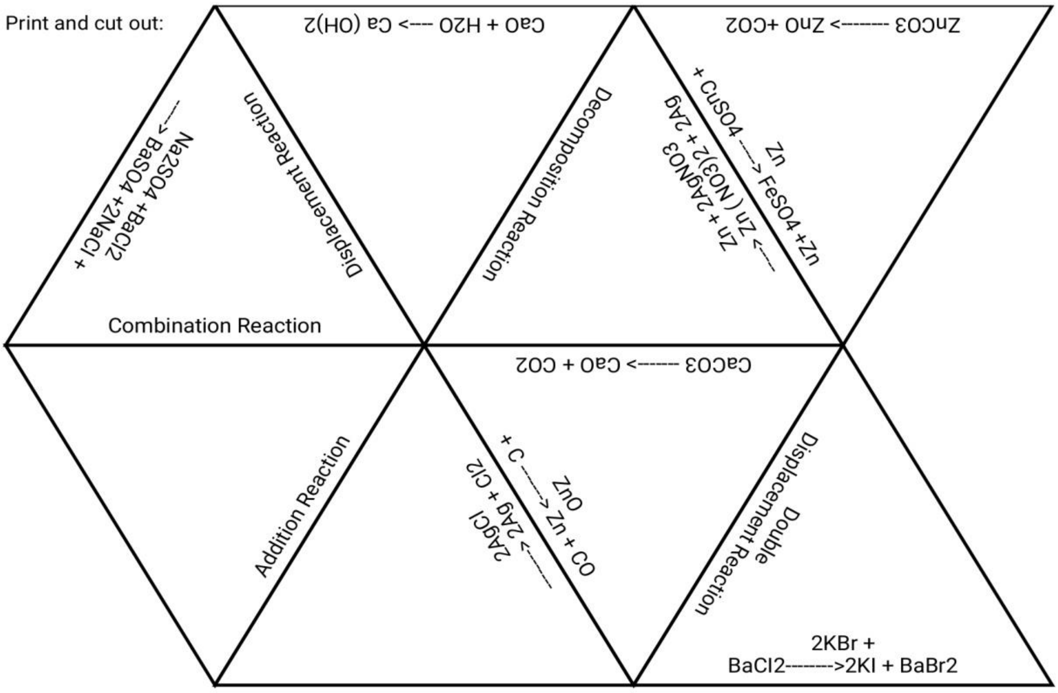

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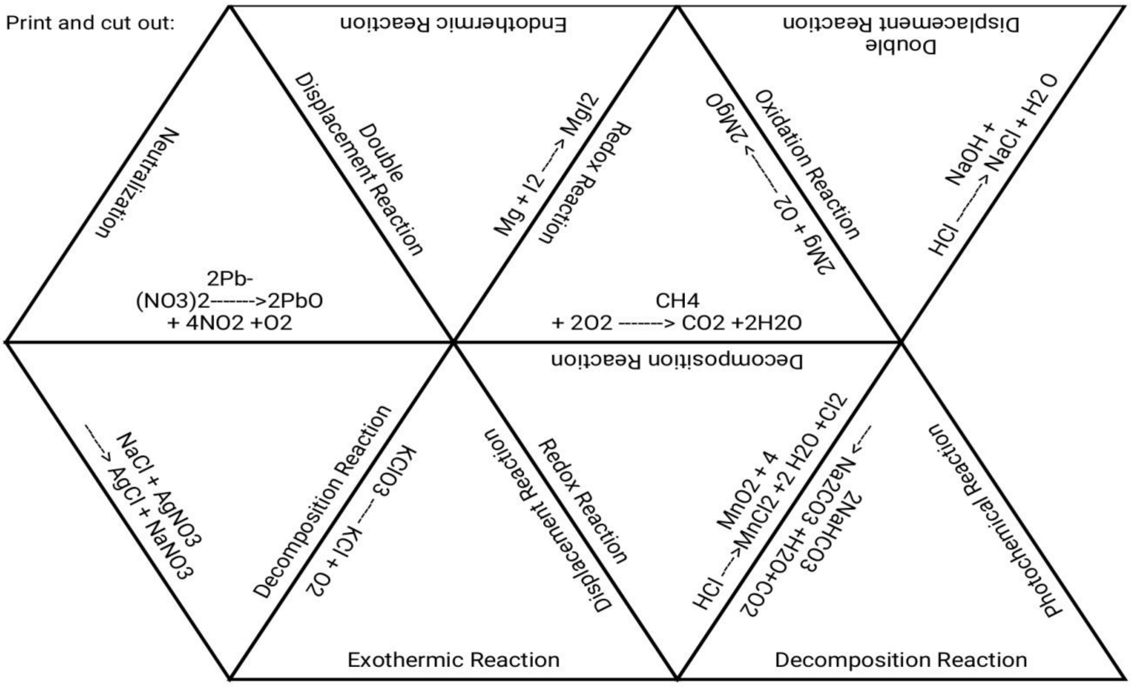

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Feedback Form and Responses

RIE BHOPAL FEEDBACK FORM FOR PAC:23.29

rashmirie@gmail.com Switch account

* Required

Email *

Your email

NAME OF THE PARTICIPANT (IN CAPITAL LETTER) *

Your answer

SCHOOL ADDRESS WITH PINCODE *

Your answer

DESIGNATION *

Your answer

TEACHING EXPERIENCE IN YEARS *

Your answer

1. WAS THE IDEA OF THE PROGRAM CLEARLY DEFINED AT THE BEGINNING OF THE PROGRAM *

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○

2. DID THE RESOURCE PERSONS PRESENT THE IDEA OF THE HOTS IN EFFECTIVE MANNER *

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○

3. WAS IT HELPFUL TO RAISE YOUR UNDERSTANDING ABOUT PREPARATION OF HOTS *

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○

4. HOW HAVE YOU FIND THE IDEA OF TEAM WORK FOR PREPARATION OF HOTS IN GROUP *

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○

5. HOW THE MODULE PROVIDED TO YOU HAS HELPED YOU AS REFERENCE MATERIAL FOR PREPARATION OF HOTS *

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○

6. HOW WOULD YOU OVERALL RATE THE PROGRAM IN ENHANCING YOUR UNDERSTANDING ABOUT HOTS *

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○

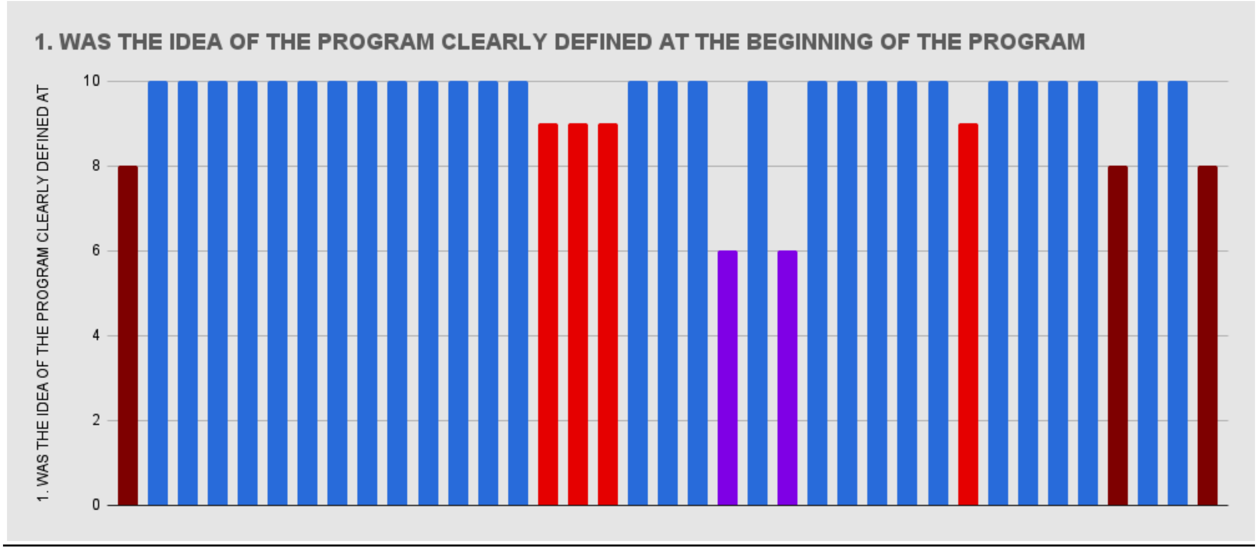
7. ANY OTHER SPECIFIC COMMENT/SUGGESTION *

Your answer

Submit Clear form

Name Of The Participant	Was The Idea Of The Program Clearly Defined At The Beginning Of The Program	Did The Resource Persons Present The Idea Of The Hots In Effective Manner	Was It Helpful To Raise Your Understanding About Preparation Of Hots	How Have You Find The Idea Of Team Work For Preparation Of Hots In Group	How The Module Provided To You Has Helped You As Reference Material For Preparation Of Hots	How Would You Overall Rate The Program In Enhancing Your Understanding About Hots
Beni Ram Kaushik	8	10	10	8	10	9
Sangeeta Maun	10	10	10	10	10	10
Kulkarni Pralhad Vithalrao	10	9	10	7	7	10
Janardan Trambak Shinde	10	10	10	9	9	10
Rajesh Wamanrao Roman	10	10	10	10	10	10
Sheetalkumar Sopanrao Bhong	10	10	10	10	10	10
Ajay Kumar Singh	10	10	10	10	9	8
Dileep Kumar Sahu	10	10	10	10	10	10
Dr. (Ms.) Udita Vora	10	10	9	10	10	10
Patil Hemant Madhavrao	10	10	10	10	10	10
Dr. Saili Ghanekar	10	9	8	8	7	8
Kalpana Rajendra Desai	10	10	10	10	10	10
Dr Anjali Ruikar	10	10	10	10	10	10
Sunita Pandey	10	10	8	9	9	9
Rajiv Ratna Pandey	9	9	10	8	9	9
Beni Ram Kaushik	9	10	10	10	10	9
Shri. Lina Verma	9	9	9	10	10	9
Satish Pandey	10	10	8	9	8	9
Mr. Sachin Ashok Bartakke	10	10	8	9	8	9
Devesh Kumar Verma	10	10	10	9	9	9
Abhimanyu Singh	6	10	7	7	9	6
Tanweer Ahmad	10	10	10	10	9	10
Shailendra Kasturiya	6	9	10	10	9	10
Manisha Deshmukh	10	10	10	10	10	10
Soma Banik	10	10	10	10	10	10
Lalit Ranoji Shintre	10	10	10	10	10	10

Ragini Atul Ghorpade	10	10	10	9	10	10
Mrs.Anuja Arun Gadage	10	10	10	10	10	10
Dr.Sumantrao B Bikkad	9	10	8	9	9	9
Dr. Sangita Madhukar Lavate	10	10	10	10	10	10
Mrs Smita Umesh Parab	10	10	10	10	10	10
Dr. Sangita Madhukar Lavate	10	10	10	10	10	10
Smita Nitin Pokharkar	10	10	10	10	10	10
Raj Kumar Sahu	8	9	8	7	7	8
Archana Deepak Harimkar	10	10	10	10	9	10
Aparna Tiwari	10	10	10	10	10	10
Kanchan Chandanan	8	10	10	10	10	10


1. WAS THE IDEA OF THE PROGRAM CLEARLY DEFINED AT THE BEGINNING OF THE PROGRAM
1. WAS THE IDEA OF THE PROGRAM CLEARLY DEFINED AT
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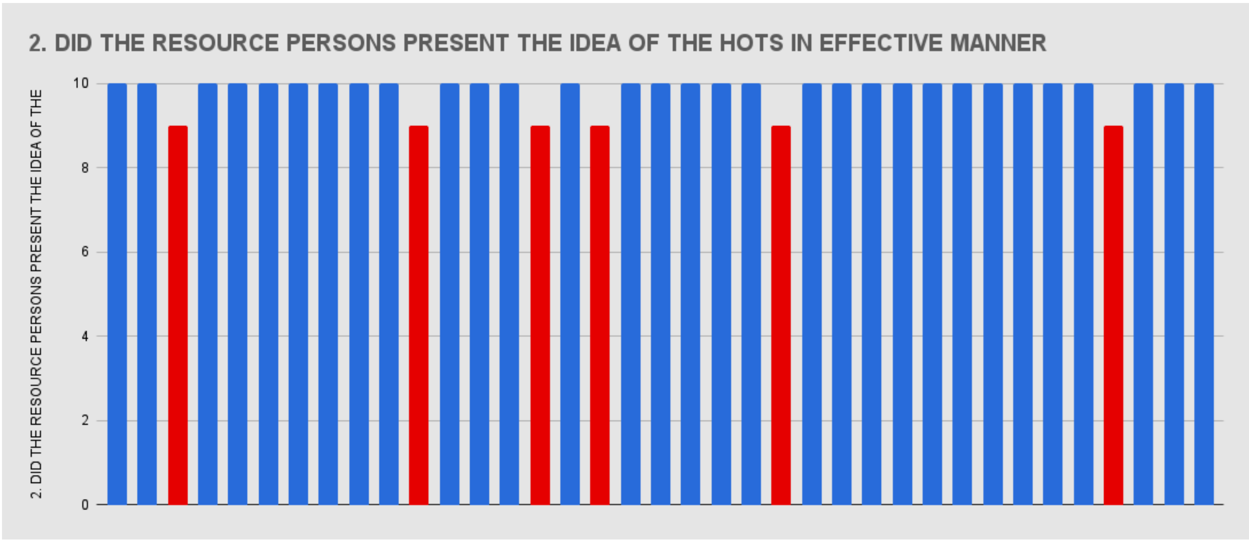
2. DID THE RESOURCE PERSONS PRESENT THE IDEA OF THE HOTS IN EFFECTIVE MANNER
2. DID THE RESOURCE PERSONS PRESENT THE IDEA OF THE
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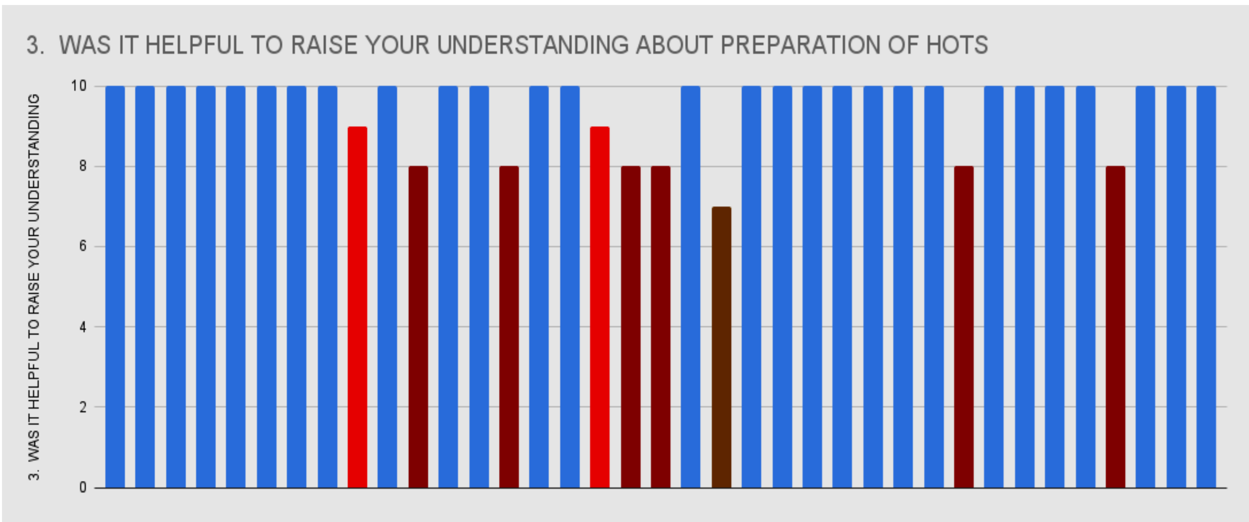
3. WAS IT HELPFUL TO RAISE YOUR UNDERSTANDING ABOUT PREPARATION OF HOTS
3. WAS IT HELPFUL TO RAISE YOUR UNDERSTANDING
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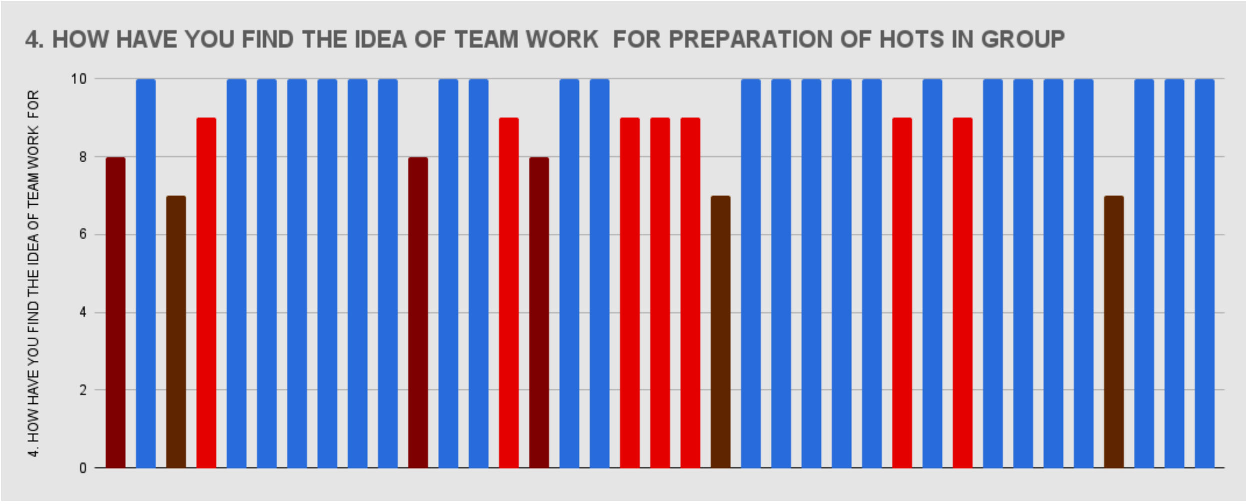
4. HOW HAVE YOU FIND THE IDEA OF TEAM WORK FOR PREPARATION OF HOTS IN GROUP
4. HOW HAVE YOU FIND THE IDEA OF TEAM WORK FOR
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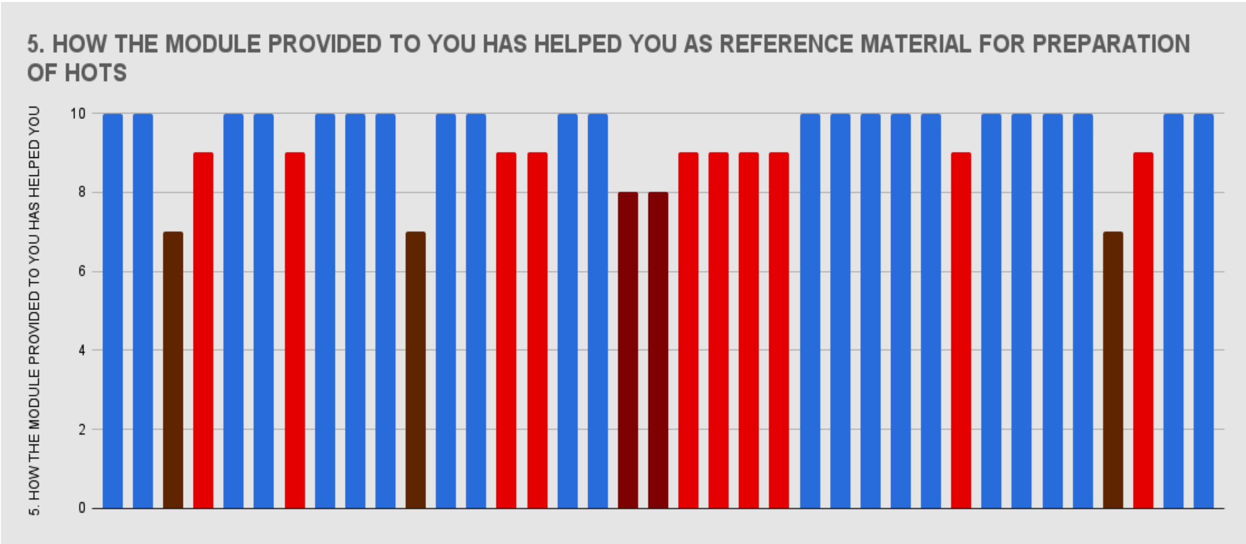
5. HOW THE MODULE PROVIDED TO YOU HAS HELPED YOU AS REFERENCE MATERIAL FOR PREPARATION OF HOTS
5. HOW THE MODULE PROVIDED TO YOU HAS HELPED YOU
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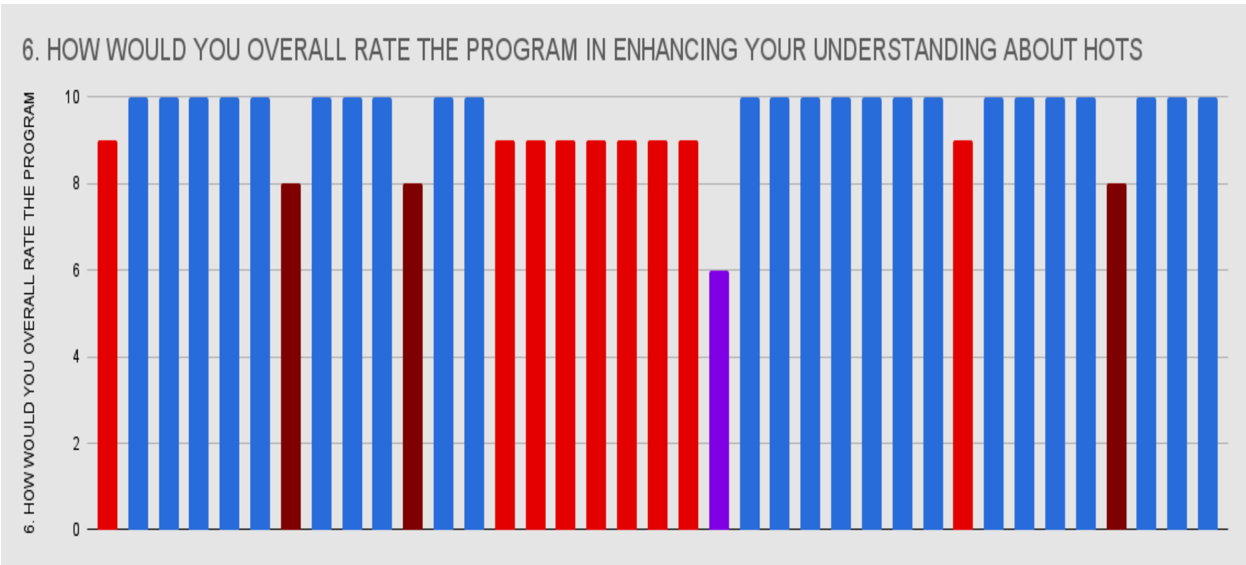
6. HOW WOULD YOU OVERALL RATE THE PROGRAM IN ENHANCING YOUR UNDERSTANDING ABOUT HOTS
6. HOW WOULD YOU OVERALL RATE THE PROGRAM
0
2
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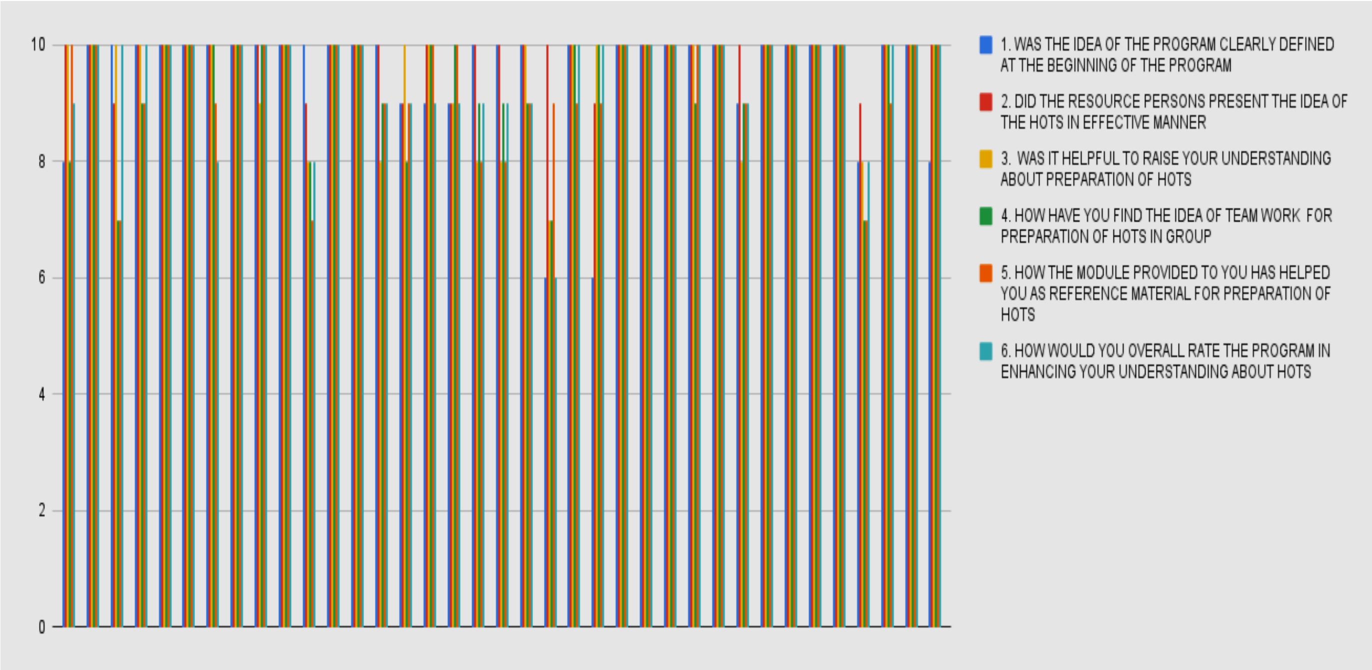
8
10

Consolidated Bar Diagram



RESULTS:

A Google form was developed and send to the participants online. Out of 39 participants 37 responses were received. The filled form was then analysed. The analysis was done and a pie chart and bar diagram for the same was prepared. As per the bar diagram, it shows that 97% participants 100% agrees to the satisfaction of the programme for which they have been benefitted. The questions asked were all related to the training which was given to the participants.

As per the training the participants have started incorporating various methodologies in their teaching learning process in their classes few examples are mentioned here which the participant has communicated to the coordinator.