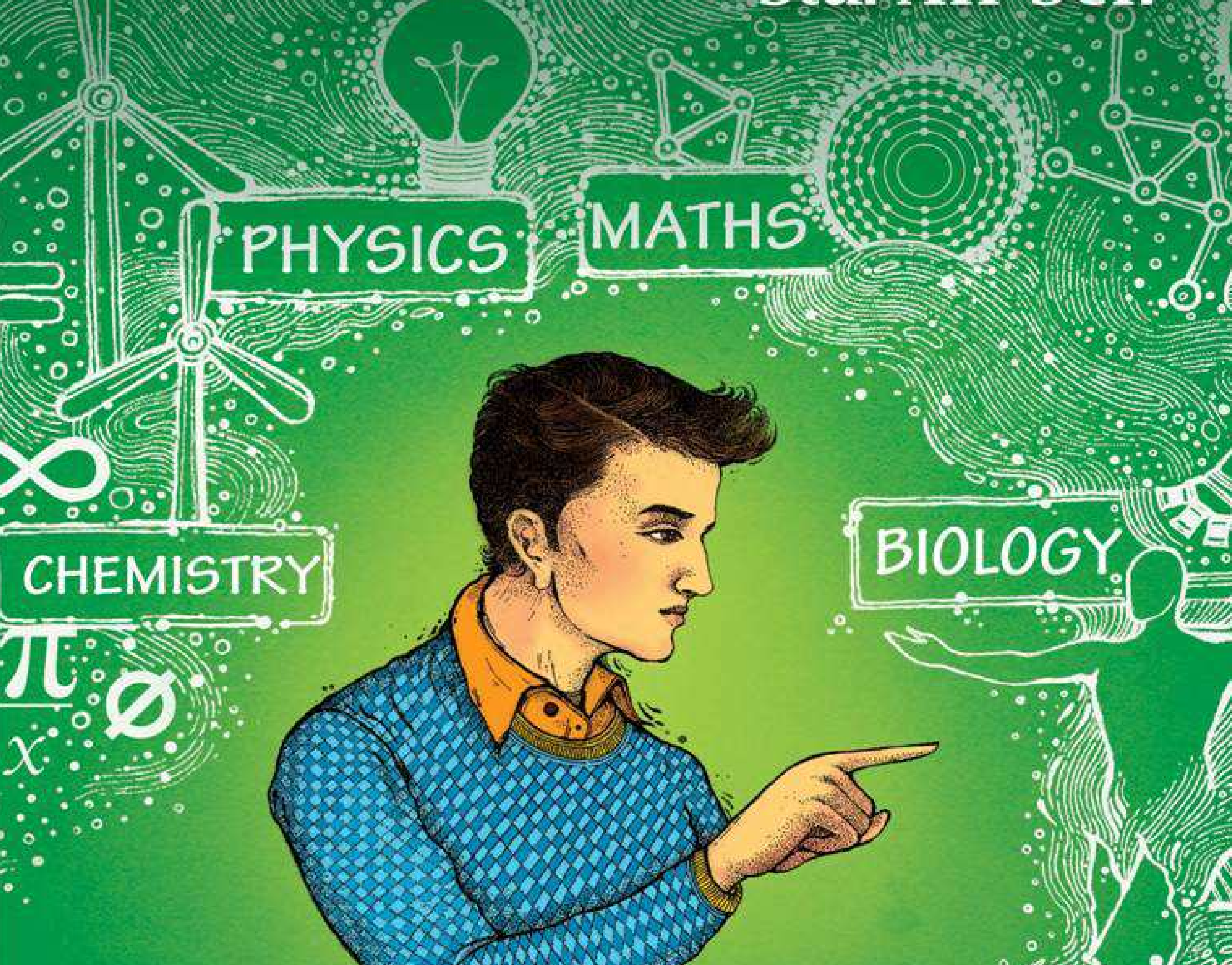
Model

Question Papers

with solutions

Std. XII Sci.



Target Publications Pvt. Ltd.

Model
Question Papers
With Solutions

STD. XII Sci.

Salient Features

- A set of 4 Question Papers with solutions each for Physics, Chemistry, Maths & Biology (Total 16 Question Papers)
- Prepared as per the new board paper pattern.
- Includes Board Question Papers of 2015 and 2016.
- Complete answers to every question with relevant marking scheme.
- Graphs and diagrams provided wherever necessary.
- Simple and lucid language.
- Self-evaluative in nature.

*Solutions with relevant marking scheme to Board Question papers available in downloadable PDF format at **www.targetpublications.org/tp10121***

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Preface

HSC is the cornerstone of a student's career as it opens up the doors to turn their dreams into reality. It acts as a platform for students to specialize in a field that interests them the most. However, to achieve this it becomes imperative to get into the details of each subject and to clarify its fundamentals. Adequate knowledge base thus helps kids to boost their self confidence and pave their way up in the final examinations.

It is rightly said, 'practice makes a man perfect'. Keeping this adage in mind, we are proud to introduce **"Std XII Science Model Question Papers".** This set of question papers provides students thorough practice for preparation of their final examinations. The book consists of 16 question papers in all based on Physics, Chemistry, Maths and Biology (*a set of four question papers for each subject*). Along with the question papers, we've provided model answers with relevant marking schemes so as to make sure that students understand the importance of each question. These question papers reflect the latest changes in content and paper pattern as updated by the Board of Higher Secondary Education.

Furthermore we have also included Board Question Papers of March, October 2015 and March, July 2016 examinations, solutions to which are available in downloadable PDF format at our website *www. targetpublications.org*. The purpose behind this is to make students familiar with the current question pattern and marking schemes. It also gives them a holistic understanding of the exact nature of the board question papers.

We are sure that, these question papers would provide ample practice to students in a systematic manner and would boost their confidence to face the challenges posed in examinations.

We welcome your valuable suggestions and feedback towards this book.

We wish the students all the best for their examinations.

Yours faithfully
Publisher

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PHYSICS : MARKING SCHEME

- There will be one single paper of 70 marks in Physics.
- Duration of the paper will be 3 hours.
- Physics paper will consist of two parts viz: Section-I and Section-II.
- Each section will be of 35 marks.
- Same answer sheet will be used for both the sections.
- Each section will consist of 4 questions.
- The sequence of the 4 questions in each section may or may not remain same.
- The paper pattern for Section–I and Section–II will be as follows:

Question 1: **(7 Marks)**

This question will be based on Multiple Choice Questions.

There will be 7 MCQs, each carrying one mark.

One question will be based on calculations.

Students will have to attempt all these questions.

Question 2: **(12 Marks)**

This question will contain 8 questions, each carrying 2 marks.

Students will have to answer any 6 out of the given 8 questions.

4 questions will be theory-based and 4 will be numericals.

Question 3: **(9 Marks)**

This question will contain 4 questions, each carrying 3 marks.

Students will have to answer any 3 out of the given 4 questions.

2 questions will be theory-based and 2 will be numericals.

Question 4: **(7 Marks)**

This question will contain 2 questions, each carrying 7 marks.

Students will have to answer any 1 out of the given 2 questions.

4/5 marks are allocated for theory-based question and 3/2 marks for numerical.

Distribution of Marks According to Type of Questions

Type of Questions	Marks	Marks with option	Percentage (%)
Objectives	14	14	20
Short Answers	42	56	60
Brief Answers	14	28	20
Total	**70**	**98**	**100**

Sr. No.	Unit	Marks Without option	Marks with option
1	Circular Motion	04	05
2	Gravitation	03	05
3	Rotational Motion	04	06
4	Oscillations	05	07
5	Elasticity	03	04
6	Surface Tension	04	05
7	Wave Motion	03	04
8	Stationary Waves	05	07
9	Kinetic Theory of Gases and Radiation	04	06
10	Wave Theory of light	03	04
11	Interference and Diffraction	04	06
12	Electrostatics	03	04
13	Current Electricity	03	04
14	Magnetic Effects of Electric Current	03	04
15	Magnetism	03	04
16	Electromagnetic Induction	04	06
17	Electrons and Photons	03	04
18	Atoms, Molecules and Nuclei	04	06
19	Semiconductors	03	04
20	Communication Systems	02	03

CHEMISTRY : MARKING SCHEME

- There will be one written paper of 70 Marks in Chemistry.
- Duration of the paper will be 3 hours.
- Chemistry paper will have two parts viz: Part I of 35 marks and Part II of 35 marks.
- Same Answer Sheet will be used for both the parts.
- In the question paper, for each part there will be 4 Questions.
- The sequence of the 4 Questions in each part may or may not remain same.
- Students have freedom to decide the sequence of answers.
- The paper pattern as per the marking scheme for Part I and Part II will be as follows:

Question 1: **(7 Marks)**

There will be 7 Multiple Choice Questions (MCQs), each carrying 1 mark.

Total marks = 7

Question 2: **(12 Marks)**

There will be 8 Questions out of which 6 Questions are to be answered, each carrying 2 marks.

Total marks = 12

Question 3: **(9 Marks)**

There will be 4 Questions out of which 3 Questions are to be answered, each carrying 3 marks.

Total marks = 9

(There will be 3 Questions based on numericals from Part I)

Question 4: **(7 Marks)**

There will be 2 Questions out of which 1 Question has to be answered.

It will carry 7 marks.

Total Marks = 7

(There will be 2/3 marks Questions based on numericals from Part I)

Distribution of Marks According to Type of Questions

Type of Questions	Marks	Marks with option	Percentage (%)
Objectives	14	14	20
Short Answers	42	56	60
Brief Answers	14	28	20
Total	**70**	**98**	**100**

No.	Topic Name	Marks Without Option	Marks With Option
1	Solid State	04	06
2	Solutions and Colligative Properties	05	07
3	Chemical Thermodynamics and Energetics	06	08
4	Electrochemistry	05	07
5	Chemical Kinetics	04	06
6	General Principles and Processes of Isolation of Elements	03	05
7	p–Block Elements	08	10
8	d and f–Block Elements	05	06
9	Coordination Compounds	03	04
10	Halogen Derivatives of Alkanes and Arenes	04	06
11	Alcohols, Phenols and Ethers	04	06
12	Aldehydes, Ketones and Carboxylic Acids	05	07
13	Compounds Containing Nitrogen	04	06
14	Biomolecules	04	06
15	Polymers	03	04
16	Chemistry in Everyday Life	03	04

MATHEMATICS : MARKING SCHEME

- There will be one single paper of 80 Marks in Mathematics.
- Duration of the paper will be 3 hours.
- Mathematics paper will consist of two parts viz: Part-I and Part-II.
- Each Part will be of 40 Marks.
- Same Answer Sheet will be used for both the parts.
- Each Part will consist of 3 Questions.
- The sequence of the Questions will be determined by the Moderator.
- The paper pattern for Part–I and Part–II will be as follows:

Question 1:

This Question will carry 12 marks and consist of two sections (A) and (B) as follows: **(12 Marks)**

(A) This Question will be based on Multiple Choice Questions.
There will be 3 MCQs, each carrying two marks.

(B) This Question will have 5 sub-questions, each carrying two marks.
Students will have to attempt any 3 out of the given 5 sub-questions.

Question 2:

This Question will carry 14 marks and consist of two sections (A) and (B) as follows: **(14 Marks)**

(A) This Question will have 3 sub-questions, each carrying three marks.
Students will have to attempt any 2 out of the given 3 sub-questions.

(B) This Question will have 3 sub-questions, each carrying four marks.
Students will have to attempt any 2 out of the given 3 sub-questions.

Question 3:

This Question will carry 14 marks and consist of two sections (A) and (B) as follows: **(14 Marks)**

(A) This Question will have 3 sub-questions, each carrying three marks.
Students will have to attempt any 2 out of the given 3 sub-questions.

(B) This Question will have 3 sub-questions, each carrying four marks.
Students will have to attempt any 2 out of the given 3 sub-questions.

Distribution of Marks According to Type of Questions

Type of Questions	Marks	Marks with option	Percentage (%)
Short Answers	24	32	30
Brief Answers	24	36	30
Detailed Answers	32	48	40
Total	**80**	**116**	**100**

Maths – I

Sr. No.	Unit	Marks With Option
1	Mathematical Logic	08
2	Matrices	06
3	Trigonometric Functions	10
4	Pair of Straight Lines	07
5	Vectors	08
6	Three Dimensional Geometry	04
7	Line	05
8	Plane	06
9	Linear Programming	04
	Total	58

Maths – II

Sr. No.	Unit	Marks With Option
1	Continuity	06
2	Differentiation	08
3	Applications of Derivatives	08
4	Integration	09
5	Definite Integral	08
6	Applications of Definite Integral	
7	Differential Equations	08
8	Probability Distribution	06
9	Binomial Distribution	05
	Total	58

BIOLOGY : MARKING SCHEME

- There will be one written paper of 70 Marks in Biology.
- Duration of the paper will be 3 hours.
- Biology paper will have two parts viz: Part I of 35 marks and Part II of 35 marks
- There will be two separate answer sheets for both the parts.
- In the same question paper, each part will have 4 Questions.
- Sequence of answering the questions can be determined by the students.
- The paper pattern for Part I and Part II will be as follows:

Question 1: **(7 Marks)**
There will be 7 multiple choice Questions (MCQs), each carrying one mark.
Total marks = 7

Question 2: **(12 Marks)**
This will have Questions as 'A', 'B' and 'C'.
In that,
Q.A will be based on : Answer in one sentence.
There will be 6 Questions each carrying 1 mark
Total marks = 6
Q.B will have one Question based on diagrams
Total Marks = 2
Q.C will have 4 Questions, each carrying 2 marks
Students will have to answer any 2 out of given 4 Questions
Total marks = 4
Total Marks (A + B + C) = 12

Question 3: **(9 Marks)**
This will have Questions as 'A' and 'B'
Q.A will have 3 Questions each carrying 3 marks
Students will have to answer any 2 out of given 3 Questions
Total Marks = 6
Q.B will have one Question based on diagrams
Total Marks = 3
Total Marks (A + B) = 9

Question 4: **(7 Marks)**
In this Question, 2 Questions will be asked each carrying 7 marks.
Students will have to answer any one out of given 2 Questions
Total Marks = 7

Distribution of Marks According to Type of Questions

Type of Questions	Marks	Marks with option	Percentage (%)
Objectives	14	14	20
Short Answers	42	56	60
Brief Answers	14	28	20
Total	**70**	**98**	**100**

No.	Topic Name	Marks Without Option	Marks With Option
1	Genetic Basis of Inheritance	08	12
2	Gene : It's Nature, Expression and Regulation		
3	Biotechnology: Process and Application	07	09
4	Enhancement in Food Production		
5	Microbes in Human Welfare	03	05
6	Photosynthesis	07	09
7	Respiration		
8	Reproduction in Plants	07	09
9	Organisms and Environment – I	03	05
10	Origin and Evolution of Life	07	09
11	Chromosomal Basis of Inheritance		
12	Genetic Engineering and Genomics	03	05
13	Human Health and Diseases	05	07
14	Animal Husbandry		
15	Circulation	10	14
16	Excretion and Osmoregulation		
17	Control and Co-ordination		
18	Human Reproduction	07	09
19	Organisms and Environment – II	03	05

MODEL QUESTION PAPER SET – I
PHYSICS

Time: 3 Hours **Total Marks: 70**

Note:

i. All questions are compulsory
ii. Neat diagrams must be drawn wherever necessary.
iii. Figure to the right indicate full marks.
iv. Use of logarithmic table is allowed.
v. All symbols have their usual meaning unless otherwise stated.

SECTION – I

Q.1. Select and write the most appropriate answer from the given alternatives for each sub-question: **[7]**

i. If a wave enters from air to water, then what remains unchanged?
(A) Frequency (B) Amplitude
(C) Velocity (D) Wavelength

ii. If the earth stops rotating, the value of 'g' at the equator will _______.
(A) increase (B) decrease
(C) remain same (D) become zero

iii. On being churned the butter separates out of milk due to _______.
(A) centrifugal force (B) adhesive force
(C) cohesive force (D) frictional force

iv. The average kinetic energy of a gas molecule is _______.
(A) proportional to pressure of gas
(B) inversely proportional to volume of gas
(C) inversely proportional to absolute temperature of gas
(D) proportional to absolute temperature of gas

v. Speed of sound in air is 300 m/s. The distance between two successive nodes of a stationary wave of frequency 1000 Hz is _______.
(A) 10 cm (B) 20 cm (C) 15 cm (D) 30 cm

vi. The time period of a spring of force constant k loaded with mass m is _______.
(A) $T \propto m$ and $T \propto k$ (B) $T \propto \sqrt{m}$ and $T \propto \frac{1}{\sqrt{k}}$
(C) $T \propto \left(\frac{1}{m}\right)$ and $T \propto k$ (D) $T \propto \left(\frac{1}{m}\right)$ and $T \propto \frac{1}{\sqrt{k}}$

vii. If a person, sitting on a rotating table, with his arms outstretched and holding heavy dumb bells in each hand, suddenly lowers his hands, then _______.
(A) his angular velocity decreases (B) his angular velocity does not change
(C) his angular momentum increases (D) his moment of inertia decreases

Q.2. Attempt any SIX: **[12]**

i. Distinguish between deforming force and stress.
ii. A simple harmonic progressive wave of frequency 5 Hz is travelling along the positive X direction with a velocity of 40 m/s. Calculate the phase difference between two points separated by a distance of 0.8 m.

iii. State Wien's displacement law. State its significance.

iv. Obtain an expression for time period of a satellite orbiting very close to earth's surface in terms of mean density.

Show that, $T = \sqrt{\frac{3\pi}{G\rho}}$, where ρ = mean density of earth

v. Define frequency of S.H.M. Discuss its unit and dimension.

vi. A bullet of mass 10 g and speed 500 m/s is fired into a door and gets embedded exactly at the centre of the door. The door is 1.0 m wide and weighs 9 kg. It rotates about a vertical axis practically without friction. Find the angular speed of the door just after the bullet embeds into it.

vii. A uniform wire under tension is fixed at its ends. If the ratio of tensions in the wire to the square of its length is 320 dyne/cm^2 and fundamental frequency of vibration of wire is 400 Hz, find its linear density.

viii. A mass of 4 kg is tied at the end of a string 1.2 m long, revolving in a horizontal circle. If the breaking tension in the string is 200 N, find the maximum number of revolutions per minute the mass can make.

Q.3. Attempt any THREE: **[9]**

i. A cyclist speeding at 18 km/hr on a level road takes a sharp circular turn of radius 4 m without reducing the speed. The coefficient of static friction between the tyres and the road is 0.2. Will the cyclist slip while taking the turn? Calculate maximum safety speed. Will it be constant always?

ii. A brass wire of radius 2 mm is loaded by a mass of 32.8 kg. What would be the decrease in its radius?
($Y = 9 \times 10^{10}$ N/m^2, Poisson's ratio $\sigma = 0.36$)

iii. State and prove law of conservation of angular momentum. Give two examples.

iv. What is a heat engine? Explain working and efficiency of heat engine.

Q.4. Discuss analytically the composition of two S.H.M's of same period and parallel to each other. Obtain their resultant amplitude. Also find the resultant amplitude when phase difference of two S.H.M's is a. 0 b. π
Find the height of a geostationary satellite (communication satellite) from the surface of the earth.
(Mass of the earth = 6×10^{24} kg, radius of the earth = 6400 km,
$G = 6.67 \times 10^{-11}$ N.m^2/kg^2) **[7]**

OR

Q.4. Derive an expression for the kinetic energy of a body rotating with uniform angular velocity**.**

A body describes S.H.M in a path 0.16 m long. Its velocity at the centre of the line is 0.12 m/s. Find the period and magnitude of velocity at a distance 1.7×10^{-2} m from the mean position. **[7]**

SECTION - II

Q.5. Select and write the most appropriate answer from the given alternatives for each sub-question: **[7]**

i. Velocity of light in air is 'c'. Its velocity in a medium of refractive index 1.5 will be ________.

(A) c (B) $\frac{c}{1.5}$ (C) $c \times 1.5$ (D) $c + 1.5$

ii. For what value of velocity of electrons, the stopping potential will be able to stop them?
(A) 10^3 m/s (B) Very high speeds (C) Very low speeds (D) All speeds

iii. If the lengths of two wires of same material are in the ratio 2 : 1, then the ratio of their specific resistances will be ________.
(A) 1 : 2 (B) 2 : 1 (C) 4 : 1 (D) 1 : 1

iv. If ‘R’ and ‘L’ stand for the resistance and inductance respectively, then among the following the one having the dimensions of frequency is _______.

(A) $\frac{R}{L}$ (B) $\frac{L}{R}$ (C) $\frac{\sqrt{R}}{L}$ (D) $\frac{\sqrt{L}}{R}$

v. The phenomenon of paramagnetism is a consequence of _______.

(A) distortion effect (B) orientation effect
(C) both (A) and (B) (D) neither (A) nor (B)

vi. In an amplitude modulated wave, the power content of the carrier is maximum for which value of ‘m’?

(A) zero (B) 1 (C) 0.1 (D) 0.4

vii. In Boolean algebra, $\overline{A+B}$ = _______.

(A) $A \cdot B$ (B) $A + B$ (C) $\overline{A}+\overline{B}$ (D) $\overline{A}\cdot\overline{B}$

Q.6. Attempt any SIX: **[12]**

i. A solenoid of 100 turns per unit length and cross-sectional area 2×10^{-4} m^2 carries a current of 6 A. It is placed in horizontal axis at 30° with direction of uniform magnetic field of 0.3 T. Calculate magnetic moment of solenoid and torque experienced by solenoid due to the field.

ii. Four resistances 5 Ω, 5 Ω, 5 Ω and 15 Ω form a Wheatstone’s network. Find the resistance which when connected across the 15 Ω resistance, will balance the network.

iii. Define cut off potential. Show graphically variation of photoelectric current with collector plate potential for different intensity of incident radiation.

iv. Explain why microscopes of high magnifying power have oil-immersion objectives.

v. Explain I – V characteristics of zener diode with suitable graph.

vi. Calculate the de Broglie wavelength of proton if it is moving with speed of 8×10^6 m/s. ($m_p = 1.67 \times 10^{-27}$ kg).

vii. An alternating emf E = 250 sinωt V is connected to a 1250 Ω resistor. Calculate the rms current through the resistor and the average power dissipated in one cycle.

viii. Write any two points of difference between amplitude modulation and frequency modulation.

Q.7. Attempt any THREE **[9]**

i. An alternating e.m.f is applied to a circuit containing resistance. Discuss the behaviour of current in the circuit.

ii. With the help of a neat circuit diagram, explain working of P-N junction diode as a half-wave rectifier.

iii. A resistance of 5 Ω is connected in parallel to a galvanometer of resistance 495 Ω. Find the fraction of the total current, passing through galvanometer.

iv. Two parallel plate air capacitors have their plate areas 100 cm^2 and 400 cm^2 respectively. If they have the same charge and potential and the distance between the plates of the first capacitor is 0.4 mm, what is the distance between the plates of the second capacitor?

Q.8. Explain origin of spectral line and obtain Bohr’s formula.

If the difference in velocities of light in glass and water is 0.24×10^8 m/s, find the velocity of light in air (Given : $\mu_g = \frac{3}{2}$, $\mu_w = 4/3$) **[7]**

OR

Q.8. Explain principle, construction and working of transformer. Also, derive equation of transformer.
When a surface is irradiated with light of wavelength 4950 Å, a photocurrent appears which vanishes if a retarding potential greater than 0.6 V is applied across the phototube. When different source of light is used, it is found that the critical retarding potential is changed to 1.1 V. Find the work function of the emitting surface and the wavelength of the second source. **[7]**

MODEL ANSWER PAPER SET – I
PHYSICS

SECTION – I

Q.1. Select and write the most appropriate answer from the given alternatives for each sub-question:

i. (A) [1]

ii. (A)
$g_E = g - R\omega^2$
For $\omega = 0$,
$g'_E = g$.
$g'_E > g_E$. [1]

iii. (A) [1]

iv. (D)
Average kinetic energy of a gas $\frac{1}{2}mv^2 = \frac{3}{2}k_BT$
$\therefore$ Kinetic energy of gas $\propto$ Temperature [1]

v. (C)
Distance between two successive antinode = $\frac{\lambda}{2}$
$= \frac{v}{2n} = \frac{300}{10^3 \times 2} = 15 \times 10^{-2}$ m = 15 cm. [1]

vi. (B) [1]

vii. (D)
When the man pulls his arms, the speed of rotation of the table increases but the distance R of the dumbells from the axis of rotation decreases. Hence, moment of inertia of the man decreases and angular velocity of turn table increases. [1]

Q.2. Attempt any SIX:

i.

No.	Deforming force	Stress
i.	It is externally applied force.	It is internal restoring force per unit area.
ii.	It tries to deform the body.	It opposes the deformation.
iii.	S.I unit is N.	S.I unit is N/m^2.
iv.	Its dimension is $[M^1L^1T^{-2}]$.	Its dimension is $[M^1L^{-1}T^{-2}]$.
v.	It is a vector quantity.	It is a tensor quantity.

(any two correct points of difference) (1 × 2) [2]

ii. Given: n = 5Hz, v = 40 m/s, x = 0.8 m,
To find: Phase difference (δ)
Formulae: i. $v = n\lambda$ ii. $\delta = \frac{2\pi x}{\lambda}$ [1]
Calculation: From formula (i),
$\lambda = \frac{v}{n} = \frac{40}{5} = 8$ m

From formula (ii),

$$\delta = \frac{2\times\pi\times0.8}{8}$$

$\therefore$ $\delta = 2\pi\times0.1$

$\therefore$ $\delta = \frac{\pi}{5}$ rad

The phase difference between two points is $\frac{\pi}{5}$ rad [1]

iii. Wien's displacement law: The wavelength (λ_m) emitted with maximum intensity by a black body is inversely proportional to its absolute temperature.
Mathematically,

$\lambda_m \propto \frac{1}{T}$ i.e., $\lambda_m = b.\frac{1}{T}$

where b = constant called Wien's constant. [1]

Significance:

a. It can be used to estimate very high temperature such as surface temperature of stars, sun, moon, celestial bodies etc.
b. It explains the common observation of the change of colour of a solid from dull red to yellow and then to white on heating.
c. As the temperature increases, the maximum intensity of radiation shifts towards the shorter wavelength side. Thus Wien's law is also called displacement law.

(any two points of significance) (½ × 2) [1]

iv. Time period in terms of mean density:

a. Since $T = 2\pi\sqrt{\frac{(R+h)^3}{GM}}$ ….(i)

b. Mass of the earth, $M = \frac{4}{3}\pi R^3\rho$ [½]

where ρ = mean density of the earth

c. Substituting, the value of M in the equation (i),

$$T = 2\pi\sqrt{\frac{(R+h)^3}{G\times\frac{4}{3}\pi R^3\rho}} = \sqrt{\frac{4\pi^2(R+h)^3}{\frac{4}{3}\pi R^3\rho G}}$$

$\therefore$ $T = \sqrt{\frac{3\pi(R+h)^3}{GR^3\rho}}$ ….(ii) [1]

d. When satellite is orbiting very close to the earth, $h \approx 0$.

$\therefore$ Equation (ii) becomes,

$$T = \sqrt{\frac{3\pi R^3}{GR^3\rho}}$$

$\therefore$ $T = \sqrt{\frac{3\pi}{G\rho}}$ [½]

v. a. The number of oscillations performed by a particle executing S.H.M. per unit time is called frequency of S.H.M. [1]

It is given by $n = \frac{1}{T} = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$

b. Unit: Hz or c.p.s or r.p.s in SI system. [½]
c. Dimension: $[M^0L^0T^{-1}]$ [½]

vi. Given: $m = 10\text{ g} = 10 \times 10^{-3}\text{ kg}$, $v = 500\text{ m/s}$, $r = 0.5\text{ m}$, $l = 1\text{ m}$, $m = 9\text{ kg}$,
To find: Angular speed (ω)
Formulae: i. $L = mvr$ ii. $I = \frac{ml^2}{3}$ iii. $L = I\omega$ [1]
Calculation: From formula (i),
$L = (10 \times 10^{-3}) \times 500 \times 0.5$
$\therefore$ $L = 2.5\text{ kg m}^2\text{/s}$
From formula (ii),
$I = \frac{9 \times 1^2}{3} = 3\text{ kg m}^2$
From formula (iii),
$\therefore$ $\omega = \frac{L}{I} = \frac{2.5}{3} = 0.83\text{ rad/s}$
Angular speed of the door is 0.83 rad/s. [1]

vii. Given: $\frac{T}{l^2} = 320\text{ dyne/cm}^2$, $n = 400\text{ Hz}$,
To find: Linear density (m)
Formula: $n = \frac{1}{2l}\sqrt{\frac{T}{m}}$ [½]
Calculation: From formula,
$\therefore$ $m = \frac{1}{4n^2} \times \frac{T}{l^2}$
$m = \frac{1}{4 \times (400)^2} \times 320$ [½]
$m = \frac{80}{160000}$
$\therefore$ $m = 5 \times 10^{-4}\text{ kg/m}$
Linear density of the wire is 5×10^{-4} kg/m. [1]

viii. Given: $r = 1.2\text{ m}$, $m = 4\text{ kg}$, $T = 200\text{ N}$,
To find: Maximum no of revolutions (n_{max})
Formula: $T_{max} = mr\omega^2_{max} = mr\,(2\pi n_{max})^2$ [½]
Calculation: From formula,
$\therefore$ $n^2_{max} = \frac{200}{4 \times 1.2 \times 4 \times (3.14)^2}$ [½]
$\therefore$ $n_{max} = \left[\frac{200}{16 \times 1.2 \times (3.14)^2}\right]^{\frac{1}{2}}$
$= \text{antilog}\left\{\frac{1}{2}[\log(200) - \log(16) - \log(1.2) - 2\log(3.14)]\right\}$
$= \text{antilog}\left\{\frac{1}{2}[2.3010 - 1.2041 - 0.0792 - 2 \times 0.4969]\right\}$
$= \text{antilog}\left\{\frac{1}{2} \times 0.0239\right\}$
$= \text{antilog}[0.0120]$
$\therefore$ $n_{max} = 1.028\text{ r.p.s.}$
$\therefore$ $n_{max} = 1.028 \times 60\text{ r.p.m.}$
$\therefore$ $n_{max} = 61.68\text{ Hz}$
The maximum number of revolutions per minute is 61.68 Hz [1]

Q.3. Attempt any THREE:

i. $v = 18 \text{ km/hr} = \frac{18000}{3600} \text{ m/s} = 5 \text{ m/s}, r = 4 \text{ m}, \mu_s = 0.2$

$v^2 = 5^2 = 25 \text{ m}^2/\text{s}^2$

$\mu_s rg = 0.2 \times 4 \times 9.8 = 7.84 \text{ m}^2/\text{s}^2$ [½]

Condition for safe turning is, $v^2 \leq \mu_s rg$ [½]

Comparing values of v^2 and ($\mu_s rg$)

$25 \not\leq 7.84$

As condition for safe turning is not met, the cyclist will slip while taking circular turn. [½]

Max. Safe speed, $v_{max} = \sqrt{\mu_s rg} = \sqrt{7.84}$

$= 2.8 \text{ m/s}$ [½]

This speed limit is not always constant. It depends upon friction between tyres and roads. For worn-out tyres or road wet with oil or water, magnitude of friction will change. Thus value of maximum safe speed will vary. [1]

ii. Given: $r = 2 \text{ mm} = 2 \times 10^{-3} \text{ m}, m = 32.8 \text{ kg}, Y = 9 \times 10^{10} \text{ N/m}^2$,

To find: Decrease in radius (Δr)

Formulae: i. $Y = \frac{FL}{(\pi r^2)l}$ ii. $\sigma = \frac{L\Delta r}{lr}$ [1]

Calculation: From formula (i),

$\therefore \frac{l}{L} = \frac{F}{AY} = \frac{mg}{(\pi r^2)Y}$

$\therefore \frac{l}{L} = \frac{32.8 \times 9.8}{\pi \times (2 \times 10^{-3})^2 \times 9 \times 10^{10}}$

$= \frac{32.8 \times 9.8}{3.14 \times 4 \times 9 \times 10^4}$

$= \{\text{antilog}[\log(32.8) + \log(9.8) - \log(3.14) - \log(4) - \log(9)]\} \times 10^{-4}$

$= \{\text{antilog}[1.5159 + 0.9912 - 0.4969 - 0.6021 - 0.9542]\} \times 10^{-4}$

$= \{\text{antilog}[0.4539]\} \times 10^{-4}$

$= 2.844 \times 10^{-4}$ [1]

From formula (ii),

$\Delta r = \frac{lr\sigma}{L}$

$= 2.842 \times 10^{-4} \times 2 \times 10^{-3} \times 0.36$

$\Delta r = \{\text{antilog}[\log(2.842) + \log(2) + \log(0.36)]\} \times 10^{-7}$

$= \{\text{antilog}[0.4536 + 0.3010 + \bar{1}.5563]\} \times 10^{-7}$

$= \{\text{antilog}[0.3109]\} \times 10^{-7}$

$\therefore \Delta r = 2.046 \times 10^{-7} \text{ m}$

The decrease in radius of wire is 2.046×10^{-7} m. [1]

iii. Statement:

The angular momentum of a body remains constant, if resultant external torque acting on the body is zero. [½]

Proof:

a. Consider a particle of mass m, rotating about an axis with torque 'τ'.

Let $\vec{p}$ be the linear momentum of the particle and $\vec{r}$ be its position vector.

b. By definition, angular momentum is given by, $\vec{L} = \vec{r} \times \vec{p}$ ....(i)

c. Differentiating equation (i) with respect to time t,

$$\frac{d\vec{L}}{dt} = \frac{d}{dt}(\vec{r} \times \vec{p})$$

$\therefore$ $$\frac{d\vec{L}}{dt} = \vec{r} \times \frac{d\vec{p}}{dt} + \vec{p} \times \frac{d\vec{r}}{dt} \quad \text{....(ii)}$$ [½]

d. But, $\frac{d\vec{r}}{dt} = \vec{v}$, $\frac{d\vec{p}}{dt} = \vec{F}$ and $\vec{p} = m\vec{v}$

$\therefore$ Equation (ii) becomes,

$$\frac{d\vec{L}}{dt} = \vec{r} \times \vec{F} + 0 \quad [\because \vec{v} \times \vec{v} = v^2 \sin 0° = 0]$$

e. Also, $\vec{\tau} = \vec{r} \times \vec{F}$

$\therefore$ $$\frac{d\vec{L}}{dt} = \vec{\tau}$$ [½]

f. If resultant external torque (τ) acting on the particle is zero, then $\frac{d\vec{L}}{dt} = 0$.

$\therefore$ $\vec{L}$ = constant $\quad\therefore$ $I\omega$ = constant

Hence, angular momentum remains conserved. [½]

Examples:

1. The angular velocity of revolution of a planet around the sun in an elliptical orbit increases, when the planet comes closer to the sun and vice-versa.
2. A person carrying heavy weights in his hands and standing on a rotating platform can change the speed of the platform.
3. A diver performs somersaults by jumping from a high diving board keeping his legs and arms out stretched first, and then curling his body.

(*Any 2 of the above examples*) (½ × 2) [1]

iv. Heat engine:

a. A heat engine is a device which converts heat energy into mechanical energy.
b. This engine works in cyclic process. It takes heat from bodies at higher temperature, converts part of it to mechanical work and remaining to a body at lower temperature.
c. The cycle is repeated again and again to get useful work for some purpose. [1]

Working:

a. Suppose,
Q_1 = amount of heat absorbed by the working substance from the source at temperature in one complete cycle.
Q_2 = amount of heat rejected at temperature in the cycle.
W = net amount of external work done by the working substance, on the environment in the cycle.

b. Net amount of heat absorbed in one cycle, $\Delta Q = Q_1 - Q_2$

c. As the working substance returns to its initial state, the change in its internal energy = 0

$\therefore$ $\Delta U = 0$

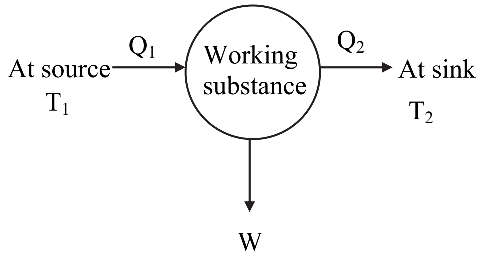
According to the first law of thermodynamics,

$\Delta Q = \Delta U + \Delta W$

$\therefore$ $\Delta Q = \Delta W$

i.e., Net amount of heat absorbed = External work done by the engine

$\therefore$ $Q_1 - Q_2 = W$



[1]

Thermal efficiency:

a. Thermal efficiency of a heat engine is the ratio of net work done per cycle by the engine to the total amount of heat absorbed per cycle by the working substance from the source.

b. It is given by $\eta = \frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1}$

where, Q_1 = Heat absorbed by the system in one complete cycle,
Q_2 = Heat rejected to the environment.

c. For $Q_2 = 0$, $\eta = 1$, i.e., the engine will have 100% efficiency in converting heat into work.

d. It is not possible experimentally to construct such an ideal engine with $\eta = 1$. [1]

Q.4. Analytical treatment of composition of two S.H.M's:

i. Let the two linear S.H.M's be given by equations,

$x_1 = A_1 \sin(\omega t + \alpha_1)$ ….(1)

$x_2 = A_2 \sin(\omega t + \alpha_2)$ ….(2)

where A_1, A_2 are amplitudes, α_1, α_2 are initial phase angles and x_1, x_2 are the displacement of two S.H.M's in time 't'. ω is same for both S.H.M's.

ii. The resultant displacement of the two S.H.M's is given by,

$x = x_1 + x_2$ ....(3)

iii. Using equations (1) and (2) , equation (3) can be written as,

$x = A_1 \sin(\omega t + \alpha_1) + A_2 \sin(\omega t + \alpha_2)$

$= A_1 [\sin \omega t \cos \alpha_1 + \cos \omega t \sin \alpha_1] + A_2 [\sin \omega t \cos \alpha_2 + \cos \omega t \sin \alpha_2]$

$= A_1 \sin \omega t \cos \alpha_1 + A_1 \cos \omega t \sin \alpha_1 + A_2 \sin \omega t \cos \alpha_2 + A_2 \cos \omega t \sin \alpha_2$

$= [A_1 \sin \omega t \cos \alpha_1 + A_2 \sin \omega t \cos \alpha_2] + [A_1 \cos\omega t \sin \alpha_1 + A_2 \cos \omega t \sin\alpha_2]$

$\therefore$ $x = \sin \omega t [A_1 \cos \alpha_1 + A_2 \cos \alpha_2] + \cos \omega t [A_1 \sin \alpha_1 + A_2 \sin \alpha_2]$ ….(4) [1]

iv. Let $A_1 \cos \alpha_1 + A_2 \cos \alpha_2 = R\cos \delta$ ….(5)

and $A_1 \sin \alpha_1 + A_2 \sin \alpha_2 = R \sin \delta$ ….(6)

v. Using equations (5) and (6), equation (4) can be written as,

$x = \sin \omega t.\ R \cos \delta + \cos \omega t.R \sin \delta$

$= R [\sin \omega t \cos \delta + \cos \omega t \sin \delta]$

$\therefore$ $x = R \sin(\omega t + \delta)$ ….(7)

Equation (7) represents linear S.H.M. of amplitude R and initial phase angle δ with same period. [1]

Resultant amplitude (R):

Squaring and adding, equations (5) and (6),we get,

$(A_1 \cos \alpha_1 + A_2 \cos \alpha_2)^2 + (A_1 \sin \alpha_1 + A_2 \sin \alpha_2)^2 = R^2\cos^2\delta + R^2\sin^2\delta$

$\therefore$ $A_1^2\cos^2 \alpha_1 + A_2^2 \cos^2 \alpha_2 + 2A_1 A_2 \cos \alpha_1 \cos\alpha_2 + A_1^2 \sin^2\alpha_1 + A_2^2\sin^2 \alpha_2 + 2A_1A_2 \sin\alpha_1 \sin\alpha_2$

$= R^2 (\cos^2 \delta + \sin^2 \delta)$

$\therefore$ $A_1^2 (\cos^2 \alpha_1 + \sin^2 \alpha_1) + A_2^2 (\cos^2 \alpha_2 + \sin^2\alpha_2) + 2A_1A_2 (\cos \alpha_1 \cos \alpha_2 + \sin\alpha_1 \sin\alpha_2) = R^2$

$\therefore$ $A_1^2 + A_2^2 + 2A_1 A_2 \cos(\alpha_1 - \alpha_2) = R^2$

$\therefore$ $R = \pm \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos(\alpha_1 - \alpha_2)}$ ....(8)

Equation (8) represents resultant amplitude of two S.H.M's. [1]

Case I: For phase difference = 0

If $\alpha_1 - \alpha_2 = 0$ then $\alpha_1 = \alpha_2$

In this case both S.H.M's have same initial phase angle

$\therefore$ From equation (viii),

$$R = \sqrt{A_1^2 + A_2^2 + 2A_1A_2} = \sqrt{(A_1 + A_2)^2}$$

$\therefore$ $R = (A_1 + A_2)$

If $A_1 = A_2 = A$ then, $R = 2A$ [½]

Case II: For phase difference = π

If $\alpha_1 - \alpha_2 = \pi$ then, $\cos(\alpha_1 - \alpha_2) = -1$

From equation (viii),

$$R = \sqrt{A_1^2 + A_2^2 - 2A_1A_2} = \sqrt{(A_1 - A_2)^2}$$

$\therefore$ $R = (A_1 - A_2)$

If $A_1 = A_2 = A$ then, $R = 0$

Since particle has resultant amplitude zero, therefore it will be at rest. [½]

Solution:

Given: $M = 6 \times 10^{24}$ kg, $R = 6400$ km $= 6.4 \times 10^6$ m, $G = 6.67 \times 10^{-11}$ N.m^2/kg^2

For geostationary satellite, period of revolution is one day.

$\therefore$ T = 1 day = (24 × 3600)s.

To find: Height (h)

Formula: $T^2 = \left(\dfrac{4\pi^2}{GM}\right)(R + h)^3$ [1]

Calculation: From formula,

$$(R + h)^3 = \frac{GMT^2}{4\pi^2}$$

$$\therefore \quad R + h = \left[\frac{6.67 \times 10^{-11} \times 6 \times 10^{24} \times (24 \times 3600)^2}{4 \times (3.142)^2}\right]^{\frac{1}{3}}$$ [½]

$$= \left[\frac{6.67 \times 0.6 \times 24^2 \times 36^2 \times 10^{25} \times 10^{-11} \times 10^4}{4 \times (3.142)^2}\right]^{\frac{1}{3}}$$

$$= \left\{\text{anti}\log\left[\frac{1}{3} \times (\log 6.67 + \log 0.6 + 2\log 24 + 2\log 36 - \log 4 - 2\log 3.14)\right]\right\} \times 10^6$$

$$= \left\{\text{anti}\log\left[\frac{1}{3} \times \left(0.8241 + \bar{1}.7782 + 2 \times 1.3802 + 2 \times 1.5563 - 0.6021 - 2 \times 0.4972\right)\right]\right\} \times 10^6$$

$$= \left\{\text{anti}\log\left[\frac{1}{3} \times \left(0.8241 + \bar{1}.7782 + 2.7604 + 3.1126 - 0.6021 - 0.9944\right)\right]\right\} \times 10^6$$

$$= \text{antilog}\left\{\frac{1}{3} \times 4.8788\right\} \times 10^6$$

$$= \text{antilog}[1.6263] \times 10^6$$

$\therefore$ $R + h = 4.23 \times 10^7$ m $= 42.3 \times 10^6$ m [½]

$\therefore$ $h = 42.3 \times 10^6 - 6.4 \times 10^6$

$h = 35.900 \times 10^6$ m

$= 35,900$ km

The height of geostationary satellite from the surface of the earth is 35,900 km. [1]

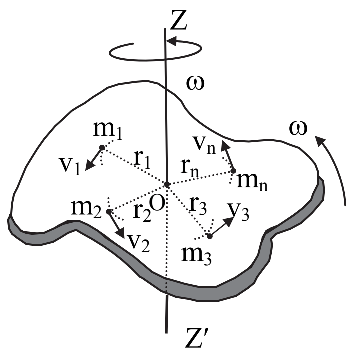
OR

Q.4. Expression for kinetic energy of a rotating body:

i. Suppose a rigid body is rotating with constant angular velocity ω about an axis ZZ′ through a point O as shown in the figure.

ii. Let the body consists of n particles of masses $m_1, m_2, m_3, \ldots, m_n$ situated at distances $r_1, r_2, r_3, \ldots, r_n$ respectively from the axis of rotation.

iii. Linear velocity of particles of masses $m_1, m_2, \ldots m_n$ are given by $v_1 = r_1\omega$, $v_2 = r_2\omega$, $v_3 = r_3\omega \ldots$, $v_n = r_n\omega$, respectively. [1]



iv. Kinetic energy of particle of mass m_1,

$$(K.E)_1 = \frac{1}{2}m_1v_1^2 = \frac{1}{2}m_1r_1^2\omega^2$$

Kinetic energy of particle of mass m_2,

$$(K.E)_2 = \frac{1}{2}m_2v_2^2 = \frac{1}{2}m_2r_2^2\omega^2$$

v. Similarly kinetic energy of particle of masses $m_3, m_4 \ldots\ldots m_n$ are given by,

$$(K.E)_3 = \frac{1}{2}\ m_3r_3^2\,\omega^2,$$

$$(K.E)_4 = \frac{1}{2}\ m_4r_4^2\,\omega^2,$$

$$\vdots \qquad \vdots$$

$$(K.E)_n = \frac{1}{2}\ m_nr_n^2\,\omega^2$$ [1]

vi. Total K.E of the rotating body is given by,

$$K.E = (K.E)_1 + (K.E)_2 + (K.E)_3 + \ldots + (K.E)_n$$

$$= \frac{1}{2}m_1r_1^2\omega^2 + \frac{1}{2}m_2r_2^2\omega^2 + \frac{1}{2}m_3r_3^2\omega^2 + \ldots + \frac{1}{2}m_nr_n^2\omega^2$$

$\therefore$ $$K.E = \frac{1}{2}\left[m_1r_1^2 + m_2r_2^2 + m_3r_3^2 + \ldots + m_nr_n^2\right]\omega^2$$ [1]

$\therefore$ $$K.E = \frac{1}{2}\left[\sum_{i=1}^{n} m_ir_i^2\right]\omega^2$$

$\because$ $$\sum_{i=1}^{n} m_ir_i^2 = I$$

$\therefore$ $$K.E = \frac{1}{2}I\omega^2$$ [1]

Solution:

Given: $2A = 0.16$ m $\therefore$ $A = 0.08$ m,

$v_{max} = 0.12$ m/s, $x = 1.7 \times 10^{-2}$m

To find: Period (T), magnitude of velocity (v)

Formulae: i. $v_{max} = A\omega$ ii. $v = \omega\sqrt{A^2 - x^2}$ [1]

Calculation: From formula (i),

$$\omega = \frac{v_{max}}{A} = \frac{0.12}{0.08} = 1.5 \text{ rad/s}$$

$$\text{But } \omega = \frac{2\pi}{T} \therefore T = \frac{2 \times 3.14}{1.5} = 4.1865 \text{ s.}$$

The period of body is 4.1865 s. [½]

From formula (ii),

$$v = 1.5 \times \sqrt{(0.08)^2 - (1.7 \times 10^{-2})^2}$$

$$= 1.5 \times \sqrt{[(8)^2 - (1.7)^2] \times 10^{-4}}$$ [½]

$$\therefore \quad v = \{\text{antilog}[\log(1.5) + \frac{1}{2}\log(61.11)]\} \times 10^{-2}$$

$$= \{\text{antilog}[0.1761 + \frac{1}{2} \times 1.7861]\} \times 10^{-2}$$

$$= \{\text{antilog}[1.0692]\} \times 10^{-2}$$

$$\therefore \quad v = 11.73 \times 10^{-2} \text{ m/s} = 0.1173 \text{ m/s}$$

The magnitude of velocity is 0.1173 m/s. [1]

SECTION – II

Q.5. Select and write the most appropriate answer from the given alternatives for each sub-question:

i. (B)

$${}_{air}\mu_{med} = \frac{v_{air}}{v_{med}} = \frac{c}{v_{med}} = 1.5$$

$$\therefore \quad v_{med} = \frac{c}{1.5}$$ [1]

ii. (D) [1]

iii. (D)

Specific resistance is the same for two wires as the material is the same. [1]

iv. (A)

$$\frac{L}{R} = \frac{(Vs/A)}{(V/A)} = \frac{Vs}{A} \times \frac{A}{V} = s\text{. Hence option (B) is wrong.}$$

$$\frac{R}{L} = \frac{(V/A)}{(Vs/A)} = \frac{V}{A} \times \frac{A}{Vs} = \frac{1}{s} \Rightarrow \text{option (A) is correct.}$$

Options (C) and (D) are incorrect. [1]

v. (B) [1]

vi. (A) [1]

vii. (D) [1]

Q.6. Attempt any SIX:

i. Given: N = 100 turns per unit length, $A = 2 \times 10^{-4}$ m^2, I = 6 A, θ = 30°, B = 0.3 T

To find: Magnetic moment (M), torque (τ)

Formulae: i. M = NIA   ii. τ = MB sin θ [1]

Calculation: From formula (i),

$M = 100 \times 6 \times 2 \times 10^{-4}$

∴ $= 0.12\ Am^2$

Magnetic moment of solenoid d is 0.12 Am². [½]

From formula (ii),

$\tau = 0.12 \times 0.3 \times \sin 30°$

∴ $= 0.018$ N.m

Torque experienced by solenoid is 0.018 N m. [½]

ii. Let $R_1 = 5\ \Omega$, $R_2 = 5\ \Omega$, $R_3 = 5\ \Omega$, $R_4 = 15\ \Omega$.

Let X be resistance connected across R_4.

Equivalent resistance $R'_4 = \frac{R_4 X}{R_4 + X} = \frac{15X}{15 + X}$ [½]

Balancing condition of network,

$$\frac{R_1}{R_2} = \frac{R_3}{R'_4}$$ [½]

$$\frac{5}{5} = \frac{5}{\left(\frac{15X}{15+X}\right)}$$

∴ $15X = 5\,(15 + X)$

$3X = 15 + X$ [½]

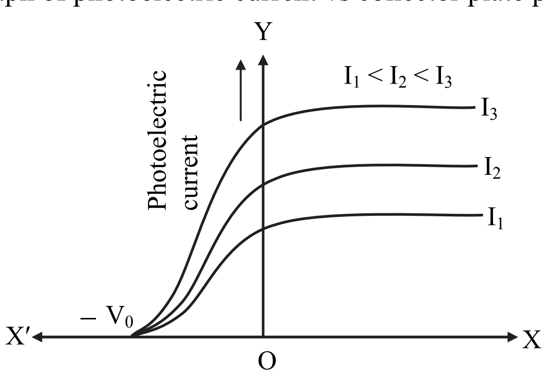
$2X = 15\ \Omega$

∴ $X = 7.5$

The resistance to be connected across R_4 is 7.5 Ω [½]

iii. The minimum negative potential given to collector plate for which photoelectric current stops or becomes zero is called stopping potential or cut off potential. It is denoted by V_0. [1]

The graph of photoelectric current vs collector plate potential:



[1]

iv. a. To avoid obscuration of details of micro-objects by diffraction effects, microscope of high magnifying power must have high resolving power.

b. R.P. of microscope $= \frac{2\mu \sin\alpha}{\lambda}$, where μsinα is termed as numerical aperture.

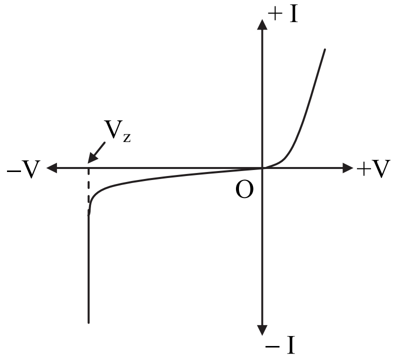
Thus, R.P. ∝ μsinα [½]

c. To increase α, the diameter of objective would have to be increased. This would degrade image by decreasing resolving power. [½]

d. Oil has higher refractive index ($\mu_{oil} > \mu_{air}$) hence to increase resolving power of microscopes of high magnifying power, the object is immersed in oil that is in contact with objective. [½]

e. Usually cedar oil having refractive index 1.5, close to that of the objective glass is used. [½]

v. I-V characteristic of a zener diode is as shown below:



Zener diode characteristics

[1]

a. Zener diode is p–n junction diode manufactured to operate in breakdown region.

b. Its forward bias characteristic is same as that of ordinary junction diode. This means current does not flow until bias is less than barrier potential. Current increases rapidly beyond it with increase in forward voltage. [½]

c. In reverse bias, initially a small reverse saturated current flows and at particular value of reverse voltage, increases suddenly. This voltage is zener breakdown voltage (Vz) [½]

vi. Given: $v = 8 \times 10^6$ m/s, $m_P = 1.67 \times 10^{-27}$ kg,

To find: de Broglie wavelength (λ_P)

Formula: $\lambda_P = \dfrac{h}{p} = \dfrac{h}{m_P v}$ [1]

Calculation: From formula,

$$\lambda_P = \frac{6.63 \times 10^{-34}}{1.67 \times 10^{-27} \times 8 \times 10^6}$$

$$= 4.9626 \times 10^{-14} \text{ m}$$

de Broglie wavelength of given proton is 4.9626 × 10^{-14} m. [1]

vii. Given: $E = 250 \sin \omega t$ v $\therefore$ $E_0 = 250$ V, $R = 1250\ \Omega$

To find: R.M.S. current (I_{rms}), average power (P_{av})

Formulae: i. $I_0 = \dfrac{E_0}{R}$ ii. $I_{rms} = \dfrac{I_0}{\sqrt{2}}$ iii. $E_{rms} = \dfrac{E_0}{\sqrt{2}}$ iv. $P_{av} = I_{rms} \times E_{rms}$ [1]

Calculation: From formula (i),

$$I_0 = \frac{250}{1250}$$

$$= 0.2 \text{ A}$$

From formula (ii),

$$I_{rms} = \frac{0.2}{\sqrt{2}}$$

$\therefore$ $= 0.1414$ A

R.M.S. current through resistor is 0.1414 A [½]

From formula (iii),

$$E_{rms} = \frac{250}{\sqrt{2}} = 176.78 \text{ V}$$

From formula (iv),

$P_{av} = 0.1414 \times 176.78$

$P_{av} \approx 25$ W

Average power dissipated in one cycle is around 25 W. [½]

viii.

No.	Amplitude Modulation	Frequency Modulation
i.	In AM, alternation in amplitude of the desired signal amounts to marked distortion	Noise can be easily minimised in FM system.
ii.	In AM, use of an excessively large modulating signal may result in distortion because of over modulation.	No restriction is placed on the modulation index. The instantaneous frequency deviation is proportional to the instantaneous magnitude of the signal.
iii.	The average power in modulated wave is greater than that contained in unmodulated wave.	The average power in frequency modulated wave is the same as that contained in the unmodulated wave.

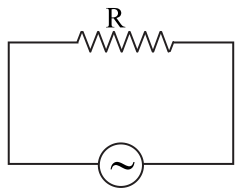
(*Any of the above two points*) (1 × 2) [2]

Q.7. Attempt any THREE

i. A.C circuit with resistance:

a. Suppose an alternating source of e.m.f is applied between the terminals of a resistor of resistance R as shown in figure below.

The instantaneous value of e.m.f is given by, $e = e_0 \sin \omega t$ ….(i)



[1]

b. By Ohm's law, the instantaneous current flowing through the circuit is given by

$$I = \frac{e}{R}$$

But, $e = e_0 \sin \omega t$

$\therefore$ $I = \dfrac{e_0 \sin \omega t}{R}$ ….(ii) [½]

Equation (ii) represents instantaneous current in the circuit.

c. For maximum current through the circuit, $\sin \omega t = 1$. [½]

$I_{max} = \dfrac{e_0}{R} = I_0$ ….(iii)

Equation (iii) represents peak value of current

d. From equation (ii) and (iii),

$I = I_0 \sin \omega t$ ….(iv)

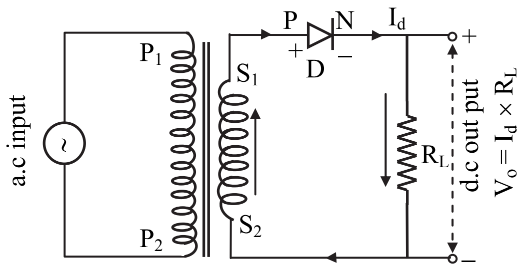
Equation (iv) represents instantaneous current of a.c circuit with resistance only.

e. From equation (iv) it is observed that instantaneous current varies sinusoidally with peak current. [1]

ii. Working of P-N junction diode as half-wave rectifier:

a. A rectifier, which rectifies only one half cycle of each a.c input supply, is called a half wave rectifier.

b. The circuit diagram is as shown,



Half-wave rectifier

P_1P_2	:	Primary coil of step down transformer
S_1S_2	:	Secondary coil of step down transformer
D	:	P-N junction diode
R_L	:	Load resistance

[1]

c. When a.c input is applied to a junction diode, it gets forward biased during one half cycle and reverse biased during the next opposite half cycle.

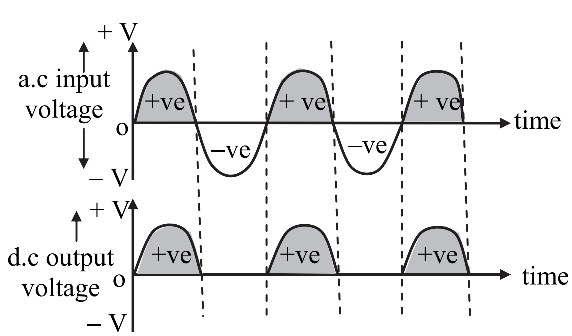
d. The a.c supply is fed across the primary coil P_1P_2 of a step down transformer. The secondary coil S_1S_2 of the transformer is connected to the junction diode D and a load resistance R_L. The output d.c. voltage is obtained across the load resistance R_L. The output d.c. voltage is given by $V_o = I_d \times R_L$.

e. Suppose that during the first half of the input, a.c voltage terminal S_1 becomes positive w.r.t S_2. Then, P region of diode D becomes positive w.r.t N region. This makes the junction diode forward biased, thus the conventional current flows in the direction of the arrow-heads through R_L.

f. During the negative half cycle, the terminal S_2 is at positive potential w.r.t S_1. Thus, P region of diode D is negative w.r.t N region. This makes the diode reverse biased. Thus diode does not allow current through it and no current will flow through R_L.

g. During the next half cycle, output is again obtained as the junction diode gets forward biased. Thus, a half wave rectifier gives pulsating unidirectional and intermittent d.c output voltage V across the load resistance R_L. [1]

h. Graph of a.c input and d.c output voltage with respect to time is as shown,



[1]

iii. Given: S = 5 Ω, G = 495 Ω,
For parallel combination
$V_g = V_S$ [½]
$I_g G = (I - I_g)S$ [½]
$I_g G = IS - I_gS$
$I_g(G + S) = IS$ [½]
$\frac{I_g}{I} = \frac{S}{G+S}$ [½]
$= \frac{5}{495+5} = \frac{5}{500}$
$\frac{I_g}{I} = \frac{1}{100} = 1\%$
The fraction of the total current passing through galvanometer is 1%. [1]

iv. Given: $A_1 = 100\ cm^2 = 100 \times 10^{-4}\ m^2$, $A_2 = 400\ cm^2 = 400 \times 10^{-4}\ m^2$
$Q_1 = Q_2$, $V_1 = V_2$, $d_1 = 0.4$ mm = 4×10^{-4} m
To find: Distance between plates (d_2)
Formulae: i. $C = \frac{\varepsilon_0 A}{d}$ ii. $C = \frac{Q}{V}$ [1]
Calculation: From formula (i),
∴ $C_1 = \frac{\varepsilon_0 A_1}{d_1}$ ….(1)
$C_2 = \frac{\varepsilon_0 A_2}{d_2}$ ….(2)
Since, $Q_1 = Q_2$, $V_1 = V_2$
From formula (ii),
∴ $C_1 = C_2$ [½]
From equation (1) and (2),
$\frac{\varepsilon_0 A_1}{d_1} = \frac{\varepsilon_0 A_2}{d_2}$
∴ $d_2 = \frac{A_2}{A_1} d_1$ [½]
$= \frac{400 \times 10^{-4}}{100 \times 10^{-4}} \times 4 \times 10^{-4}$
$= 16 \times 10^{-4}$ m = 0.16 cm
Distance between plates of the second capacitor is 0.16 cm. [1]

Q.8. Origin of spectral line:

i. According to Bohr's third postulate, when an electron in a hydrogen atom jumps from higher energy level to the lower energy level, the difference of energies of the two energy levels is emitted as a radiation of particular wavelength called spectral line.
ii. The wavelength of the spectral line depends upon the energy associated with the two energy levels, between which the transition of the electron takes place.
iii. If the energy absorbed is equal to difference between the energies of the two levels then it jumps to a higher permitted orbit and revolves in it. In this case, electron is said to be in the excited state.
iv. In the excited state, the electron is not stable and tries to attain stability by going back to the ground state by emitting the extra amount of energy it had gained in one or more jumps.
v. The energy is emitted as electromagnetic waves and produces a spectral line of the corresponding frequency or wavelength. [1]

Bohr's formula for spectral lines in hydrogen spectrum:

i. Let, E_n = Energy of electron in n^{th} higher orbit
E_p = Energy of electron in p^{th} lower orbit

ii. According to Bohr's third postulate,
$E_n - E_p = h\nu$

$\therefore \quad \nu = \dfrac{E_n - E_p}{h}$ ….(1) [½]

iii. But $E_n = -\dfrac{me^4}{8\varepsilon_0^2 h^2 n^2}$ ….(2)

$E_p = -\dfrac{me^4}{8\varepsilon_0^2 h^2 p^2}$ ….(3) [½]

iv. From equations (1), (2) and (3),

$$\nu = \frac{\dfrac{-me^4}{8\varepsilon_0^2 h^2 n^2} - \left(-\dfrac{me^4}{8\varepsilon_0^2 h^2 p^2}\right)}{h}$$

$$\therefore \quad \nu = \frac{me^4}{8\varepsilon_0^2 h^3}\left[-\frac{1}{n^2} + \frac{1}{p^2}\right]$$

$$\therefore \quad \frac{c}{\lambda} = \frac{me^4}{8\varepsilon_0^2 h^3}\left[\frac{1}{p^2} - \frac{1}{n^2}\right] \qquad [\because \ \nu = \frac{c}{\lambda}]$$ [1]

where, c = speed of electromagnetic radiation

$$\therefore \quad \frac{1}{\lambda} = \frac{me^4}{8\varepsilon_0^2 h^3 c}\left[\frac{1}{p^2} - \frac{1}{n^2}\right]$$

v. But, $\dfrac{me^4}{8\varepsilon_0^2 h^3 c}$ = R = Rydberg's constant

$\therefore \quad \dfrac{1}{\lambda} = R\left[\dfrac{1}{p^2} - \dfrac{1}{n^2}\right]$ ….(4)

Equation (4) represents Bohr's formula for hydrogen spectrum. [1]

Solution:

Given: $\mu_g = \dfrac{3}{2}$, $\mu_w = \dfrac{4}{3}$, $v_w - v_g = 0.24 \times 10^8$ m/s

To find: Velocity of light (c)

Formula: $\mu = \dfrac{c}{v}$ [½]

Calculation: From formula,

$\therefore \quad \mu_g = \dfrac{c}{v_g}$ and $\mu_w = \dfrac{c}{v_w}$ [½]

$\therefore \quad v_g = \dfrac{c}{\mu_g}$ and $v_w = \dfrac{c}{\mu_w}$

$\therefore \quad v_w - v_g = \dfrac{c}{\mu_w} - \dfrac{c}{\mu_g} = c\left[\dfrac{1}{\mu_w} - \dfrac{1}{\mu_g}\right]$ [½]

$\therefore \quad 0.24 \times 10^8 = c\left[\dfrac{1}{4/3} - \dfrac{1}{3/2}\right]$ [½]

$\therefore \quad 0.24 \times 10^8 = c\left[\frac{3}{4} - \frac{2}{3}\right]$

$= c\left[\frac{9-8}{12}\right]$

$\therefore \quad = c\left[\frac{1}{12}\right]$

$\therefore \quad c = 0.24 \times 10^8 \times 12 = 2.88 \times 10^8 \approx 3 \times 10^8$ m/s

Velocity of light in air is 3×10^8 m/s. [1]

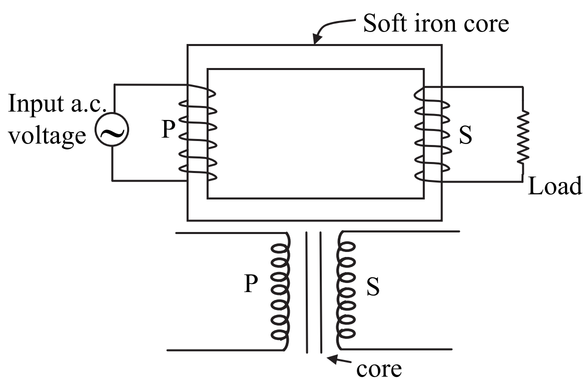
OR

Q.8. Principle of transformer:

It is based on the principle of mutual induction i.e. whenever the magnetic flux linked with a coil changes, an e.m.f is induced in the neighbouring coil. [1]

Construction:

i. A transformer consists of two sets of coils P and S insulated from each other. The coil P is called the primary coil and coil S is called the secondary coil.
ii. The two coils are wound separately on a laminated soft iron core.
iii. The a.c input voltage is applied across the primary and the induced output a.c voltage is obtained across the secondary, which is used to drive current in the desired circuit.
iv. The two coils are electrically insulated from each other but they are magnetically linked.
v. To minimise eddy currents, the soft iron core is laminated.



[1]

Working:

i. When an alternating voltage is applied to the primary coil the current through the coil goes on changing. Hence, the magnetic flux through the core also changes.
ii. As this changing magnetic flux is linked with both the coils, an e.m.f is induced in each coil.
iii. The amount of the magnetic flux linked with the coil depends upon the number of turns of the coil. [1]

Equation of transformation:

i. Let, 'ϕ' be the magnetic flux linked per turn with both the coils at certain instant 't'.
ii. Let 'N_P and 'N_S' be the number of turns of primary and secondary coil,
   $N_P\phi$ = magnetic flux linked with the primary coil at certain instant 't'
   $N_S\phi$ = magnetic flux linked with the secondary coil at certain instant 't'
iii. Induced e.m.f produced in the primary and secondary coil is given by,

$$e_P = -\frac{d\phi_P}{dt} = -N_P\frac{d\phi}{dt} \quad \text{....(1)}$$

$$e_S = -\frac{d\phi_S}{dt} = -N_S\frac{d\phi}{dt} \quad \text{....(2)}$$

iv. Dividing equation (2) by (1),

$\therefore \quad \frac{e_S}{e_P} = \frac{N_S}{N_P}$ ….(3)

Equation (3) represents equation of transformer. [1]

Solution:

Given: $\lambda_1 = 4950$ Å $= 4.95 \times 10^{-7}$m, $e = 1.6 \times 10^{-19}$ C, $V_{0_1} = 0.6$ V,

$h = 6.63 \times 10^{-34}$ J.s, $V_{0_2} = 1.1$ V.

To find: Work function (W_0), wavelength of second source (λ_2)

Formulae: i. $c = \nu\lambda$ ii. $h\nu - W_0 = eV_0$ iii. $\frac{hc}{\lambda} - W_0 = eV_0$ [1]

Calculation: From formula (i),

$$\therefore \quad \nu_1 = \frac{3\times10^8}{4.95\times10^{-7}} = 6.06 \times 10^{14} \text{ Hz}$$

From formula (ii),

$$\begin{aligned} W_0 &= 6.63 \times 10^{-34} \times 6.06 \times 10^{14} - (1.6 \times 10^{-19} \times 0.6) \\ &= 4.018 \times 10^{-19} - 0.96 \times 10^{-19} \\ &= 3.058 \times 10^{-19} \text{ J} \end{aligned}$$

$$\therefore \quad W_0 = \frac{3.058\times10^{-19}}{1.6\times10^{-19}} \text{ eV}$$

$$\therefore \quad W_0 = 1.911 \text{ eV}$$

The work function of surface is 1.911 eV. [1]

From formula (iii),

$$\begin{aligned} \lambda_2 &= \frac{hc}{eV_{0_2} + W_0} \\ &= \frac{6.63\times10^{-34}\times3\times10^8}{(1.6\times10^{-19}\times1.1)+(1.6\times10^{-19}\times1.911)} \\ &= \frac{3\times6.63\times10^{-26}}{(1.1+1.911)\times1.6\times10^{-19}} = \frac{19.89}{3.011\times1.6}\times 10^{-7} \\ &= 4.129 \times 10^{-7} \text{ m} \end{aligned}$$

$$\therefore \quad \lambda_2 = 4129 \text{ Å}$$

The Wavelength of second source is 4129 Å. [1]