

FINAL JEE(Advanced) EXAMINATION – 2023**(Held On Sunday 04th June, 2023)****PAPER-1****TEST PAPER****PHYSICS****SECTION-1 : (Maximum Marks : 12)**

- This section contains **THREE (03)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MORE THAN ONE** of these four option(s) is(are) correct answer(s).
- For each question, choose the option(s) corresponding to (all) the correct answer(s).
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : +4 **ONLY** if (all) the correct option(s) is(are) chosen;

Partial Marks : +3 If all the four options are correct but **ONLY** three options are chosen;

Partial Marks : +2 If three or more options are correct but **ONLY** two options are chosen, both of which are correct;

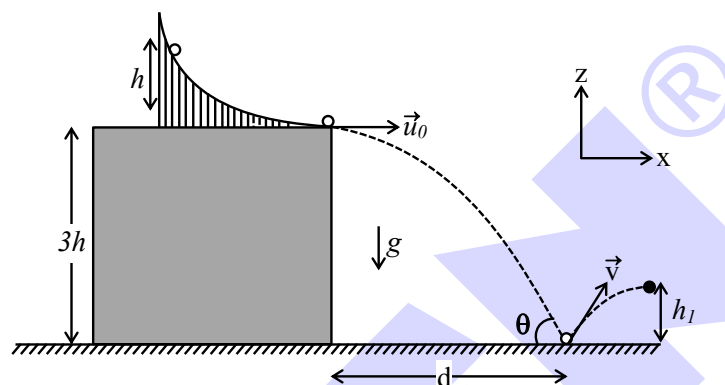
Partial Marks : +1 If two or more options are correct but **ONLY** one option is chosen and it is a correct option;

Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);

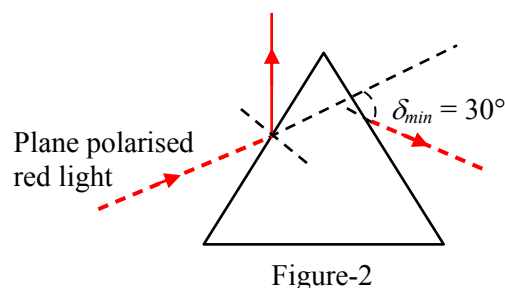
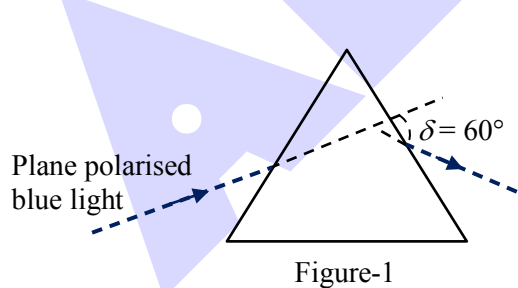
Negative Marks : -2 In all other cases.

- For example, in a question, if (A), (B) and (D) are the **ONLY** three options corresponding to correct answers, then
choosing **ONLY** (A), (B) and (D) will get +4 marks;
choosing **ONLY** (A) and (B) will get +2 marks;
choosing **ONLY** (A) and (D) will get +2 marks;
choosing **ONLY** (B) and (D) will get +2 marks;
choosing **ONLY** (A) will get +1 marks;
choosing **ONLY** (B) will get +1 marks;
choosing **ONLY** (D) will get +1 marks;
choosing no option (i.e. the question is unanswered) will get 0 marks; and
choosing any other combination of options will get -2 marks.

1. A slide with a frictionless curved surface, which becomes horizontal at its lower end, is fixed on the terrace of a building of height $3h$ from the ground, as shown in the figure. A spherical ball of mass m is released on the slide from rest at a height h from the top of the terrace. The ball leaves the slide with a velocity $\vec{u}_0 = u_0 \hat{x}$ and falls on the ground at a distance d from the building making an angle θ with the horizontal. It bounces off with a velocity \vec{v} and reaches a maximum height h_1 . The acceleration due to gravity is g and the coefficient of restitution of the ground is $1/\sqrt{3}$. Which of the following statement(s) is(are) correct?



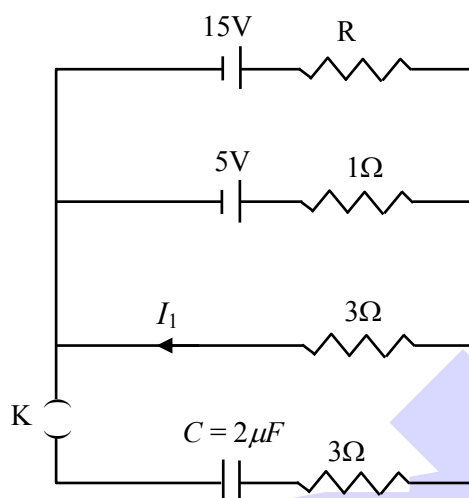
- (A) $\vec{u}_0 = \sqrt{2gh} \hat{x}$ (B) $\vec{v} = \sqrt{2gh} (\hat{x} - \hat{z})$ (C) $\theta = 60^\circ$ (D) $d/h_1 = 2\sqrt{3}$
2. A plane polarized blue light ray is incident on a prism such that there is no reflection from the surface of the prism. The angle of deviation of the emergent ray is $\delta = 60^\circ$ (see Figure-1). The angle of minimum deviation for red light from the same prism is $\delta_{min} = 30^\circ$ (see Figure-2). The refractive index of the prism material for blue light is $\sqrt{3}$. Which of the following statement(s) is(are) correct?



- (A) The blue light is polarized in the plane of incidence.
 (B) The angle of the prism is 45° .
 (C) The refractive index of the material of the prism for red light is $\sqrt{2}$.
 (D) The angle of refraction for blue light in air at the exit plane of the prism is 60° .

3. In a circuit shown in the figure, the capacitor C is initially uncharged and the key K is open. In this condition, a current of 1 A flows through the $1\ \Omega$ resistor. The key is closed at time $t = t_0$. Which of the following statement(s) is(are) correct?

[Given: $e^{-1} = 0.36$]



- (A) The value of the resistance R is $3\ \Omega$.
 (B) For $t < t_0$, the value of current I_1 is 2 A .
 (C) At $t = t_0 + 7.2\ \mu\text{s}$, the current in the capacitor is 0.6 A .
 (D) For $t \rightarrow \infty$, the charge on the capacitor is $12\ \mu\text{C}$.

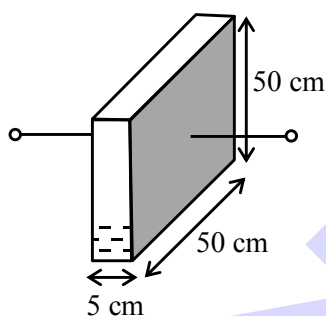
SECTION-2 : (Maximum Marks : 12)

- This section contains **FOUR (04)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, choose the option corresponding to the correct answer.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks	: +3	If ONLY the correct option is chosen;
Zero Marks	: 0	If none of the options is chosen (i.e. the question is unanswered);
Negative Marks	: -1	In all other cases.

4. A bar of mass $M = 1.00\text{ kg}$ and length $L = 0.20\text{ m}$ is lying on a horizontal frictionless surface. One end of the bar is pivoted at a point about which it is free to rotate. A small mass $m = 0.10\text{ kg}$ is moving on the same horizontal surface with 5.00 m s^{-1} speed on a path perpendicular to the bar. It hits the bar at a distance $L/2$ from the pivoted end and returns back on the same path with speed v . After this elastic collision, the bar rotates with an angular velocity ω . Which of the following statement is correct?
- (A) $\omega = 6.98\text{ rad s}^{-1}$ and $v = 4.30\text{ m s}^{-1}$
 (B) $\omega = 3.75\text{ rad s}^{-1}$ and $v = 4.30\text{ m s}^{-1}$
 (C) $\omega = 3.75\text{ rad s}^{-1}$ and $v = 10.0\text{ m s}^{-1}$
 (D) $\omega = 6.80\text{ rad s}^{-1}$ and $v = 4.10\text{ m s}^{-1}$

5. A container has a base of $50 \text{ cm} \times 5 \text{ cm}$ and height 50 cm , as shown in the figure. It has two parallel electrically conducting walls each of area $50 \text{ cm} \times 50 \text{ cm}$. The remaining walls of the container are thin and non-conducting. The container is being filled with a liquid of dielectric constant 3 at a uniform rate of $250 \text{ cm}^3 \text{ s}^{-1}$. What is the value of the capacitance of the container after 10 seconds? [Given: Permittivity of free space $\epsilon_0 = 9 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$, the effects of the non-conducting walls on the capacitance are negligible]



- (A) 27 pF (B) 63 pF (C) 81 pF (D) 135 pF
6. One mole of an ideal gas expands adiabatically from an initial state (T_A, V_0) to final state $(T_f, 5V_0)$. Another mole of the same gas expands isothermally from a different initial state (T_B, V_0) to the same final state $(T_f, 5V_0)$. The ratio of the specific heats at constant pressure and constant volume of this ideal gas is γ . What is the ratio T_A/T_B ?
- (A) $5^{\gamma-1}$ (B) $5^{1-\gamma}$ (C) 5^γ (D) $5^{1+\gamma}$
7. Two satellites P and Q are moving in different circular orbits around the Earth (radius R). The heights of P and Q from the Earth surface are h_P and h_Q , respectively, where $h_P = R/3$. The accelerations of P and Q due to Earth's gravity are g_P and g_Q , respectively. If $g_P/g_Q = 36/25$, what is the value of h_Q ?
- (A) $3R/5$ (B) $R/6$ (C) $6R/5$ (D) $5R/6$

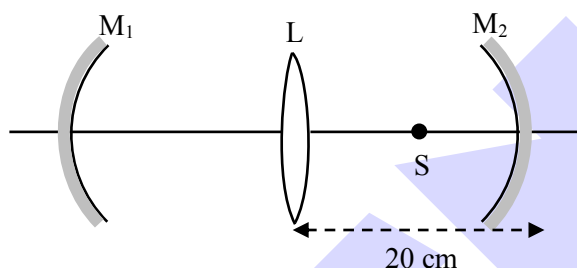
SECTION-3 : (Maximum Marks : 24)

- This section contains **SIX (06)** questions.
- The answer to each question is a **NON-NEGATIVE INTEGER**.
- For each question, enter the correct integer corresponding to the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.
- Answer to each question will be evaluated according to the following marking scheme:

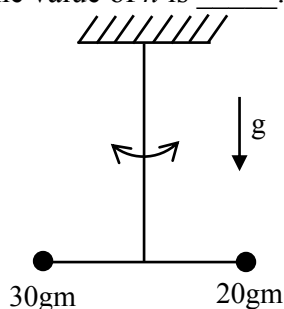
Full Marks	: +4	If ONLY the correct integer is entered;
Zero Marks	: 0	In all other cases.

8. A Hydrogen-like atom has atomic number Z . Photons emitted in the electronic transitions from level $n = 4$ to level $n = 3$ in these atoms are used to perform photoelectric effect experiment on a target metal. The maximum kinetic energy of the photoelectrons generated is 1.95 eV. If the photoelectric threshold wavelength for the target metal is 310 nm, the value of Z is _____.
[Given: $hc = 1240$ eV-nm and $Rhc = 13.6$ eV, where R is the Rydberg constant, h is the Planck's constant and c is the speed of light in vacuum]

9. An optical arrangement consists of two concave mirrors M_1 and M_2 , and a convex lens L with a common principal axis, as shown in the figure. The focal length of L is 10 cm. The radii of curvature of M_1 and M_2 are 20 cm and 24 cm, respectively. The distance between L and M_2 is 20 cm. A point object S is placed at the mid-point between L and M_2 on the axis. When the distance between L and M_1 is $n/7$ cm, one of the images coincides with S . The value of n is _____.



10. In an experiment for determination of the focal length of a thin convex lens, the distance of the object from the lens is 10 ± 0.1 cm and the distance of its real image from the lens is 20 ± 0.2 cm. The error in the determination of focal length of the lens is $n\%$. The value of n is _____.
11. A closed container contains a homogeneous mixture of two moles of an ideal monatomic gas ($\gamma = 5/3$) and one mole of an ideal diatomic gas ($\gamma = 7/5$). Here, γ is the ratio of the specific heats at constant pressure and constant volume of an ideal gas. The gas mixture does a work of 66 Joule when heated at constant pressure. The change in its internal energy is _____ Joule.
12. A person of height 1.6 m is walking away from a lamp post of height 4 m along a straight path on the flat ground. The lamp post and the person are always perpendicular to the ground. If the speed of the person is 60 cm s^{-1} , the speed of the tip of the person's shadow on the ground with respect to the person is _____ cm s^{-1} .
13. Two point-like objects of masses 20 gm and 30 gm are fixed at the two ends of a rigid massless rod of length 10 cm. This system is suspended vertically from a rigid ceiling using a thin wire attached to its center of mass, as shown in the figure. The resulting torsional pendulum undergoes small oscillations. The torsional constant of the wire is $1.2 \times 10^{-8} \text{ N m rad}^{-1}$. The angular frequency of the oscillations is $n \times 10^{-3} \text{ rad s}^{-1}$. The value of n is _____.



SECTION-4 : (Maximum Marks : 12)

- This section contains **FOUR (04)** Matching List Sets.
- Each set has **ONE** Multiple Choice Question.
- Each set has **TWO** lists : **List-I** and **List-II**.
- **List-I** has **Four** entries (P), (Q), (R) and (S) and **List-II** has **Five** entries (1), (2), (3), (4) and (5).
- **FOUR** options are given in each Multiple Choice Question based on **List-I** and **List-II** and **ONLY ONE** of these four options satisfies the condition asked in the Multiple Choice Question.
- Answer to each question will be evaluated according to the following marking scheme:
Full Marks : +3 **ONLY** if the option corresponding to the correct combination is chosen;
Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);
Negative Marks : -1 In all other cases.

14. List-I shows different radioactive decay processes and List-II provides possible emitted particles. Match each entry in List-I with an appropriate entry from List-II, and choose the correct option.

List-I

- (P) ${}_{92}^{238}\text{U} \rightarrow {}_{91}^{234}\text{Pa}$
 (Q) ${}_{82}^{214}\text{Pb} \rightarrow {}_{82}^{210}\text{Pb}$
 (R) ${}_{81}^{210}\text{Tl} \rightarrow {}_{82}^{206}\text{Pb}$
 (S) ${}_{91}^{228}\text{Pa} \rightarrow {}_{88}^{224}\text{Ra}$

List-II

- (1) one α particle and one β^+ particle
 (2) three β^- particles and one α particle
 (3) two β^- particles and one α particle
 (4) one α particle and one β^- particle
 (5) one α particle and two β^+ particles

- (A) $P \rightarrow 4, Q \rightarrow 3, R \rightarrow 2, S \rightarrow 1$
 (B) $P \rightarrow 4, Q \rightarrow 1, R \rightarrow 2, S \rightarrow 5$
 (C) $P \rightarrow 5, Q \rightarrow 3, R \rightarrow 1, S \rightarrow 4$
 (D) $P \rightarrow 5, Q \rightarrow 1, R \rightarrow 3, S \rightarrow 2$

15. Match the temperature of a black body given in List-I with an appropriate statement in List-II, and choose the correct option.

[Given: Wien's constant as 2.9×10^{-3} m-K and $\frac{hc}{e} = 1.24 \times 10^{-6}$ V-m]

List-I

- (P) 2000 K
 (Q) 3000 K
 (R) 5000 K
 (S) 10000 K

List-II

- (1) The radiation at peak wavelength can lead to emission of photoelectrons from a metal of work function 4 eV
 (2) The radiation at peak wavelength is visible to human eye.
 (3) The radiation at peak emission wavelength will result in the widest central maximum of a single slit diffraction.
 (4) The power emitted per unit area is 1/16 of that emitted by a blackbody at temperature 6000 K.
 (5) The radiation at peak emission wavelength can be used to image human bones.

- (A) $P \rightarrow 3, Q \rightarrow 5, R \rightarrow 2, S \rightarrow 3$
 (B) $P \rightarrow 3, Q \rightarrow 2, R \rightarrow 4, S \rightarrow 1$
 (C) $P \rightarrow 3, Q \rightarrow 4, R \rightarrow 2, S \rightarrow 1$
 (D) $P \rightarrow 1, Q \rightarrow 2, R \rightarrow 5, S \rightarrow 3$

16. A series LCR circuit is connected to a $45 \sin(\omega t)$ Volt source. The resonant angular frequency of the circuit is 10^5 rad s^{-1} and current amplitude at resonance is I_0 . When the angular frequency of the source is $\omega = 8 \times 10^4 \text{ rad s}^{-1}$, the current amplitude in the circuit is $0.05 I_0$. If $L = 50 \text{ mH}$, match each entry in List-I with an appropriate value from List-II and choose the correct option.

List-I

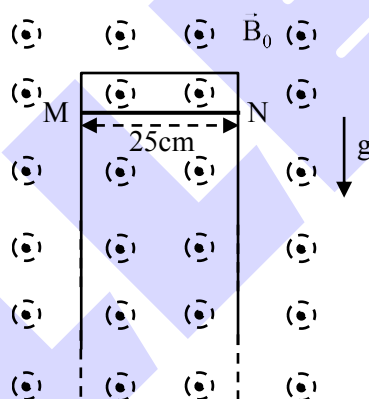
- (P) I_0 in mA
(Q) The quality factor of the circuit
(R) The bandwidth of the circuit in rad s^{-1}
(S) The peak power dissipated at resonance in Watt

List-II

- (1) 44.4
(2) 18
(3) 400
(4) 2250
(5) 500

- (A) $P \rightarrow 2, Q \rightarrow 3, R \rightarrow 5, S \rightarrow 1$ (B) $P \rightarrow 3, Q \rightarrow 1, R \rightarrow 4, S \rightarrow 2$
(C) $P \rightarrow 4, Q \rightarrow 5, R \rightarrow 3, S \rightarrow 1$ (D) $P \rightarrow 4, Q \rightarrow 2, R \rightarrow 1, S \rightarrow 5$

17. A thin conducting rod MN of mass 20 gm, length 25 cm and resistance 10Ω is held on frictionless, long, perfectly conducting vertical rails as shown in the figure. There is a uniform magnetic field $B_0 = 4 \text{ T}$ directed perpendicular to the plane of the rod-rail arrangement. The rod is released from rest at time $t = 0$ and it moves down along the rails. Assume air drag is negligible. Match each quantity in List-I with an appropriate value from List-II, and choose the correct option.
[Given: The acceleration due to gravity $g = 10 \text{ ms}^{-2}$ and $e^{-1} = 0.4$]



List-I

- (P) At $t = 0.2 \text{ s}$, the magnitude of the induced emf in Volt
(Q) At $t = 0.2 \text{ s}$, the magnitude of the magnetic force in Newton
(R) At $t = 0.2 \text{ s}$, the power dissipated as heat in Watt
(S) The magnitude of terminal velocity of the rod in m s^{-1}

List-II

- (1) 0.07
(2) 0.14
(3) 1.20
(4) 0.12
(5) 2.00

- (A) $P \rightarrow 5, Q \rightarrow 2, R \rightarrow 3, S \rightarrow 1$ (B) $P \rightarrow 3, Q \rightarrow 1, R \rightarrow 4, S \rightarrow 5$
(C) $P \rightarrow 4, Q \rightarrow 3, R \rightarrow 1, S \rightarrow 2$ (D) $P \rightarrow 3, Q \rightarrow 4, R \rightarrow 2, S \rightarrow 5$