

JEE ADVANCED-2015

PHYSICS

Note: Answers have been highlighted in “Yellow” color and Explanations to answers are given at the end

General Instructions:

1. This sealed booklet is your Question Paper. Do not break the seal till you are instructed to do so.
2. The question paper CODE is printed on the left hand top corner of this sheet and the right hand top corner of the back cover of this booklet.
3. Use the Optical Response Sheet (ORS) provided separately for answering the questions.
4. The ORS CODE is printed on its left part as well as the right part. Ensure that both these codes are identical and same as that on the question paper booklet. If not, contact the invigilator.
5. Blank spaces are provided within this booklet for rough work.
6. Write your name and roll number in the space provided on the back cover of this booklet.
7. After breaking the seal of the booklet, Verify that the booklet contains 32 pages and that all the 60 questions along with the options are legible.

Question paper format and marking scheme :

8. The question paper has three parts: Physics. Each part has three sections.
9. Carefully read the instructions given at the beginning of each section.
10. Section 1 contains 8 questions. The answer to each question is a single digit integer ranging from 0 to 9 (both inclusive).

Marking scheme: +4 correct answer and 0 in all other cases.

11. Section 2 contains 10 multiple choice questions with one or more than one correct option.

Marking scheme: +4 for correct answer, 0 if not attempted and -2 in all other cases.

12. Section 3 contains 2 “ match the following” type questions and you will have to match entries in Column I with the entries in Column II.

Marking scheme: for each entry in Column I, +2 for correct answer, 0 if not attempted and - 1 in all other cases.

OPTICAL RESPONSE SHEET :

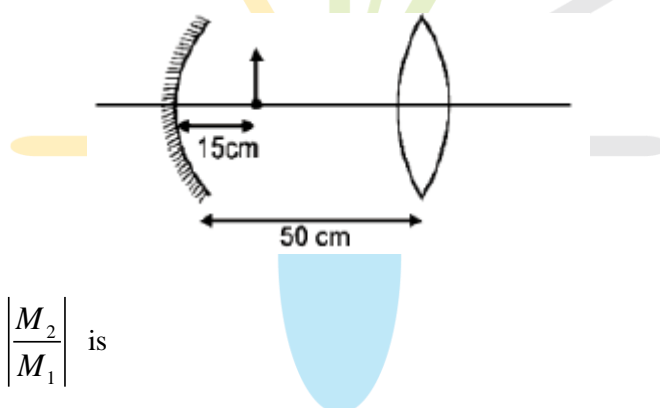
13. The ORS consists of an original (top sheet) and its carbon-less copy. (bottom sheet).
14. Darken the appropriate bubbles on the original by applying sufficient pressure. This will leave an impression at the corresponding place on the carbon-less copy.
15. The original is machine-gradable and will be collected by the invigilator at the end of the examination.
16. You will be allowed to take away the carbon-less copy at the end of the examination.
17. Do not tamper with or mutilate the ORS.
18. Write your name, roll number and the name of the examination center and sign with pen in the space provided for this purpose on the original. Do not write any of these details anywhere else. Darken the appropriate bubble under each digit of your roll number.

Note: Answers have been highlighted in “Yellow” color and Explanations to answers are given at the end

SECTION-1 (Maximum Mark : 32)

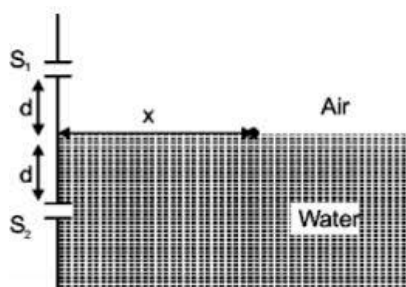
- This section contains **EIGHT** questions.
- The answer to each question is a **SINGLE DIGIT INTEGER** ranging from 0 to 9, both inclusive
- For each question, darken the bubble corresponding to the correct integer in the ORS
- Marking scheme:
 +4 If the bubble corresponding to the answer is darkened
 0 In all other cases

- Q.1** Consider a concave mirror and a convex lens (*refractive index* = 1.5) of focal length 10 cm each, separated by a distance of 50 cm in air (*refractive index* = 1) as shown in the figure. An object is placed at a distance of 15 cm from the mirror. Its erect image formed by this combination has magnification M_1 . When the set-up is kept in a medium of refractive index $7/6$, the magnification becomes M_2 .

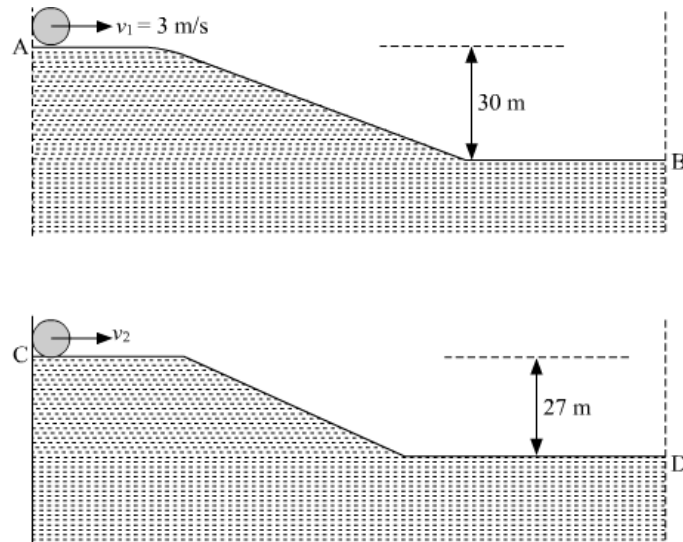


The magnitude $\left| \frac{M_2}{M_1} \right|$ is

- Q.2** A Young's double slit interference arrangement with slits S_1 and S_2 is immersed in water (*refractive index* = $4/3$) as shown in the figure. The positions of maxima on the surface of water are given by $x^2 = p^2 m^2 \lambda^2 - d^2$, where λ is the wavelength of light in air (*refractive index* = 1), $2d$ is the separation between the slits and m is an integer. The value of p is

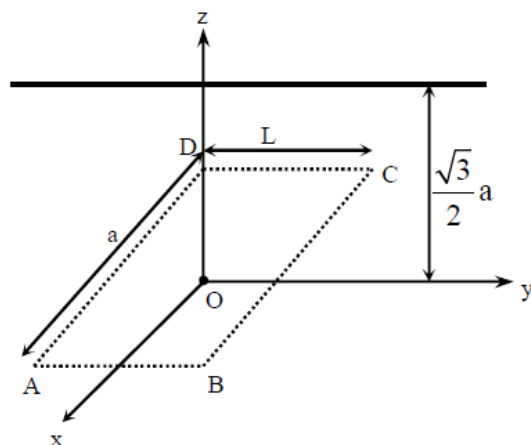


- Q.3** Two identical uniform discs roll without slipping on two different surfaces AB and CD (see figure) starting at A and C with linear speeds v_1 and v_2 respectively, and always remain in contact with the surfaces. If they reach B and D with the same linear speed and $v_1 = 3 \text{ m/s}$, then v_3 in m/s is ($g = 10 \text{ m/s}^2$)



- Q.4** A bullet is fired vertically upwards with velocity v from the surface of a spherical planet. When it reaches its maximum height, its acceleration due to the planet's gravity is $1/4^{\text{th}}$ of its value at the surface of the planet. If the escape velocity from the planet is $v_{\text{esc}} = v\sqrt{N}$, then the value of N is (ignore energy loss due to atmosphere)
- Q.5** Two spherical stars A and B emit blackbody radiation. The radius of A is 400 times that of B and A emits 104 times the power emitted from B . The ratio $\left(\frac{\lambda_A}{\lambda_B}\right)$ of their wavelengths λ_A and λ_B at which the peaks occur in their respective radiation curves is
- Q.6** A nuclear power plant supplying electrical power to a village uses a radioactive material of half-life T years as the fuel. The amount of fuel at the beginning is such that the total power requirement of the village is 12.5% of the electrical power available from the plant at that time. If the plant is able to meet the total power needs of the village for a maximum period of nT years, the value of n is

- Q.7** An infinitely long uniform line charge distribution of charge per unit length λ lies parallel to the y -axis in the $y-z$ plane at $z = \sqrt{\frac{3}{2}}a$ (see figure). If the magnitude of the flux of the electric field through the rectangular surface $ABCD$ lying in the $x-y$ plane with its centre at the origin is $\frac{\lambda L}{n\epsilon_0}$ (ϵ_0 = permittivity of free space), then the value of n is



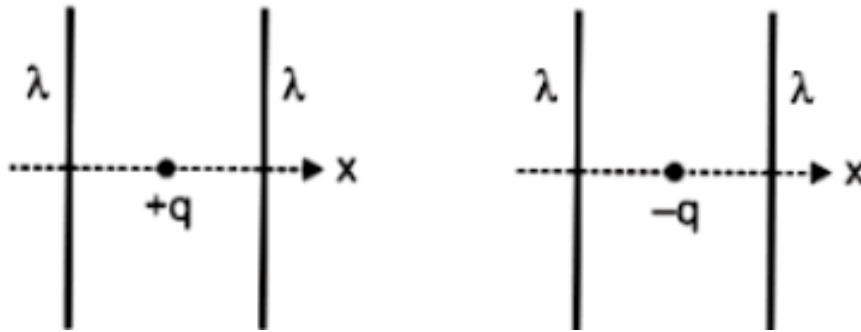
- Q.8** Consider a hydrogen atom with its electron in the n^{th} orbital. An electromagnetic radiation of wavelength 90 nm is used to ionize the atom. If the kinetic energy of the ejected electron is 10.4 eV , then the value of n is ($hc = 1242 \text{ eV nm}$)

SECTION-2 (Maximum Mark : 40)

- This section contains **TEN** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct
- For each question, darken the bubble(s) corresponding to all the correct option(s) in the ORS
- Marking scheme:

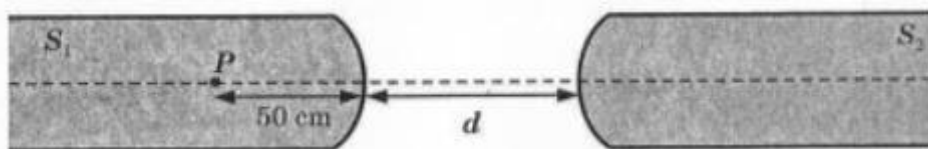
+4	If the bubble corresponding to the answer is darkened
0	In all other cases

- Q.9** The figures below depict two situations in which two infinitely long static line charges of constant positive line charge density λ are kept parallel to each other. In their resulting electric field, Point charges q and $-q$ are kept in equilibrium between them. The point charges are confined to move in the x direction only. If they are given a small displacement about their equilibrium positions, then the correct statement(s) is (are)



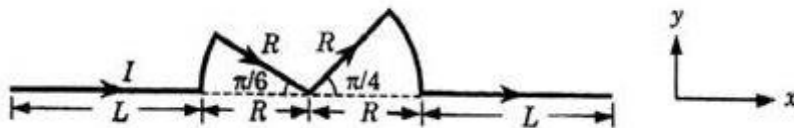
- (A) Both charges execute simple harmonic motion.
- (B) Both charges will continue moving in the direction of their displacement.
- (C) Charge $+q$ executes simple harmonic motion while charge $-q$ continues moving in the direction of its displacement.
- (D) Charge $-q$ executes simple harmonic motion while charge $+q$ continues moving in the direction of its displacement.

- Q.10** Two identical glass rods S_1 and S_2 (refractive index = 1.5) have one convex end of radius of curvature 10 cm. They are placed with the curved surfaces at a distance d as shown in the figure, with their axes (shown by the dashed line) aligned. When a point source of light P is placed inside rod S_1 on its axis at a distance of 50 cm from the curved face, the light rays emanating from it are found to be parallel to the axis inside S_2 . The distance d is



- (A) 60 cm
- (B) 70 cm
- (C) 80 cm
- (D) 90 cm

Q.11 A conductor (shown in the figure) carrying constant current I is kept in the x - y plane in a uniform magnetic field \vec{B} . If F is the magnitude of the total magnetic force acting on the conductor, then correct statement(s) is (are)

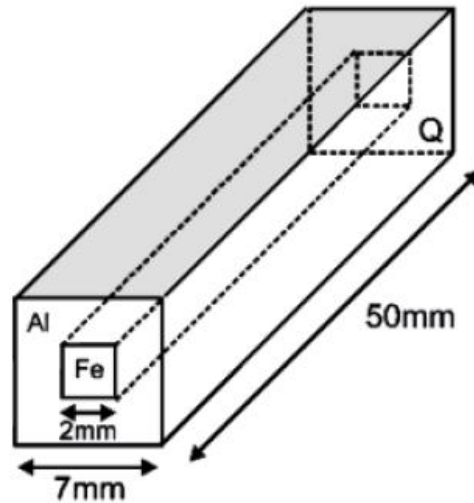


- (A) If \vec{B} is along \hat{z} , $F \propto (L+R)$
- (B) If \vec{B} is along x , $F = 0$
- (C) If \vec{B} is along y , $F \propto (L+R)$
- (D) If \vec{B} is along \hat{z} , $F = 0$

Q.12 A container of fixed volume has a mixture of one mole of hydrogen and one mole of helium in equilibrium at temperature T . Assuming the gasses are ideal, the correct statement(s) is (are)

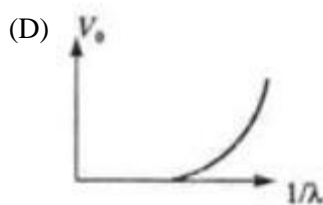
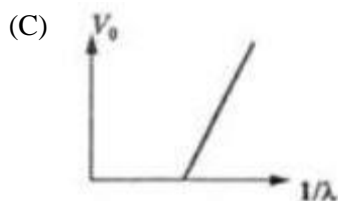
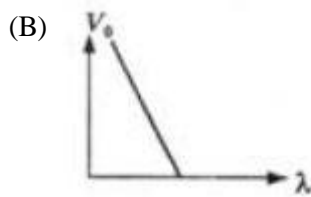
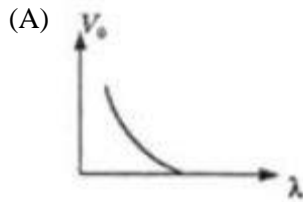
- (A) The average energy per mole of the gas mixture is $2RT$.
- (B) The ratio of speed of sound in the gas mixture to that in helium gas is $\sqrt{6/5}$.
- (C) The ratio of the rms speed of helium atoms to that of hydrogen molecules is $1/2$.
- (D) The ratio of the rms speed of helium atoms to that of hydrogen molecules is $1/\sqrt{2}$.

Q.13 In an aluminum (Al) bar of square cross section, a square hole is drilled and is filled with iron (Fe) as shown in the figure. The electrical resistivities of Al and Fe are $2.7 \times 10^{-8} \Omega \text{ m}$ and $1.0 \times 10^{-7} \Omega \text{ m}$, respectively. The electrical resistance between the two faces P and Q of the composite bar is



- (A) $\frac{2475}{64} \mu\Omega$
- (B) $\frac{1875}{64} \mu\Omega$
- (C) $\frac{1875}{49} \mu\Omega$
- (D) $\frac{2475}{132} \mu\Omega$

Q.14 For photo-electric effect with incident photon wavelength λ , the stopping potential is V_0 . Identify the correct variation(s) of V_0 with λ and $1/\lambda$



Q.15 Consider a Vernier callipers in which each 1 cm on the main scale is divided into 8 equal divisions and a screw gauge with 100 divisions on its circular scale. In the Vernier callipers, 5 divisions of the Vernier scale coincide with 4 divisions on the main scale and in the screw gauge, one complete rotation of the circular scale moves it by two divisions on the linear scale. Then:

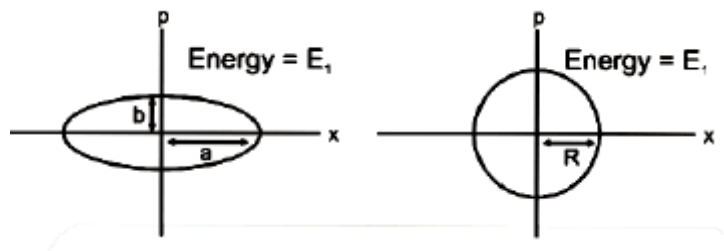
- (A) If the pitch of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is 0.01 mm .
- (B) If the pitch of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is 0.005 mm .

- (C) If the least count of the linear scale of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is 0.01 mm .
- (D) If the least count of the linear scale of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is 0.005 mm .

Q.16 Planck's constant h , speed of light c and gravitational constant G are used to form a unit of length L and a unit of mass M . Then the correct option(s) is (are)

- (A) $M \propto \sqrt{c}$
- (B) $M \propto \sqrt{G}$
- (C) $L \propto \sqrt{h}$
- (D) $L \propto \sqrt{G}$

Q.17 Two independent harmonic oscillators of equal mass are oscillating about the origin with angular frequencies ω_1 and ω_2 and have total energies E_1 and E_2 , respectively. The variations of their momenta p with positions x are shown in the figures. If $\frac{a}{b} = n^2$ and $\frac{a}{R} = n$, then the correct equation(s) is (are)



- (A) $E_1 \omega_1 = E_2 \omega_2$
- (B) $\frac{\omega_2}{\omega_1} = n^2$

(C) $\omega_1 \omega_2 = n^2$

(D) $\frac{E_1}{\omega_1} = \frac{E_2}{\omega_2}$

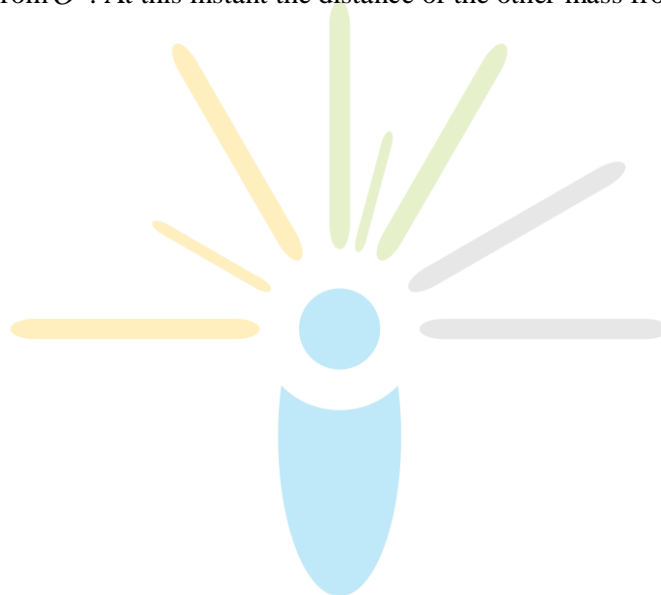
Q.18 A ring of mass M and radius R is rotating with angular speed ω about a fixed vertical axis passing through its centre O with two point masses each of mass $\frac{M}{8}$ at rest at O . These masses can move radially outwards along two massless rods fixed on the ring as shown in the figure. At some instant the angular speed of the system is $\frac{8}{9}\omega$ and one of the masses is at a distance of R from O . At this instant the distance of the other mass from O is

(A) $\frac{2}{3}R$

(B) $\frac{1}{3}R$

(C) $\frac{3}{5}R$

(D) $\frac{4}{5}R$



SECTION-3 (Maximum Mark : 16)

- This section contains **TWO** questions.
- Each question contains two columns, **Column I** and **Column II**
- Column I has four entries (A), (B), (C) and (D)
- Column II has five entries (P), (Q), (R), (S) and (T)
- Match the entries in **Column I** with the entries in **Column II**
- One or more entries in **Column I** may match with one or more entries in **Column II**
- The ORS Contains a 4 x 5 matrix whose layout will be similar to the one shown below:

(A)	<input type="checkbox"/> (P)	<input type="checkbox"/> (Q)	<input type="checkbox"/> (R)	<input type="checkbox"/> (S)	<input type="checkbox"/> (T)
(B)	<input type="checkbox"/> (P)	<input type="checkbox"/> (Q)	<input type="checkbox"/> (R)	<input type="checkbox"/> (S)	<input type="checkbox"/> (T)
(C)	<input type="checkbox"/> (P)	<input type="checkbox"/> (Q)	<input type="checkbox"/> (R)	<input type="checkbox"/> (S)	<input type="checkbox"/> (T)
(D)	<input type="checkbox"/> (P)	<input type="checkbox"/> (Q)	<input type="checkbox"/> (R)	<input type="checkbox"/> (S)	<input type="checkbox"/> (T)

- For each entry in **Column I**, darken the bubbles of all the matching entries. For example, if entry (A) in **Column I** matches with entries (Q), (R) and (T), then darken these three bubbles in the ORS. Similarly, for entries (B), (C) and (D).
- Marking scheme:

For each entry in **Column I**

- +2 If only the bubble(s) corresponding to all the correct match(es) is(are) darkened
- 0 If none of the bubbles is darkened
- 2 In all other cases

Q.19 Match the nuclear processes given in column I with the appropriate option(s) in column II.

Column I

(A) Nuclear fusion

(B) Fission in a nuclear reactor

(C) β – decay

(D) γ – ray

Column II

(P) Absorption of thermal neutrons by ${}_{92}^{235}\text{U}$

(Q) ${}_{27}^{60}\text{Co}$ nucleus

(R) Energy production in stars via hydrogen conversion to helium

(S) Heavy water

(T) Neutrino emission

Q.20 A particle of unit mass is moving along the x -axis under the influence of a force and its total energy is conserved. Four possible forms of the potential energy of the particle are given in column I (a and U_0 are constants). Match the potential energies in column I to the corresponding statement(s) in column II.

Column I

- (A) $U_1(x) = \frac{U_0}{2} \left[1 - \left(\frac{x}{a} \right)^2 \right]$
- (B) $U_2(x) = \frac{U_0}{2} \left(\frac{x}{a} \right)^2$
- (C) $U_2(x) = \frac{U_0}{2} \left(\frac{x}{a} \right)^2 \exp \left[- \left(\frac{x}{a} \right)^2 \right]$
- (D) $U_3(x) = \frac{U_0}{2} \left(\frac{x}{a} \right)^2 \exp \left[- \left(\frac{x}{a} \right)^2 \right]$

Column II

- (P) The force acting on the particle is zero at $x = a$.
- (R) The force acting on the particle is zero at $x = -a$.
- (S) The particle experiences an attractive force towards $x = a$ in the region $|x| < a$.
- (T) The particle with total energy $\frac{U_0}{4}$ can oscillate about the point $x = -a$.

