IIT-JEE-2007

PAPER-I

PHYSICS

[Time allowed: 3 hours] [Maximum Marks: 243]

GENERAL INSTRUCTIONS

1. **Section I** contains 9 multiple choice questions which have only one correct answer. Each question carries +3 marks each for correct answer and **-1 mark** for each wrong answer.

2. **Section II** contains 4 questions. Each question contains STATEMENT-1 (Assertion) and STATEMENT-2 (Reason).

   Bubble (A)   if both the statements are TRUE and STATEMENT-2 is the correct explanation of STATEMENT-1

   Bubble (B)   if both the statements are TRUE but STATEMENT-2 is NOT the correct explanation of STATEMENT-1

   Bubble (C)   if STATEMENT-1 is TRUE and STATEMENT-2 is FALSE.

   Bubble (D)   if STATEMENT-1 is FALSE and STATEMENT-2 is TRUE.

   Carries +3 marks each for correct answer and -1 mark for each wrong answer.

3. **Section III** contains 2 paragraphs. Based upon each paragraph, 3 multiple choice questions have to be answered. Each question has only one correct answer and carries +4 marks for correct answer and **-1 mark** for wrong answer.

4. **Section IV** contains 3 questions. Each question contains statements given in 2 columns. Statements in the first column have to be matched with statements in the second column and each question carries +6 marks and marks will be awarded if all the four parts are correctly matched. No marks will be given for any wrong match in any question. There is **no negative marking.**
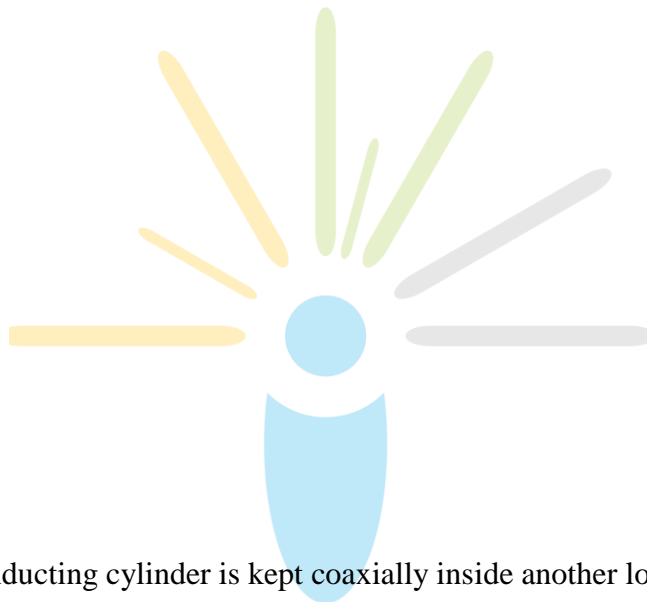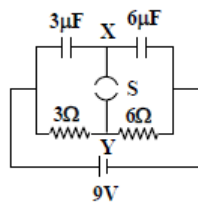
1

SECTION – I

Straight Objective Type

This section contains 9 multiple choice questions numbered 1 to 9. Each question has 4 choices (A), (B), (C) and (D), out of which ONLY ONE is correct.

1. A circuit is connected as shown in the figure with the switch S open. When the switch is closed the total amount of charge that flows from Y to X is

   (A) 0

   (B) $54 \mu C$

   (C) $27 \mu C$

   (D) $81 \mu C$

2. A long, hollow conducting cylinder is kept coaxially inside another long, hollow conducting cylinder of larger radius. Both the cylinders are initially electrically neutral.

   (A) A potential difference appears between the two cylinders when a charge density is given to the inner cylinder.

   (B) A potential difference appears between the two cylinders when a charge density is given to the outer cylinder.

   (C) No potential difference appears between the two cylinders when a uniform line charge is kept along the axis of the cylinders.

   (D) No potential difference appears between the two cylinders when same charge density is given to both the cylinders.

3. In the options given below, let E denote the rest mass energy of a nucleus and n a neutron. The correct option is

(A) $E\left({}^{236}_{92}U \right) > E\left({}^{137}_{53}I \right) + E\left({}^{97}_{39}Y \right) + 2E(n)$

(B) $E\left({}^{236}_{92}U \right) < E\left({}^{137}_{53}I \right) + E\left({}^{97}_{39}Y \right) + 2E(n)$

(C) $E\left({}^{236}_{92}U \right) < E\left({}^{140}_{56}Ba \right) + E\left({}^{94}_{36}Kr \right) + 2E(n)$

(D) $E\left({}^{236}_{92}U \right) = E\left({}^{140}_{56}Ba \right) + E\left({}^{94}_{36}Kr \right) + 2E(n)$

4. In an experiment to determine the focal length (f) of a concave mirror by the $u-v$ method, a student places the object pin A on the principal axis at a distance x from the pole P. The student looks at the pin and its inverted image from a distance keeping his/her eye in line with PA. When the student shifts his/her eye towards left, the image appears to the right of the object pin. Then,

(A) $x < f$

(B) $f < x < 2f$

(C) $x = 2f$

(D) $x > 2f$

5. The largest wavelength in the ultraviolet region of the hydrogen spectrum is $122\,\text{nm}$. The smallest wavelength in the infrared region of the hydrogen spectrum (to the nearest integer) is

(A) $802\,\text{nm}$

(B) $823\,\text{nm}$

(C) $1882\,\text{nm}$

(D) $1648\,\text{nm}$

6. A resistance of 2Ω is connected across one gap of a metre-bridge (the length of the wire is 100 cm) and an unknown resistance, greater than 2Ω, is connected across the other gap. When these resistance are interchanged, the balance point shifts by 20 cm. Neglecting any corrections, the unknown resistance is

(A) 3Ω

(B) 4Ω

(C) 5Ω

(D) 6Ω

7. A ray of light travelling in water is incident on its surface open to air. The angle of incidence is θ, which is critical angle. Then there will be

(A) only a reflected ray and no refracted ray

(B) only a refracted ray and no reflected ray

(C) a reflected ray and a refracted ray and the angle between them would be less than $180° - 2\theta$

(D) a reflected ray and a refracted ray and the angle between them would be greater than $180° - 2\theta$

8. Two particle of mass m each are tied at the ends of a light string of length $2a$. The whole system is kept on a frictionless horizontal surface with the string held tight so that each mass is at a distance 'a' from the center P (as shown in the figure). Now, the mid-point of the string is pulled vertically upwards with a small but constant force F. As a result, the particles move towards each other on the surface. The magnitude of acceleration, when the separation between them becomes $2x$ is
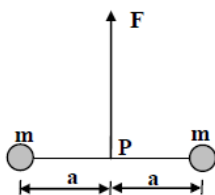
(A) $\dfrac{F}{2m} \dfrac{a}{\sqrt{a^2 - x^2}}$

(B) $\dfrac{F}{2m} \dfrac{x}{\sqrt{a^2 - x^2}}$

(C) $\dfrac{F}{2m} \dfrac{a}{x}$

(D) $\dfrac{F}{2m} \dfrac{\sqrt{a^2 - x^2}}{x}$

9. Consider a neutral conducting sphere. A positive point charge is placed outside the sphere. The net charge on the sphere is then,

   (A) negative and distributed uniformly over the surface of the sphere

   (B) negative and appears only at the point on the sphere closest to the point charge

   (C) negative and distributed non-uniformly over the entire surface of the sphere

   (D) zero
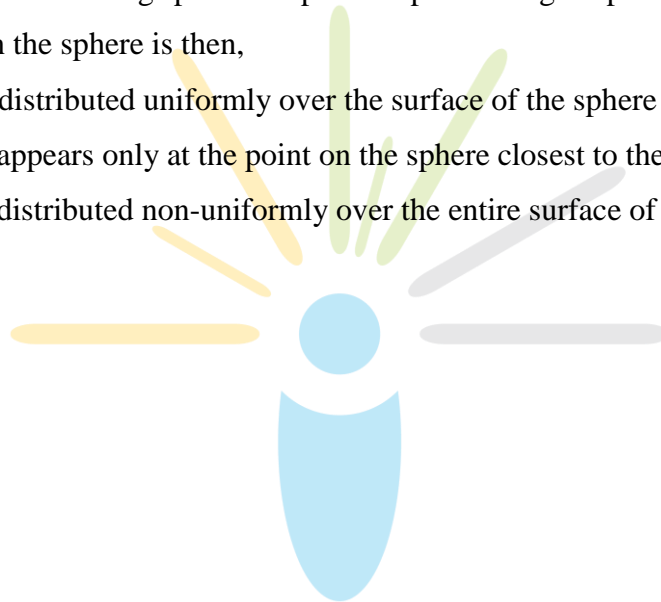
SECTION – II

Assertion - Reason Type

10. STATEMENT-1

The formula connecting u, v and f for a spherical mirror is valid only for mirrors whose sizes are very small compared to their radii of curvature.

because

STATEMENT-2

Laws of reflection are strictly valid for plane surfaces, but not for large spherical surfaces.

(A) Statement-1 is True, Statement-2 is True; Statement -2 **is** a correct explanation for Statement-1.

(B) Statement-1 is True, Statement-2 is True; Statement -2 **is NOT** a correct explanation for Statement-1.

(C) Statement -1 is True, Statement-2 is False.

(D) Statement -1 is False, Statement-2 is True.

11. STATEMENT-1

If the accelerating potential in an X-ray tube is increased, the wavelengths of the characteristic X-rays do not change.

because

STATEMENT -2

When an electron beam strikes the target in an X-ray tube, part of the kinetic energy is converted into X-ray energy.

(A) Statement-1 is True, Statement-2 is True; Statement -2 **is** a correct explanation for Statement-1.

(B) Statement-1 is True, Statement-2 is True; Statement -2 **is NOT** a correct explanation for Statement-1.

(C) Statement -1 is True, Statement-2 is False.

(D) Statement -1 is False, Statement-2 is True.

12. STATEMENT-1

A block of mass m starts moving on a rough horizontal surface with a velocity v. It stops due to friction between the block and the surface after moving through a certain distance. The surface is now tilted to an angle of 30^0 with the horizontal and the same block is made to go up on the surface with the same initial velocity v . The decrease in the mechanical energy in the second situation is smaller than that in the first situation.

because

STATEMENT-2

The coefficient of friction between the block and the surface decreases with the increase in the angle of inclination.

(A) Statement -1 is True, Statement-2 is True; Statement-2 **is** a correct explanation for statement-1.

(B) Statement -1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for statement-1.

(C) Statement -1 is True, Statement-2 is False.

(D) Statement -1 is False, Statement-2 is True.

13. STATEMENT-1

In an elastic collision between two bodies, the relative speed of the bodies after collision is equal to the relative speed before the collision.

because

STATEMENT-2

In an elastic collision, the linear momentum of the system is conserved.

(A) Statement -1 is True, Statement-2 is True; Statement -2 is a correct explanation for Statement-1.

(B) Statement -1 is True, Statement-2 is True; Statement -2 **is NOT** a correct explanation for Statement-1.

(C) Statement -1 is True, Statement-2 is False.

(D) Statement -1 is False, Statement-2 is True.

SECTION – III

Linked Comprehension Type

P14 – 16 : Paragraph for Question Nos. 14 to 16

A fixed thermally conducting cylinder has a radius R and height L_0. The cylinder is open at its bottom and has a small hole at its top. A piston of mass M is held at a distance L from the top surface, as shown in the figure. The atmospheric pressure is P_0.
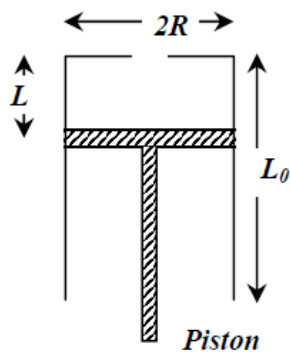
14. The piston is now pulled out slowly and held at a distance $2L$ from the top. The pressure in the cylinder between its top and the piston will then be

    (A) P_0

    (B) $\dfrac{P_0}{2}$

    (C) $\dfrac{P_0}{2} + \dfrac{Mg}{\pi R^2}$

    (D) $\dfrac{P_0}{2} - \dfrac{Mg}{\pi R^2}$

15. While the piston is at a distance $2L$ from the top, the hole at the top is sealed. The piston is then released, to a position where it can stay in equilibrium. In this condition, the distance of the piston from the top is

(A) $\left(\dfrac{2P_0\pi R^2}{\pi R^2 P_0 + Mg} \right)(2L)$

(B) $\left(\dfrac{P_0\pi R^2 - Mg}{\pi R^2 P_0} \right)(2L)$

(C) $\left(\dfrac{\pi R^2 P_0 - Mg}{2P_0\pi R^2} \right)(2L)$

(D) $\left(\dfrac{2P_0\pi R^2}{\pi R^2 P_0 - Mg} \right)(2L)$

16. The piston is taken completely out of the cylinder. The hole at the top is sealed. A water tank is brought below the cylinder and put in a position so that the water surface in the tank is at the same level as the top of the cylinder as shown in the figure. The density of the water is ρ. In equilibrium, the height H of the water column in the cylinder satisfies

(A) $\rho g \left(L_0 - H \right)^2 + P_0 \left(L_0 - H \right)^2 + L_0 P_0 = 0$

(B) $\rho g \left(L_0 - H \right)^2 - P_0 \left(L_0 - H \right)^2 - L_0 P_0 = 0$

(C) $\rho g \left(L_0 - H \right)^2 + P_0 \left(L_0 - H \right)^2 - L_0 P_0 = 0$

(D) $\rho g \left(L_0 - H \right)^2 - P_0 \left(L_0 - H \right)^2 + L_0 P_0 = 0$
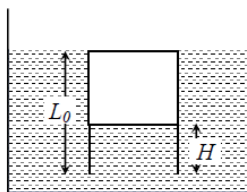
P17 – 19 : Paragraph for Question Nos. 17 to 19

Two discs A and B are mounted coaxially on a vertical axle. The discs have moments of inertia I and $2I$ respectively about the common axis. Disc A is imparted an initial angular velocity 2ω using the entire potential energy of a spring compressed by a distance x_1. Disc B is imparted an angular velocity ω by a spring having the same spring constant and compressed by a distance x_2. Both the discs rotate in the clockwise direction.

17. The ratio of x_1/x_2 x1/x2 is

    (A) 2

    (B) $\dfrac{1}{2}$

    (C) $\sqrt{2}$

    (D) $\dfrac{1}{\sqrt{2}}$
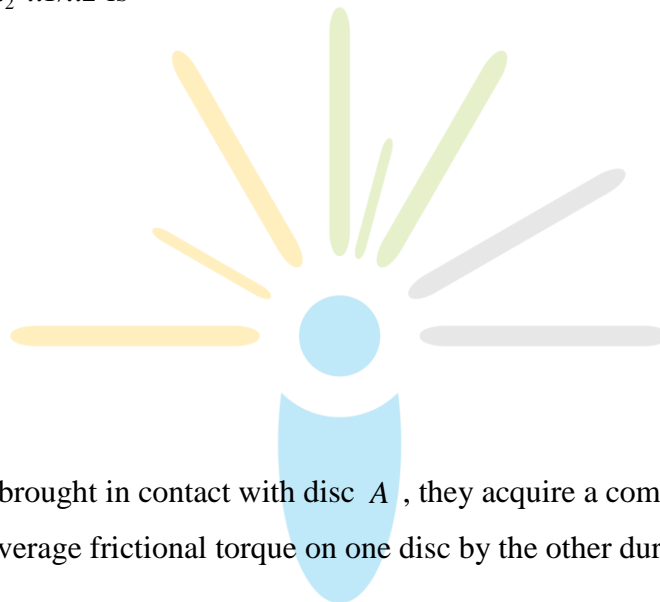
18. When disc B is brought in contact with disc A , they acquire a common angular velocity in time t t. The average frictional torque on one disc by the other during this period is

    (A) $\dfrac{2I\omega}{3t}$

    (B) $\dfrac{9I\omega}{2t}$

    (C) $\dfrac{9I\omega}{4t}$

    (D) $\dfrac{3I\omega}{2t}$

19. The loss of kinetic energy during the above process is

(A) $\dfrac{I\omega^2}{2}$

(B) $\dfrac{I\omega^2}{3}$

(C) $\dfrac{I\omega^2}{4}$

(D) $\dfrac{I\omega^2}{6}$

SECTION – IV

Matrix-Match Type

This section contains 3 questions. Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in Column-I have to be matched with statements (p, q, r, s) in Column-II. The answer to these questions have to be appropriately bubbled as illustrated in the following example.

If the correct matches are A-p, A-s, B-q, B-r, C-p, C-q and D-s, then the correctly bubbled 4 × 4 matrix should be as follows:

20. Some physical quantities are given in Column I and some possible SI units in which these quantities may be expresses are given in Column II. Match the physical quantities in Column I with the units in Column II and indicate your answer by darkening appropriate bubbles in the 4×4 matrix given in the ORS.

Column I	Column II
(A) GM_eM_s $G \rightarrow$ universal gravitational constant, $M_e \rightarrow$ mass of the earth, $M_s \rightarrow$ mass of the Sun	(p) (volt) (coulomb) (metre)
(B) $\dfrac{3RT}{M}$; $\quad R \rightarrow$ universal gas constant, $T \rightarrow$ absolute temperature, $M \rightarrow$ molar mass	(q) (kilogram) (metre)^3 (second)$^{-2}$
(C) $\dfrac{F^2}{q^2B^2}$; $\quad F \rightarrow$ force, $q \rightarrow$ charge, $B \rightarrow$ magnetic field	(r) (meter)^2 (second)$^{-2}$
(D) $\dfrac{GM_e}{R_e}$, $\quad G \rightarrow$ universal gravitational constant, $M_e \rightarrow$ mass of the earth, $R_e \rightarrow$ radius of the earth	(s) (farad) (volt)^2 (kg)$^{-1}$

22. Column I gives certain situations in which a straight metallic wire of resistance R is used and Column II gives some resulting effects. Match the statements in column I with the statements in Column II and indicate your answer by darkening appropriate bubbles in the 4×4 matrix given in the ORS.

Column I	Column II
(A) A charged capacitor is connected to the ends of the wire	(p) A constant current flows through the wire
(B) The wire is moved perpendicular to its length with a constant velocity in a uniform magnetic field perpendicular to the plane of motion	(q) Thermal energy is generated in the wire
(C) The wire is placed in a constant electric field that has a direction along the length of the wire.	(r) A constant potential difference develops between the ends of the wire
(D) A battery of constant emf is connected to the ends of the wire	(s) Charges of constant magnitude appear at the ends of the wire