IITJEE PHYSICS SAMPLE PAPER - I

SECTION – I
Straight Objective Type

This section contains 8 multiple choice questions numbered 1 to 8. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** choice is correct.

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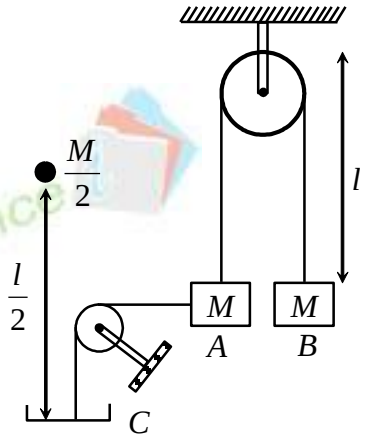
1. Two blocks A and B of same mass M are connected with each other with an ideal string of length $2l$ passing over an ideal pulley. The block A is connected to a light pan C with an ideal string as shown in figure. A particle of mass $\frac{M}{2}$ is dropped on pan from height $\frac{l}{2}$ as shown. If collision between particle and pan is plastic, acceleration of B just after the collision



(a) g (b) $\frac{g}{9}$

(c) $2g$ (d) none of these

2. A potential difference is applied between a conducting sphere and a conducting plate ("plus" on the sphere and "minus" on the plate). The dimension of the plate are much larger than the distance between sphere and plate. A point positive charge is moved from point 1 to point 2 parallel to the plate. Using the above information choose the correct statement.

(a) work done in the process is zero

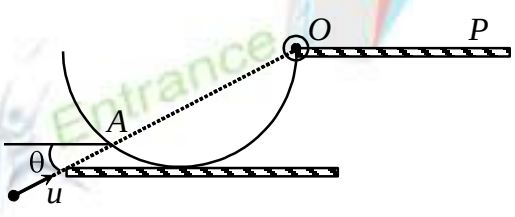
(b) net positive work will be done in moving charge from 1 to 2 by external agent

(c) net negative work will be done in moving charge from 1 to 2 by external agent

(d) information is insufficient to give any assertion regarding work.

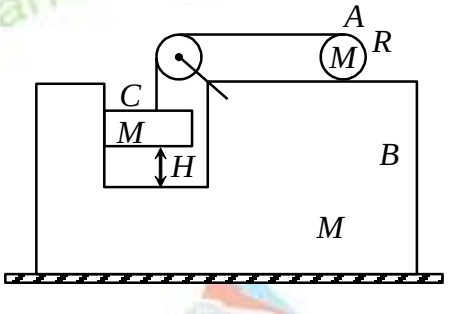
Space for rough work

3. A hemispherical shell of mass m and radius R is hinged at point O and placed on a horizontal surface. A ball of mass m moving with velocity u inclined at an angle $\theta = \tan^{-1}\left(\frac{1}{2}\right)$ strikes the shell at point A (as shown in the figure) and stops. What is the minimum speed u if the given shell is to reach the horizontal surface OP?



(a) zero (b) $\sqrt{\frac{2gR}{3}}$ (c) $\frac{gR}{\sqrt{5}}$ (d) not possible

4. A wedge B of mass M is placed on a smooth horizontal surface. An ideal string is wrapped over a cylinder A of mass M and radius R which is kept over the wedge and other end of the string is connected to block C of mass M passing over an ideal pulley as shown in the figure. If system is released from rest then after how much time the block C will hit the wedge. Friction between cylinder and wedge is sufficient to prevent slipping. All other surfaces are friction less.



(a) $\sqrt{\frac{H}{g}}$ (b) $\sqrt{\frac{2H}{g}}$ (c) $\sqrt{\frac{3H}{g}}$ (d) $\sqrt{\frac{4H}{g}}$

5. A long solenoid of cross-sectional radius R has a thin insulated wire ring tightly put on its winding. One half of the ring has the resistance 10 times that of the other half. The magnetic induction produced by the solenoid varies with time as $B = bt$, whose b is a constant. Find the magnitude of the electric field strength in the ring.

(a) $\frac{9}{11}Rb$ (b) $\frac{9}{22}Rb$ (c) $9\,Rb$ (d) Rb

Space for rough work

6. Find the maximum kinetic energy of the photo electron liberated from the surface of lithium by electromagnetic radiation whose electric component varies with time as

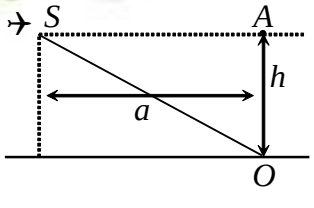
$E = a(1+\cos\omega t)\cos\omega_0 t$, where a is a constant, $\omega = 6\times10^{14}\,s^{-1}$ and $\omega_0 = 3.6\times10^{15}\,s^{-1}$

(a) 0 eV (b) 2 eV (c) 0.38 eV (d) 0.5 eV

7. A vertical capillary is brought in contact with the water surface what amount of heat is liberated while the water rises along the capillary? The wetting is assumed to be complete and the surface tension is S

(a) $\frac{2\pi S^2}{\rho g}$ (b) $\frac{\pi S^2}{\rho g}$ (c) zero (d) $\frac{4\pi S^2}{\rho g}$

8. An airplane is in supersonic flight at an altitude *h*. At what smallest distance a (along the horizontal) from the observer on the ground is there a point from which the sound emitted by the airplane motors travels to the observer faster than from point *A* that is directly above the observer



(a) $a < \frac{2\left(\frac{v_p}{v_s}\right)}{\left(\frac{v_p}{v_s}\right)^2 - 1} h$ (b) $a < \frac{\left(\frac{v_p}{v_s}\right)}{\left(\frac{v_p}{v_s}\right)^2 - 1} h$

(c) not possible for any real value of *a*

(d) $a > \frac{2\left(\frac{v_p}{v_s}\right)}{\left(\frac{v_p}{v_s}\right)^2 - 1} h$ $v_p \rightarrow$ velocity of airplane $v_s \rightarrow$ velocity of sound.

Space for rough work

SECTION – II
Reasoning Type

This section contains 4 reasoning type questions numbered 9 to 12. Each question contains Statement-1 and Statement-2. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** is correct.

Directions: Read the following questions and choose

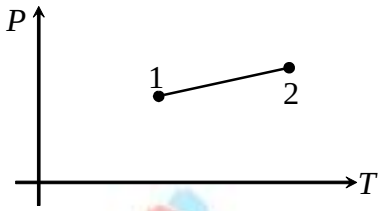
(A) If both the statements are true and statement-2 is the correct explanation of **statement-1**.

(B) If both the statements are true but statement-2 is not the correct explanation of **statement-1**.

(C) If statement-1 is True and **statement-2** is False.

(D) If statement-1 is False **and statement-2** is True.

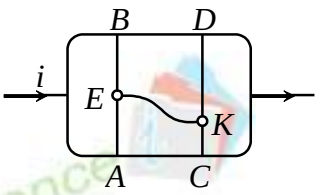
9. **Statement-1**: A curve showing the dependence of pressure on absolute temperature was a obtained for a certain gas (as shown in figure). Expansion in the gas take place on heating.



Statement-2: If the draw a line passing through origin and point 2 then it will have less slopes compared to similar line drawn from origin to point 1 and volume is inversely proportional to that slope.

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

10. **Statement-1**: The conductors *AB* and *CD* are connected to the branches of a circuit in which current is flowing. The position of the points *A, B, C* and *D* is selected in such a way that no current flows through *AB* and *CD*. If a conductor is connected between points *E* and *K* as shown then current will not flow through this conductor.

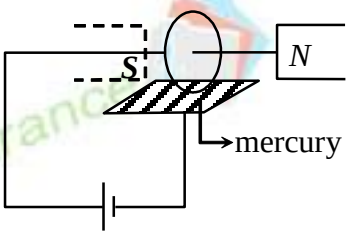


Statement-2: Potentials at *E* and *K* will not be same.

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

Space for rough work

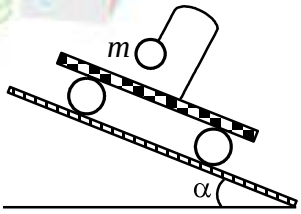
11. **Statement-1**: A copper disk is secured on a horizontal axis and placed between the poles of a strong magnet so that the north pole of the magnet is arranged on the right. The bottom of the disk is immersed in a cup of mercury. When the axis of the disc and the mercury cup are connected to a d-c source then ring starts rotating.



Statement-2: Due to the current which flows through the disc, net torque acts on the disc.

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

12. **Statement-1**: A light cart rolls without friction down an wedge which is kept on a horizontal smooth surface. A simple pendulum is fastened on the cart. At the time of releasing cart from rest thread of simple pendulum was perpendicular to the incline. If release from rest then string will make an angle α with line perpendicular to incline.



Statement-2: The angle made by string will be independent of whether wedge is accelerating or not.

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

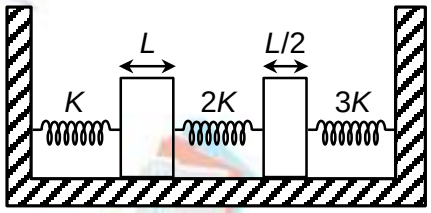
Space for rough work

SECTION–III
Linked Comprehension Type

This section contains 2 paragraphs **P_{13}–P_{18}**. Based upon each paragraph, 4 multiple choice questions have to be answered. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** choice is correct.

Passage-I

The system shown in figure consists of three springs and two rods as shown. Temperature of the rods is increased by ΔT. The springs are initially relaxed. There is no friction. Take the coefficient of linear expansion of the material of rods to be equal to α.



13. If x_1 is the extension or compression in spring with stiffness K and x_2 is the extension or compression in the spring with stiffness $2K$ then $\frac{x_1}{x_2}$

(a) $\frac{1}{2}$ (b) 2 (c) 1 (d) $\frac{3}{2}$

14. Ratio of the energy stored in springs with stiffness $2K$ and $3K$ will be

(a) $\frac{3}{2}$ (b) $\frac{2}{3}$ (c) 1 (d) none of these

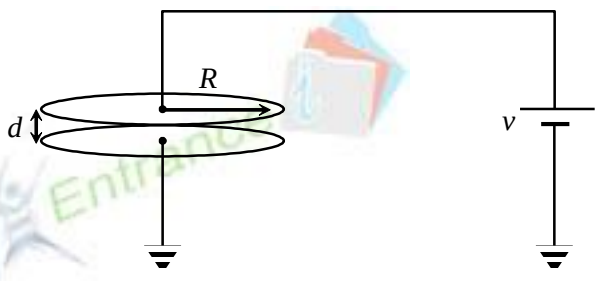
15. Energy stored in spring with spring constant (K)

(a) $\frac{81}{242}Kl^2\alpha^2\Delta T^2$ (b) $\frac{81}{484}Kl^2\alpha^2\Delta T^2$ (c) $\frac{27}{242}Kl^2\alpha^2\Delta T^2$ (d) $\frac{9}{484}Kl^2\alpha^2\Delta T^2$

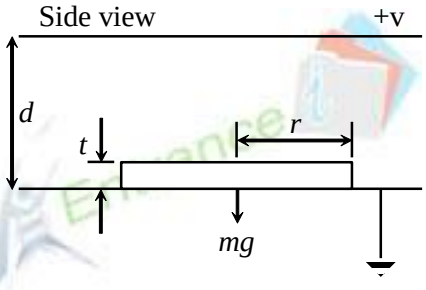
Passage-II

A capacitor consists of two circular parallel plates both with radius R separated by distance d, where $d << R$ as shown in figure (a). The top plate is connected to a constant voltage source at a potential V while bottom plate is grounded. Then a thin and small disc of mass m with radius r ($<< R, d$) and thickness t ($<< r$) is placed on the centre of bottom plate as shown in figure (b). Let us assume that space between the plates is in vacuum with dielectric constant $\in_0$; the plates and disc are made of perfect conductors and all the electrostatic edge effects may be neglected.

Space for rough work



(a)



(b)

16. When the disc is placed on the bottom plate a charge q on the disc is related to the voltage V by $q = Xv$. X in terms of r, d and $\in_0$ can be written as

(a) $\frac{\in_0 r^2}{d}$ (b) $-\in_0 \frac{\pi r^2}{d}$ (c) $\in_0 r$ (d) 1

17. The parallel plates lie perpendicular to a uniform gravitational field g. To lift up the disc initially at rest we need to increase the applied voltage beyond a threshold voltage V_{th}. If $V > V_{th}$, the disc makes an up and down motion between the plates. (Assume that the disc move only vertically without any wobbling). The collision between disc and plates are inelastic with coefficient of restitution e with plates are fixed. The speed of the disc just after the collision at the bottom plate approaches a steady state speed v_s which depends on V as $v_s = \sqrt{\alpha V^2 + \beta}$ where β and α can be written as

(a) $\left(\frac{e^2}{1-e^2}\right)2gd, \left(\frac{e}{1+e}\right)\left(\frac{-2\in_0 \pi r^2}{md}\right)$ (b) $\left(\frac{e}{1-e}\right)2gd, \left(\frac{e^2}{1+e^2}\right)\left(\frac{-2\in_0 \pi r^2}{md}\right)$

(c) $\left(\frac{e^2}{1+e^2}\right)2gd, \left(\frac{e^2}{1-e^2}\right)\left(\frac{-2\in_0 \pi r^2}{md}\right)$ (d) $\left(\frac{e}{1+e}\right)2gd, \left(\frac{e}{1-e}\right)\left(\frac{-2\in_0 \pi r^2)}{md}\right)$

18. When the applied voltage V is decreased (extremely slowly), there exists a critical voltage V_c below which the charge will cease to flow. Find V_c in terms of m, g, x, d and e where

$x = \left(-\frac{\in_0 \pi r^2}{d}\right)$

(a) $\sqrt{\frac{1-e}{1+e}}\sqrt{\frac{mgd}{x}}$ (b) $\sqrt{\frac{1+e}{1-e}}\sqrt{\frac{mgd}{x}}$ (c) $\sqrt{\frac{1+e^2}{1-e^2}}\sqrt{\frac{mgd}{x}}$ (d) $\sqrt{\frac{1-e^2}{1+e^2}}\sqrt{\frac{mgd}{x}}$

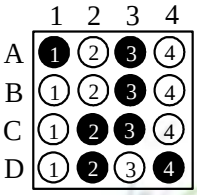
Space for rough work

SECTION–IV

Matrix–Match Type

This section contains 2 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 (1, 2, 3, 4) in **Column II**. One statement in first column has one or more than one match with the statements in second column. The answers to these questions have to be appropriately bubbled as illustrated in the following example.

If the correct matches are A–1,3, B–3, C–2,3 and D–2,4, then the correctly bubbled 4 × 4 matrix should be as follows:



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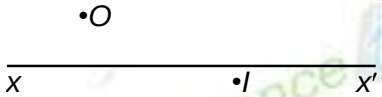
1. In column – I image I of an object *O* is formed by spherical mirror with principal axis. *xx*' . Match column – I with column – II.

Column –I	Column –II
(A)  mirror is convex	**1.** object is real
(B)  mirror is concave	**2.** object is virtual
(C)  mirror is concave	**3.** image is real
(D)  mirror is convex	**4.** image is virtual

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Space for rough work

2. Magnetic field in a region is given by

$B = B\odot$ If $x > 0$ $y > 0$

$= 2B\otimes$ If $x > 0$ $y < 0$

$= 0$ other wise

A particle of charge q, mass m, speed v parallel to x-axis enters in the region at a distance $y_0 = \eta R$ where $R = \frac{mv}{qB}$ and $\eta < 1$ and a positive constant. Based on the given situation, match column – I with column – II.

Column –I	Column –II
(A) With $\eta = \frac{1}{2}$ the time period of the motion of the particle is	**1.** $\frac{\pi m}{2qB}$
(B) With $\eta = \frac{2-\sqrt{3}}{2}$ the time period of the motion of the particle is	**2.** $\frac{\pi m}{qB}$
(C) With $\eta = \frac{1}{2}$, time taken by the particle to hit the x-axis	**3.** $\frac{m}{qB}\frac{\pi}{3}$
(D) With $\eta = \frac{1}{2}$, time taken by the particle when its velocity become parallel to x-axis after entering into magnetic field	**4.** $\frac{4m\pi}{qB3}$

Space for rough work

SECTION–V
Subjective or Numerical Type

The answer to these questions would lie between 0 to 9999. For any answer all four bubbles must be filled, for example if you plan to answer as 16 then fill 0016 and if you plan to answer 0 then fill 0000 in the grid provided in answer sheet. Any incomplete filling will be considered as incorrect filling.

Illustration: If you want to fill 2379 as your answer then it will be filled as

0	0	0	0
1	1	1	1
′	2	2	2
3	′	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	′	7
8	8	8	8
9	9	9	′

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1. Two equal rods of weight 10 N are freely joined. Their free ends are attached by strings to a fixed point. A circular disc of weight 60 N and radius r rest in the angle between the rods and the whole hangs in a vertical plane if 4 m is the length of each rod and 90º is the angle between the rods then find 'r'.

2. A particle moves in a curve $y = a\log\sec\left(\frac{x}{a}\right)$ in such a way that the tangent to the curve rotates uniformally with angular speed 2 rad/sec. Find resultant acceleration of the particle when $x = \frac{\pi}{4}a$ and a is a constant with value $\frac{1}{2}$.

Space for rough work