JEE ADVANCED-2012

PHYSICS

[Time: 3 Hours] [Maximum Marks: 210]

A. General Instructions :

1. This booklet is your Question paper. Do not break the seats of his booklet before being instructed to do so by the invigilators.

2. The question paper CODE is printed on the right hand top corner of this page and on the back page of this booklet.

3. Blank spaces and blank pages are provided in this booklet for your rough work. No additional sheets will be provided for rough work.

4. Blank papers, clipboards, log tables, slide rules, calculators, cameras, cellular phones, pagers, and electronic gadgets are NOT allowed inside the examination hall.

5. Answers to the questions and personal details are to be filled on a two-part carbon-less paper, which is provided separately. You should not separate these parts. The invigilator will separate them at the end of examination. The upper sheet is machine-gradable Objective Response Sheet (ORS) which will be taken back by the invigilator.

6. **Using a black ball point pen, darken the bubbles on the upper original sheet.** Apply sufficient pressure so that the impression is created on the bottom sheet.

7. DO NOT TAMPER WITH /MUTILATE THE ORS OR THE BOOKLET.

8. On breaking the seals of the booklet check that it contains 28 pages and all 60 questions and corresponding answer choices are legible. Read carefully the instructions printed at the beginning of each section.

B. Filling the Right Part of the ORS:

9. The ORS also has a **CODES** printed on its left and right parts.

10. Check that the same CODE is printed on the ORS and on this booklet. **IF IT IS NOT THEN ASK FOR A CHANGE OF THE BOOKLET.** Sign at the place provided on the ORS affirming that you have verified that all the code are same.

11. Write your Name, Registration Number and the name of examination centre and sign with pen in the boxes provided on the right part of the ORS. **Do not write any of this information anywhere else.** Darken the appropriate bubble UNDER each digit of your Registration Number in such a way that the impression is created on the bottom sheet. Also darken the paper CODE given on the right side of **ORS(R_4).**

C. Question paper format and Marking scheme:

12. **Section I** contains **10 multiple choice questions.** Each question has four choices (A), (B), (C) and (D) out of which **ONLY ONE is correct.**

13. **Section II** contains **5 multiple choice questions.** Each question has four choice (A), (B), (C) and (D) out of which **ONE or MORE are correct.**

14. **Section III** contains **5 questions.** The answer to each question is a **single digit integer,** ranging from 0 to 9 (both inclusive).

D. Marking Scheme

15. For each question in **Section I,** you will be awarded **3 marks** if you darken the bubble corresponding to the correct answer **ONLY** and **zero marks** if no bubbles are darkened. In all other cases, **minus one (—1)** mark will be awarded in this section.

16. For each question in **Section H,** you will be awarded **4 marks** if you darken **ALL** the bubble)s) corresponding to the correct answer(s) **ONLY.** In all other cases **zero (0) marks** will be awarded. **No negative marks** will be awarded for incorrect answer in this section.

17. For each question in **Section HI,** you will be awarded **4 marks** if you darken the bubble corresponding to the correct answer **ONLY.** In all other cases **zero (0) marks** will be awarded. **No negative marks** will be awarded for incorrect answer in this section.

SECTION I

This section contains **10 multiple choice questions**. Each question has four choices (A), (B), (C) and (D) out of which **ONLY ONE is correct.**

1. In the determination of Young's modulus $\left(Y = \frac{4MLg}{\pi \ell d^2}\right)$ by using Searle's method, a wire of length $L = 2\text{m}$ and diameter $d = 0.5\text{mm}$ is used. For a load $M = 2.5\text{kg}$, an extension $\ell = 0.25\text{mm}$ in the length of the wire is observed. Quantities d and ℓ are measured using a screw gauge and a micrometer, respectively. They have the same pitch of 0.5mm. The number of divisions on their circular scale is 100. The contributions to the maximum probable error of the Y measurement

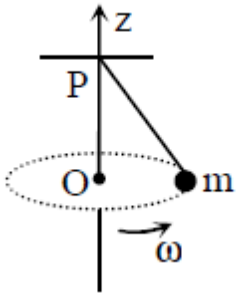
   (A) due to the errors in the measurements of d and ℓ are the same.

   (B) due to the error in the measurement of d is twice that due to the error in the measurement of ℓ.

   (C) due to the error in the measurement of ℓ is twice that due to the error in the measurement of d.

   (D) due to the error in the measurement of d is four times that due to the error in the measurement of ℓ.

2. A small mass m is attached to a massless string whose other end is fixed at P as shown in the figure. The mass is undergoing circular motion in the x-y plane with centre at O and constant angular speed ω. If the angular momentum of the system, calculated about O and P are denoted by $\vec{L}_O$ and $\vec{L}_P$ respectively, then



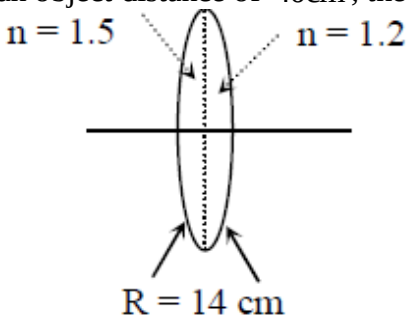
   (A) $\vec{L}_O$ and $\vec{L}_P$ do not vary with time.

(B) $\vec{L}_O$ varies with time while $\vec{L}_P$ remains constant.

(C) $\vec{L}_O$ remains constant while $\vec{L}_P$ varies with time.

(D) $\vec{L}_O$ and $\vec{L}_P$ both vary with time.

3. A bi-convex lens is formed with two thin plano-convex lenses as shown in the figure. Refractive index n of the first lens is 1.5 and that of the second lens is 1.2. Both the curved surface are of the same radius of curvature $R = 14\text{cm}$. For this bi-convex lens, for an object distance of 40cm, the image distance will be



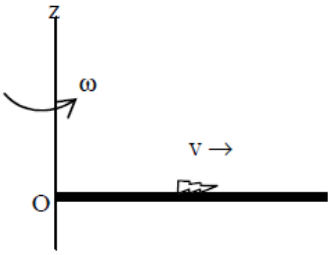
(A) $-280.0\,\text{cm}$

(B) $40.0\,\text{cm}$

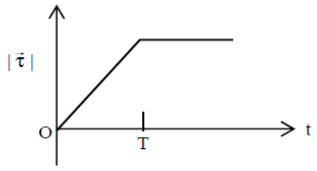
(C) $21.5\,\text{cm}$

(D) $13.3\,\text{cm}$

4. A thin uniform rod, pivoted at O, is rotating in the horizontal plane with constant angular speed ω, as shown in the figure. At time $t = 0$, a small insect starts from O and moves with constant speed v, with respect to the rod towards the other end. It reaches the end of the rod at $t = T$ and stops. The angular speed of the system remains ω throughout. The magnitude of the torque $\left(|\vec{\tau}|\right)$ about O, as a function of time is best represented by which plot?



(A)



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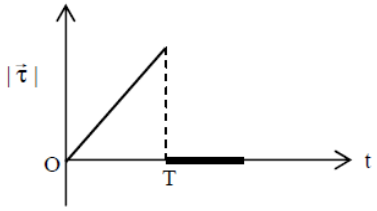

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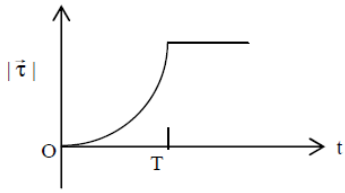

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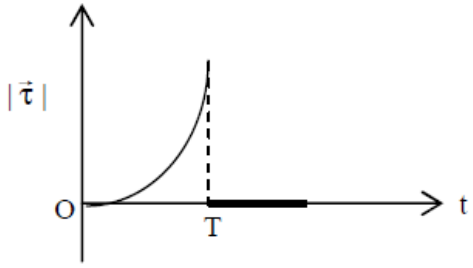


5. A mixture of 2 moles of helium gas $(\text{atomic mass} = 4\ \text{amu})$ and 1 mole of argon gas $(\text{atomic mass} = 40\ \text{amu})$ is kept at $300\,K$ in a container. The ratio of the rms speeds $\left(\frac{V_{rms}(\text{helium})}{V_{rms}(\text{argon})}\right)$ is

(A) 0.32

(B) 0.45

(C) 2.24

(D) 3.16

6. Two large vertical and parallel metal plates having a separation of 1cm are connected to a DC voltage source of potential difference X. A proton is released at rest midway between the two plates. It is found to move at 45^0 to the vertical JUST after release. Then X is nearly

(A) 1×10^{-5} V

(B) 1×10^{-7} V

(C) 1×10^{-9} V

(D) 1×10^{-10} V

7. Three very large plates of same area are kept parallel and close to each other. They are considered as ideal black surfaces and have very high thermal conductivity. The first and third plates are maintained at temperatures $2T$ and $3T$ respectively. The temperature of the middle (i.e. second) plate under steady state condition is

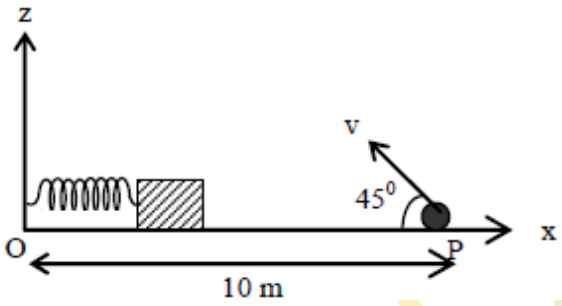
(A) $\left(\frac{65}{2}\right)^{1/4} T$

(B) $\left(\frac{97}{4}\right)^{1/4} T$

(C) $\left(\frac{97}{2}\right)^{1/4} T$

(D) $(97)^{1/4} T$

8. A small block is connected to one end of a massless spring of un-stretched length $4.9\,\text{m}$. The other end of the spring (see the figure) is fixed. The system lies on a horizontal frictionless surface. The block is stretched by $0.2\,\text{m}$ and released from rest at $t=0$. It then executes simple harmonic motion with angular frequency $\omega=\pi/3 rad/s$. Simultaneously at $t=0$, a small pebble is projected with speed v form point P at an angle of 45^0 as shown in the figure. Point P is at a horizontal distance of $10\,\text{m}$ from O. If the pebble hits the block at $t=1\text{s}$, the value of v is $\left(\text{take } g=10\,\text{m/s}^2\right)$



(A) $\sqrt{50}\,\text{m/s}$

(B) $\sqrt{51}\,\text{m/s}$

(C) $\sqrt{52}\,\text{m/s}$

(D) $\sqrt{53}\,\text{m/s}$

9. Young's double slit experiment is carried out by using green, red and blue light, one color at a time. The fringe widths recorded are β_G, β_R and β_B, respectively. Then,

(A) $\beta_G > \beta_B > \beta_R$

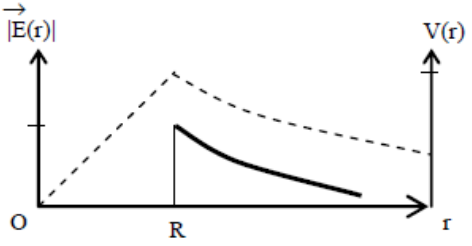
(B) $\beta_B > \beta_G > \beta_R$

(C) $\beta_R > \beta_B > \beta_G$

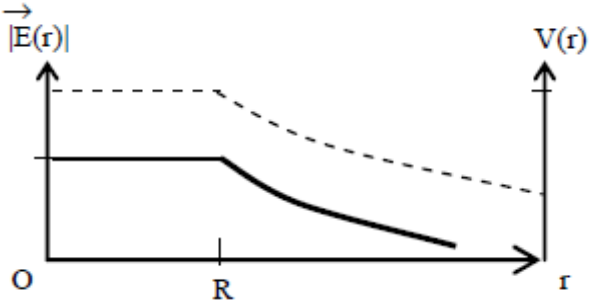
(D) $\beta_R > \beta_G > \beta_B$

10. Consider a thin spherical shell of radius R with centre at the origin, carrying uniform positive surface charge density. The variation of the magnitude of the electric field $\left|\vec{E}(r)\right|$ and the electric potential $V(r)$ with the distance r from the centre, is best represented by which graph?

(A)



(B)



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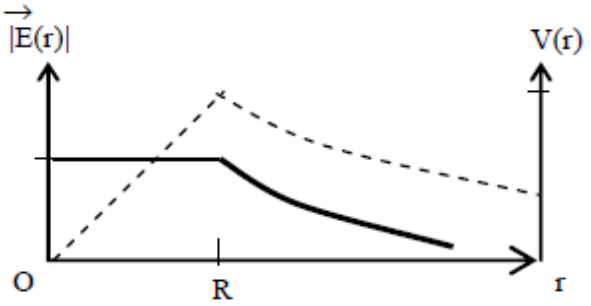
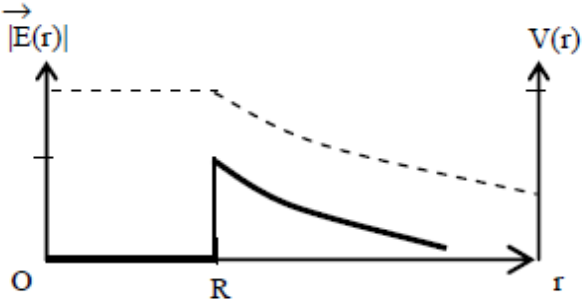


(D)



SECTION II

This section contains **5 multiple choice questions**. Each question has four choices (A), (B), (C) and (D) out of which **ONE or MORE are correct.**

11. Consider the motion of a positive point charge in a region where there are simultaneous uniform electric and magnetic fields $\vec{E} = E_0 \hat{j}$ and $\vec{B} = B_0 \hat{j}$. At time $t = 0$, this charge has velocity $\vec{v}$ in the x-y plane, making an angle θ with the x-axis. Which of the following option(s) is (are) correct for time $t > 0$?

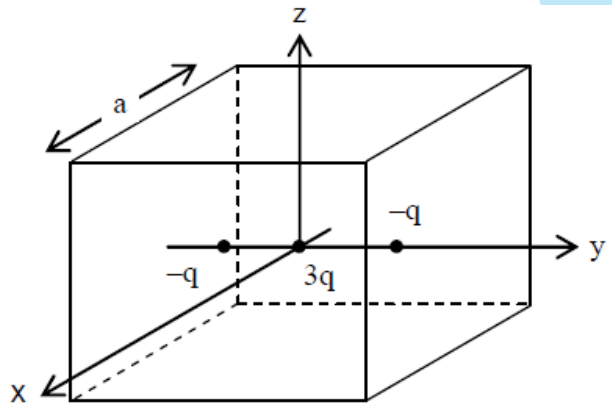
    (A) If $\theta = 0°$, the charge moves in a circular path in the x-z plane.

    (B) If $\theta = 0°$, the charge undergoes helical motion with constant pitch along the y-axis .

    (C) If $\theta = 10°$, the charge undergoes helical motion with its pitch increasing with time, along the y-axis .

    (D) If $\theta = 90°$, the charge undergoes linear but accelerated motion along the y-axis .

12. A cubical region of side a has its centre at the origin. It encloses three fixed point charges, $-q$ at $(0, -a/4), +3q$ at $(0,0,0)$ and $-q$ at $(0, +a/4, 0)$. Choose the correct options(s)



    (A) The net electric flux crossing the plane $x = +a/2$ is equal to the net electric flux crossing the plane $x = -a/2$

    (B) The net electric flux crossing the plane $y = +a/2$ is more than the net electric flux crossing the plane $y = -a/2$.

(C) The net electric flux crossing the entire region is $\frac{q}{\varepsilon_0}$.

(D) The net electric flux crossing the plane $z=+a/2$ is equal to the net electric flux crossing the plane $x=+a/2$.

13. A person blows into open-end of a long pipe. As a result, a high pressure pulse of air travels down the pipe. When this pulse reaches the other end of the pipe,

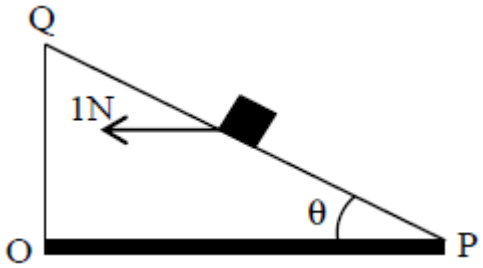
(A) a high-pressure pulse starts travelling up the pipe, if the other end of the pipe is open.

(B) a low-pressure pulse starts travelling up the pipe, if the other end of the pipe is open.

(C) a low-pressure pulse starts travelling up the pipe, if the other end of the pipe is closed.

(D) a high-pressure pulse starts travelling up the pipe, if the other end of the pipe is closed.

14. A small block of mass of 0.1kg lies on a fixed inclined plane PQ which makes an angle θ with the horizontal. A horizontal force of $1N$ acts on the block through its centre of mass as shown in the figure. The block remains stationary if $\left(\text{take } g=10\,\text{m/s}^2\right)$



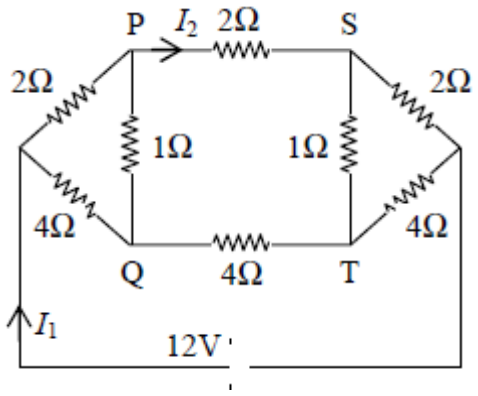
(A) $\theta=45°$

(B) $\theta>45°$ and a frictional force acts on the block towards P.

(C) $\theta>45°$ and a frictional force acts on the block towards Q.

(D) $\theta<45°$ and a frictional force acts on the block towards Q.

15. For the resistance network shown in the figure, choose the correct option(s)



(A) The current through PQ is zero.

(B) $I_1 = 3A$

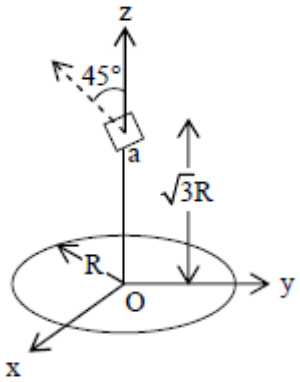
(C) The potential at S is less than that at Q.

(D) $I_2 = 2A$

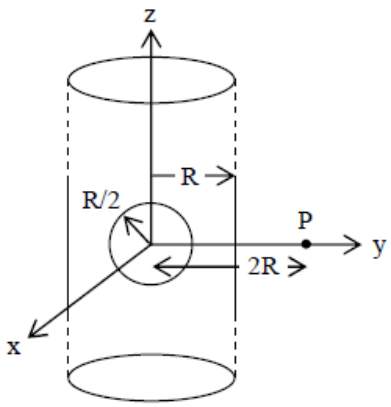
SECTION III

This section contains **5 questions**. The answer to each question is single digit integer, ranging from 0 to 9 (*both inclusive*).

16. A circular wire loop of radius R is placed in the x-y plane centered at the origin O. A square loop of side $a\left(a<<R\right)$ having two turns is placed with its centre at $z=\sqrt{3}R$ along the axis of the circular wire loop, as shown in figure. The plane of the square loop makes an angle of $45°$ with respect to the z-axis. If the mutual inductance between the loops is given by $\frac{\mu_0 a^2}{2^{p/2}R}$, then the value of p is

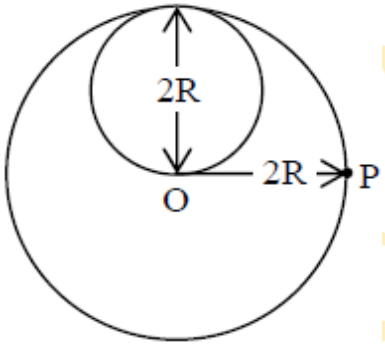


17. An infinitely long solid cylinder of radius R has a uniform volume charge density ρ. It has a spherical cavity of radius $R/2$ with its centre on the axis of the cylinder, as shown in the figure. The magnitude of the electric field at the point P, which is at a distance $2R$ from the axis of the cylinder, is given by the expression $\frac{23\rho R}{16k\varepsilon_0}$. The value of k is



18. A proton is fired from very far away towards a nucleus with charge $Q = 120e$, where e is the electronic charge. It makes a closest approach of $10\,fm$ to the nucleus. The de Broglie wavelength (in units of fm) of the proton at its start is: (take the proton mass, $m_p = (5/3)\times10^{-27}\,\text{kg};\ h/e = 4.2\times10^{-15}\ J.s/C;\ \dfrac{1}{4\pi\varepsilon_0} = 9\times10^{9}\ m/F;1\,fm = 10^{-15}$)

19. A lamina is made by removing a small disc of diameter $2R$ from a bigger disc of uniform mass density and radius $2R$, as shown in the figure. The moment of inertia of this lamina about axes passing though O and P is I_O and I_P respectively. Both these axes are perpendicular to the plane of the lamina. The ratio I_P/I_O to the nearest integer is



20. A cylindrical cavity of diameter a exists inside a cylinder of diameter $2a$ as shown in the figure. Both the cylinder and the cavity are infinity long. A uniform current density J flows along the length. If the magnitude of the magnetic field at the point P is given by $\dfrac{N}{12}\mu_0 aJ$, then the value of N is