# JEE ADVANCED-2017

## PHYSICS

## General Instructions :

**Read the Instructions carefully: General:**

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 paper CODE is printed on its left part as well as the right part of the ORS. 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 at 2:00 pm, verify that the booklet contains 36 pages and that all the 54 questions along with the options are legible. If not contact the invigilator for replacement of the booklet.

8. You are allowed to take away the Question Paper at the end of the examination.

**Optical Response Sheet**

9. The ORS (top sheet) will be provided with an attached Candidate's Sheet (bottom sheet). The Candidate's Sheet is a carbon - less copy of the ORS.

10. Darken the appropriate bubbles on the ORS by applying sufficient pressure. This will leave an impression at the corresponding place on the Candidate's Sheet.

11. The ORS will be collected by the invigilator at the end of the examination.

12. You will be allowed to take away the Candidate's Sheet at the end of the examination.

13. Do not tamper with of mutilate the ORS. Do not use the ORS for rough work.

14. Write your name, roll number and code of the examination center, and sign with pen in the space provided for this purpose on the ORS. Do not write any of these details anywhere else on the ORS. Darken the appropriate bubble under each digit of your roll number.

**Darken the Bubbles on the ORS**

15. Use a Black Ball Point Pen to darken the bubbles on the ORS.

16. Darken the bubble ◯ completely.

17. The correct way of darkening a bubble is as: ⬬

18. The ORS is machine - gradable. Ensure that the bubbles are darkened in the correct way.

19. Darken the bubbles only if you are sure of the answer. There is no way to erase or "un-darken" a darkened bubble.

# SECTION – 1

## (Maximum Marks: 21)

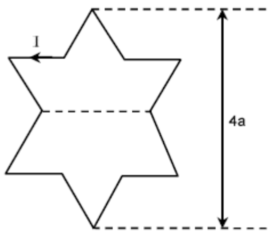
- This section contains **SEVEN** questions
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories :

Full Marks : +3 If only the bubble corresponding to the correct option is darkened.

Zero Marks : 0 If none of the bubbles is darkened.

Negative Marks : –1 In all other cases.

**1.** A symmetric shaped conducting wire loop carrying a steady state current I as shown in the figure. The distance between the diametrically opposite vertices of the star is $4a$. The magnitude of the magnetic field at the center of the loop is:




(A) $\frac{\mu_0 I}{4\pi a} 6\left[\sqrt{3}-1\right]$

(B) $\frac{\mu_0 I}{4\pi a} 6\left[\sqrt{3}+1\right]$

(C) $\frac{\mu_0 I}{4\pi a}3\left[2-\sqrt{3}\right]$

(D) $\frac{\mu_0 I}{4\pi a}3\left[\sqrt{3}-1\right]$

**2.** Consider an expanding sphere of instantaneous radius $R$ whose total mass remains constant. The expansion is such that the instantaneous density $\rho$ remains uniform throughout the volume. The rate of fractional change in density $\left(\frac{1dp}{\rho dt}\right)$ is constant. The velocity $v$ of any point on the surface of the expanding sphere is proportional to

(A) $R^3$

(B) $R$

(C) $R^{2/3}$

(D) $\frac{1}{R}$

**3.** A person measures the depth of a well by measuring the time interval between dropping a stone and receiving the sound of impact with the bottom of the well. The error in his measurement of time is $\delta T = 0.01$ seconds and he measure the depth of the well to be $L = 20$ meter. Take the acceleration due to gravity $g = 10\,\text{ms}^{-2}$ and the velocity of sound is $300\,\text{ms}^{-1}$. Then the fractional error in the measurement $\frac{\delta L}{L}$, is closest to :

(A) 0.2%

(B) 3%

(C) 5%

(D) 1%

**4.** A rocket is launched normal to the surface of the Earth, away from the Sun, along the line joining the Sun and the Earth. The Sun is $3\times10^{5}$ times heavier than the Earth and is at Distance $2.5\times10^{4}$ times larger than the radius of the earth. The escape velocity from Earth's gravitational field us $V_e = 11.2\,\text{km s}^{-1}$. The minimum initial velocity $(v_s)$ required for the rocket to be able to leave the Sun-Earth system is closest to : (Ignor the rotation and revolution of the Earth and the presence of any other planet )

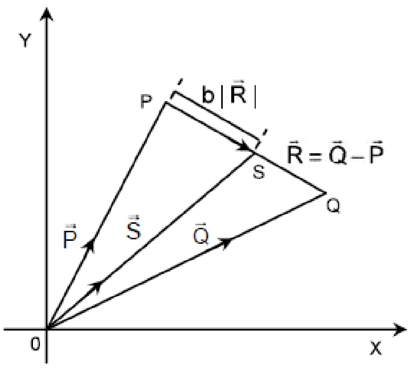
(A) $v_s = 72\,\text{km s}^{-1}$

(B) $v_s = 22\,\text{km s}^{-1}$

(C) $v_s = 42\,\text{km s}^{-1}$

(D) $v_s = 62\,\text{km s}^{-1}$

**5.** Three vectors $\vec{P}$, $\vec{Q}$ and $\vec{R}$ are shown in the figure. Let $S$ be any point on the vector $\vec{R}$. The distance between the point $P$ and $S$ is $b\,|\vec{R}|$. The general relation among vectors $\vec{P}$, $\vec{Q}$ and $\vec{S}$ is




(A) $\vec{S} = (b-1)\vec{P} + b\vec{Q}$

(B) $\vec{S} = (1-b^2)\vec{P} + b\vec{Q}$

(C) $\vec{S} = (1-b)\vec{P} + b^2\vec{Q}$

(D) $\vec{S} = (1-b)\vec{P} + b\vec{Q}$

**6.** A photoelectric material having work-function $\phi_0$ is illuminated with light of wavelength $\lambda\left(\lambda < \frac{hc}{\phi_0}\right)$. The fastest photoelectron has a de Broglie wavelength $\lambda_d$. A change in wavelength of the incident light by $\Delta\lambda$ results in change $\Delta\lambda_d$ in $\lambda_d$. then the ratio $\frac{\Delta\lambda_d}{\Delta\lambda}$ is proportional to

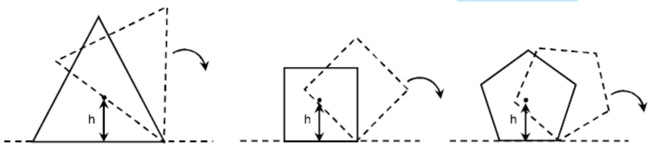
(A) $\frac{\lambda_d^3}{\lambda^2}$

(B) $\frac{\lambda_d^3}{\lambda}$

(C) $\frac{\lambda_d^2}{\lambda^2}$

(D) $\frac{\lambda_d}{\lambda}$

**7.** Consider regular polygons with number of sides $n = 3, 4, 5, \ldots\ldots$ as shown in the figure. The centre of mass of all the polygons is at height $h$ from the ground. They roll on a horizontal surface about the leading vertex without slipping and sliding as depicted. The maximum increase in height of the locus of the centre of mass for each polygon is $\Delta$. Then $\Delta$ depends on $n$ and $h$ as




(A) $\Delta = h\sin\left(\frac{2\pi}{n}\right)$

(B) $\Delta = h\tan^2\left(\frac{\pi}{2n}\right)$

(C) $\Delta = h\sin^2\left(\frac{\pi}{n}\right)$

(D) $\Delta = h\left(\frac{1}{\cos\left(\frac{\pi}{n}\right)} - 1\right)$

## SECTION – 2

(Maximum Marks : 28)

- This section contains **SEVEN** 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.
- For each question, marks will be awarded in one of the following categories:

Full Marks : +4 If only the bubble(s) corresponding to all the correct option(s) is(are) darkened.

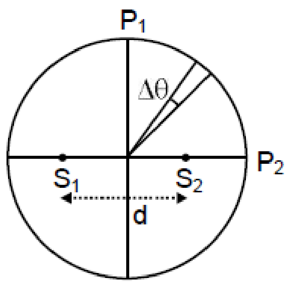
Partial Marks : +1 For darkening a bubble corresponding to each correct option, provided NO incorrect option is darkened.

Zero Marks : 0 If none of the bubbles is darkened.

Negative Marks : −2 In all other cases.

- For example, if (A), (C) and (D) are all the correct options for a question, darkening all these three will get +4 marks; darkening only (A) and (D) will get +2 marks and darkening (A) and (B) will get -2 marks, as a wrong option is also darkened.

**8.** Two coherent monochromatic point sources $S_1$ and $S_2$ of wavelength $\lambda = 600\,\text{nm}$ are placed symmetrically on either side of the centre of the circle as shown. The sources are separated by a distance $d = 1.8\,\text{mm}$. This arrangement produces interference fringes visible as alternate bright and dark spots on the circumference of the circle. The angular separation between two consecutive bright spots is $\Delta\theta$. Which of the following options is/are correct?



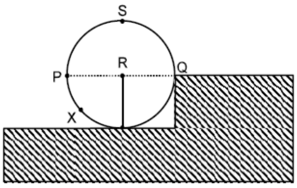
(A) The total number of fringes produced between $P_1$ and $P_2$ in the first quadrant is close to $3000$

(B) A dark spot will be formed at the point $P_2$

(C) At $P_2$ the order of the fringe will be maximum

(D) The angular separation between two consecutive bright spots decreases as we move from $P_1$ to $P_2$ along the first quadrant

**9.** A wheel of radius $R$ and mass $M$ is placed at the bottom of a fixed step of height $R$ as shown in the figure. A constant force is continuously applied on the surface of the wheel so that it just climbs the step without slipping. Consider the torque $\tau$ about an axis normal to the plane of the paper passing through the point $Q$. Which of the following options is/are correct?



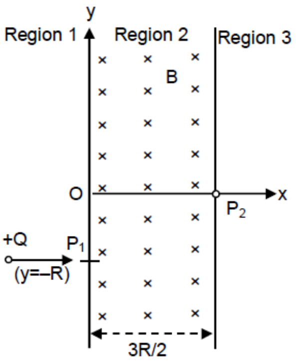

(A) If the force is applied normal to the circumference at point $P$ then $\tau$ is zero

(B) If the force is applied tangentially at point $S$ then $\tau \neq 0$ but the wheel never climbs the step

(C) If the force is applied at point $P$ tangentially then $\tau$ decreases continuously as the wheel climbs

(D) If the force is applied normal to the circumference at point $X$ then $\tau$ is constant

**10.** A uniform magnetic field $B$ exists in the region between $x = 0$ and $x = \frac{3R}{2}$ (region $2$ in the figure) pointing normally into the plane of the paper. A particle with charge $+Q$ and momentum $p$ directed along $x-axis$ enters region $2$ from region $1$ at point $P_1(y = -R)$. Which of the following option(s) is/are correct?



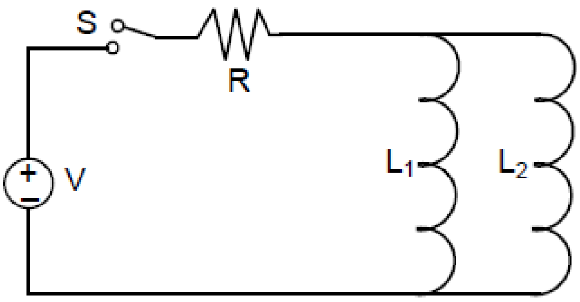

(A) When the particle re-enters region 1 through the longest possible path in region 2, the magnitude of the change in its linear momentum between point $P_1$ and the farthest point from $y-axis$ is $P/\sqrt{2}$.

(B) For a fixed $B$, particles of same charge $Q$ and same velocity $v$, the distance between the point $P_1$ and the point of re-entry into region 1 is inversely proportional to the mass of the particle.

(C) For $B=\frac{8}{13}\frac{p}{QR}$, the particle will re-enter region 3 the point $P_2$ on $x-axis$

(D) For $B>\frac{2}{3}\frac{p}{QR}$, the particle will re-enter region 1.

**11.** A source of constant voltage $V$ is connected to a resistance $R$ and two ideal inductors $L_1$ and $L_2$ through a switch $S$ as shown. There is no mutual inductance between the two inductors. The switch $S$ is initially open. At $t=0$, the switch is closed and current begins to flow. Which of the following options is/are correct?



(A) After a long time, the current through $L_2$ will be $\frac{V}{R}\frac{L_1}{L_1+L_2}$

(B) At $t=0$, the current through the resistance $R$ is $\frac{V}{R}$

(C) After a long time, the current through $L_1$ will $\frac{V}{R}\frac{L_2}{L_1+L_2}$

(D) The ratio of the currents through $L_1$ and $L_2$ is fixed at all times $(t>0)$

**12.** The instantaneous voltage at three terminals marked $X, Y$ and $Z$ are given by

$v_x = v_0 \sin \omega t,$

$v_y = v_0 \sin\left(\omega t + \frac{2\pi}{3}\right)$ and

$v_z = v_0 \sin\left(\omega t + \frac{4\pi}{3}\right)$

An ideal voltmeter is configured to read rms value of the potential difference between its terminals. It is connected between points $X$ and $Y$ and then between $Y$ and $Z$. The reading(s) of the voltmeter will be

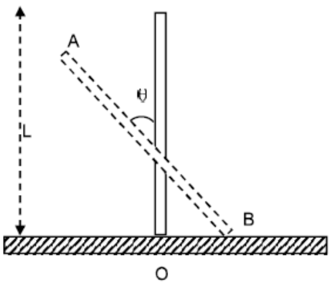
(A) $V_{XY}^{rms} = V_0\sqrt{\frac{3}{2}}$

(B) $V_{YZ}^{rms} = V_0\sqrt{\frac{1}{2}}$

(C) independent of the choice of the two terminals

(D) $V_{XY}^{rms} = V_0$

**13.** A rigid uniform bar $AB$ of length $L$ is slipping from its vertical position on a frictionless floor (as shown in the figure). At some instant of time, the angle made by the bar with the vertical is $\theta$. Which of the following statements about its motion is/are correct?



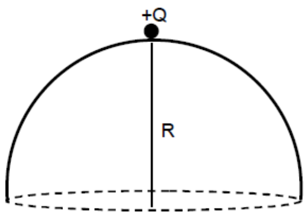

(A) The trajectory of the point $A$ is a parabola

(B) Instantaneous torque about the point in contact with the floor is proportional to $\sin\theta$.

(C) When the bar makes an angle $\theta$ with the vertical, the displacement of its midpoint from the initial position is proportional to $(1-\cos\theta)$

(D) The midpoint of the bar will fall vertically downward

**14.** A point charge $+Q$ is placed just outside an imaginary hemispherical surface of radius $R$ as shown in the figure. Which of the following statements is/are correct?




(A) Total flux through the curved and the flat surfaces is $\frac{Q}{\varepsilon_0}$

(B) The component of the electric field normal to the flat surface is constant over the surface

(C) The circumference of the flat surface is an equipotential

(D) The electric flux passing through the curved surface of the hemisphere is $-\frac{Q}{2\varepsilon_0}\left(1-\frac{1}{\sqrt{2}}\right)$

## SECTION – 3

### (Maximum Marks : 12)

- This section contains **TWO** paragraphs.
- Based on each paragraph, there are **TWO** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct integer in the ORS.
- For each question, marks will be awarded in one of the following categories :
  Full Marks : +3 If only the bubble corresponding to the correct answer is darkened.
  Zero Marks : 0 In all other cases.

**PARAGRAPH 1**

Consider a simple RC circuit as shown in Figure 1.

**Process 1:** In the circuit the switch $S$ is closed at $t = 0$ and the capacitor is fully charged to voltage $V_0$ (i.e. charging continues for time $T >> RC$ ). In the process some dissipation $\left(E_D\right)$ occurs across the resistance $R$. The amount of energy finally stored in the fully charged capacitor is $E_C$.

Process 2: In a different process the voltage is first set to $\frac{V_0}{3}$ and maintained for a charging time $T >> RC$. Then the voltage is raised to $\frac{2V_0}{3}$ without discharging the capacitor and again maintained for time $T >> RC$. The process is repeated one more time by raising the voltage to $V_0$ and the capacitor is charged to the same final voltage $V_0$ as in Process 1.

These two processes are depicted in Figure 2.

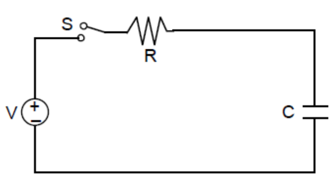


Figure 1

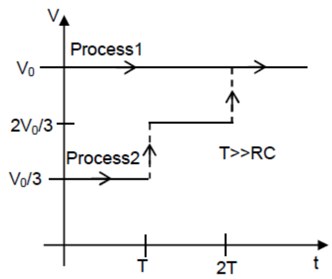


Figure 2

**15.** In Process 1, the energy stored in the capacitor $E_C$ and heat dissipated across resistance $E_D$ are released by:

(A) $E_C = \frac{1}{2} E_D$

(B) $E_C = E_D \ln 2$

(C) $E_C = 2E_D$

(D) $E_C = E_D$

**16.** In Process 2, total energy dissipated across the resistance $E_D$ is:

(A) $E_D = 3\left(\frac{1}{2} C V_0^2\right)$

(B) $E_D = \frac{1}{3}\left(\frac{1}{2} C V_0^2\right)$

(C) $E_D = 3CV_0^2$

(D) $E_D = \frac{1}{2} C V_0^2$

**PARAGRAPH 2**

One twirls a circular ring (of mass $M$ and radius $R$) near the tip of one's finger as shown in Figure-1. In the process the finger never loses contact with the inner rim of the ring. The finger traces out the surface of a cone, shown by the dotted line. The radius of the path traced out by the point where the ring and the finger is in contact is $r$. The finger rotates with an angular velocity $\omega_0$. The rotating ring rolls without slipping on the outside of a smaller circle described by the point where the ring and the finger is in contact (Figure 2). The coefficient of friction between the ring and the finger is $\mu$ and the acceleration due to gravity is $g$.

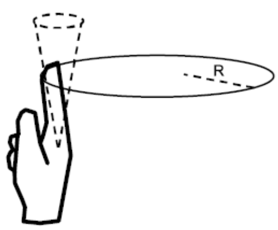


Figure-1

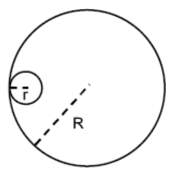


Figure-2

**17.** The total kinetic energy of the ring is :

(A) $\frac{1}{2}M\omega_0^2(R-r)^2$

(B) $\frac{3}{2}M\omega_0^2(R-r)^2$

(C) $M\omega_0^2R^2$

(D) $M\omega_0^2(R-r)^2$

**18.** The minium value of $\omega_0$ below which the ring will drop down is:

(A) $\sqrt{\frac{g}{\mu(R-r)}}$

(B) $\sqrt{\frac{g}{2\mu(R-r)}}$

(C) $\sqrt{\frac{3g}{\mu(R-r)}}$

(D) $\sqrt{\frac{2g}{\mu(R-r)}}$