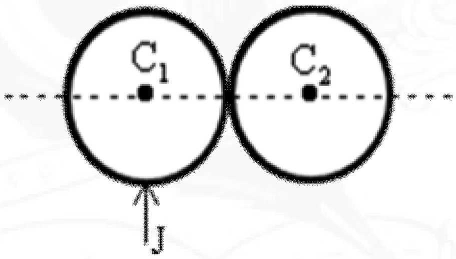
PART-I_PHYSICS **Max Marks : 60**

Section-1
(One or More options Correct Type)

This section contains 10 multiple choice equations. Each question has four choices (**A**) (**B**),(**C**) and (**D**) out of which **ONE** or **MORE THAN ONE** are correct.

1. Figure shows two uniform, smooth identical bodies kept in contact in free space. Initially two body system is at rest. An external Impulse 'J' is applied to center C_1 perpendicular to line joining centers C_1C_2. Mass and radius of both spheres is m and R. Given $J=\sqrt{\frac{Gm^3}{2R}}$



A) Angular Impulse about centre of mass of 2nd sphere 'C_2' is 2JR

B) Angular Impulse about centre of mass of system is JR

C) Just after imparting impulse contact force between spheres is zero

D) Just after imparting impulse contact force between spheres is $\frac{Gm^2}{8R^2}$ N

2. Which of the following statements is true regarding a point mass m near the centre of the circular face of a uniform solid hemisphere of Mass M, Radius R?

A) Escape speed required from the position given is $\sqrt{\frac{3GM}{2R}}$

B) Force on m is $\frac{3GMm}{2R^2}$

C) Force on 'm' due to each differential hollow thick concentric hemishell of same thickness 'dr' is same.

D) work done in moving this 'm' from given position to any point on the curved surface is same

3. Consider two particles each of mass m at a distance r_o from each other . One of them is given a velocity V_o perpendicular to line joining them and the other is simultaneously released from rest. For which of the following values of V_o the masses would be bound in orbital motion under their mutual gravitational forces

A) $\sqrt{\frac{Gm}{r_o}}$ B) $\frac{3}{2}\sqrt{\frac{Gm}{r_o}}$ C) $2\sqrt{\frac{Gm}{r_o}}$ D) $3\sqrt{\frac{Gm}{r_o}}$

4. Two charges of equal magnitudes are placed at A and B as shown in the diagram. B is fixed and A is moving in anticlockwise sense in the circle shown in figure 1. Figure 2 and 3 represents the variation of electric field intensities E_x and E_y along x and y-axis with respect to angle covered by charge A at the origin. Mark the correct option. [(Speed of particle A << c (speed of light)]

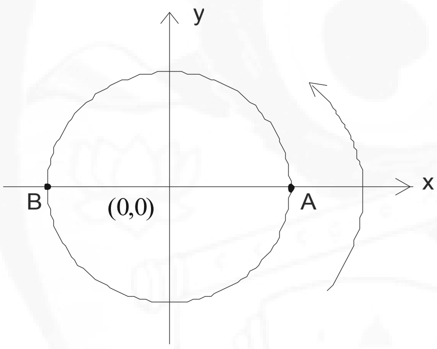


fig. 1

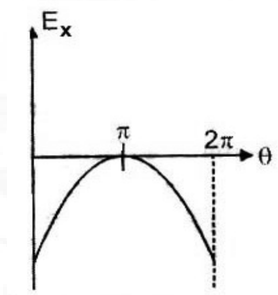


Fig. 2

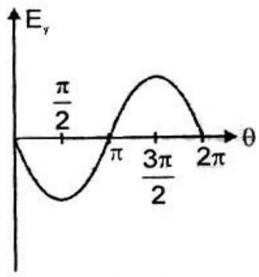


Fig. 3

A) A is negative charge B) A is positive charge

C) B is negative charge D) B is positive charge

5. A very small dipole of dipole moment $\vec{P}$ is fixed on a line in xy plane. Centre of mass of dipole lies on x-axis. A point charge +Q is fixed at origin. $0 < \theta < 90°$

A) Electric force on dipole is parallel to $\vec{p}$
B) Electric force on dipole is parallel to 'x' axis
C) about origin 'O' net Torque on dipole is in clock wise sense
D) Electrostatic interaction Energy of dipole and point charge is negative

6. Two metal spheres of masses m_1 and m_2 are suspended from a common point by a light insulating strings of same length. The spheres are given positive charges q_1 and q_2. Figure A shows angles made by the strings with vertical are different where as for figure B are same. Then, which of the following is possible

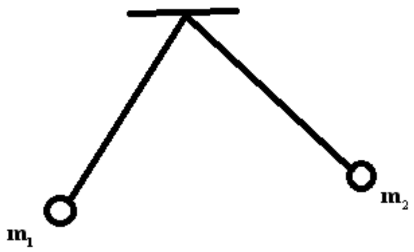


figure A

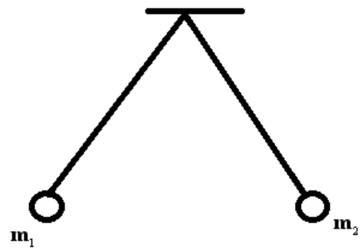
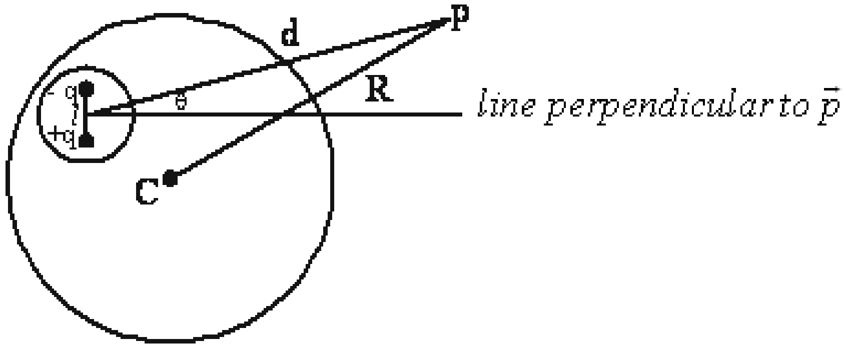


figure B

A) For figure A $m_1 > m_2$ and $q_1 = q_2$
B) For figure A $m_1 > m_2$ and $q_1 < q_2$
C) For figure B $m_1 = m_2$ and $q_1 = q_2$
D) For figure B $m_1 > m_2$ and $q_1 \neq q_2$

7. A spherical cavity is created in a neutral solid conducting sphere, inside the cavity a dipole is placed as shown is figure. Then

('l' is the distance between –q and +q and $l << d$)



A) Potential at P only due to charge induced on the inner surface of the cavity is $\frac{ql\sin\theta}{4\pi\epsilon_0 d^2}$

B) Potential at P only due to charge induced on the inner surface of the cavity is $-\frac{ql\sin\theta}{4\pi\epsilon_0 d^2}$

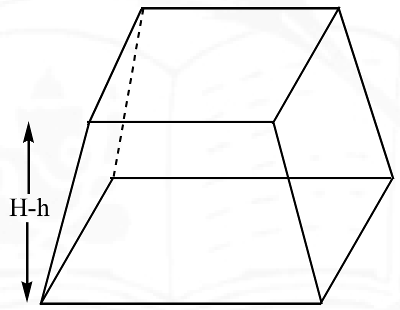
C) Electric field at P is zero

D) Electric field at P is non zero

8. A charge is uniformly distributed with the volume density $\rho = \alpha\sqrt{r}$ inside a sphere of radius a, where 'r' is distance from the centre of the sphere. Electric field strength vector $\vec{E}$ inside the sphere at a position vector $\vec{r}$ W.R.T centre of the sphere can be expressed as $\vec{E} = (kr^n)\vec{r}$ then

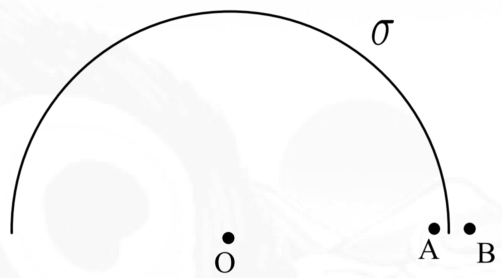
A) $K = \frac{2}{5}\frac{\alpha}{\epsilon_o}$ B) $n = \frac{3}{2}$ C) $n = \frac{1}{2}$ D) $K = \frac{2}{3}\frac{\alpha}{\epsilon_o}$

9. A right pyramid of square base and height H has a uniform charge distributed everywhere within its volume. Electric field and potential at the apex are E_o and V_o. A symmetrical portion of height 'h' $\left(h = \frac{H}{2}\right)$ from top has been removed. The electric field and potential at the same point as mentioned above is E and V respectively. Then,



A) $E = \frac{E_o}{2}$ B) $V = \frac{V_o}{4}$ C) $E = \frac{3E_o}{4}$ D) $V = \frac{3V_o}{4}$

10. A very long hemi cylindrical surface of uniform surface charge density σ is as shown. Radius of the cylinder OA=R where 'O' is a point on its axis and A is a point just inside its surface. B is a point just outside on $\overrightarrow{OA}$ extended. Electric field at ("O" is far away from ends of the hemi cylinder)



A) Point 'O' is $\frac{\sigma}{\pi \in_o}$

B) Point 'O' is $\frac{\sigma}{2\pi \in_o}$

C) Point 'A' is perpendicular to OA

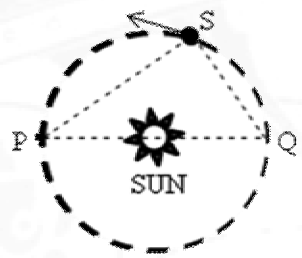
D) Point 'B' is perpendicular to OB

Section-2
(Integer Value Correct Type)

This section contains 10 questions. The answer to each question is a **single digit integer, ranging** from 0 to 9 (both inclusive).

11. Two satellite S_1 and S_2 revolves around a planet in coplanar circular orbits in same sense. Their period of revolution are T and 8T respectively. The angular speed of S_2 as observed by astronaut in S_1 at closest approach and at farthest distance is ω_1 & ω_2 respectively. Find $\frac{9\omega_1}{\omega_2}$=?

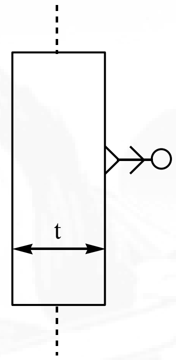
12. A satellite 'S' is revolving around sun in circular orbit. Consider two points 'P' and 'Q' on its one diameter. 'x' and 'y' are the instantaneous rate with which position vector of satellite about 'P' and 'Q' sweeps area. Fill $\frac{x}{y}$ in OMR sheet for the instant shown. Given $\angle SPQ = 30^o$.



13. If an ideal earth (uniform solid sphere of density ρ and radius R) were covered by an ocean of uniform depth h (density of ocean water is σ), then the gravity at the depth of the ocean and at the top of the ocean will be equal for (assume h<<R and no rotation of earth) $12\sigma = x\rho$ where $x =$_____

14. Imagine earth to be thick uniform infinite sheet of thickness t instead of a uniform solid sphere of radius R. If the density of both planets is same and the person standing on both surfaces of planets experiences same gravity then $t=\frac{4R}{x}$ where $x=$________

(Neglect rotation effects of planets)

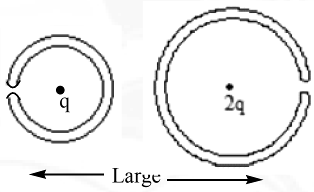


15. A small spherical uniform moon of radius r and mass m is orbiting circularly around a planet (uniform sphere) of mass M while keeping the same face towards the planet. Any object on the moon's surface facing the planet experiences weightlessness if radius of the orbit of moon is $r\sqrt[3]{\frac{xM}{m}}$ where x is --------

16. A cubical wire frame is constructed using 12 identical uniform rods of mass per unit length λ and length l. Now, nine of these rods are removed ,leaving rest of the three such that they are mutually skew perpendicular to each other and also don't touch each other. Gravitational field intensity at the centre of cube due to these three rods is found to be $\sqrt{x}\frac{G\lambda}{\ell}$ where $x=----$

17. Two identical particles A and B each having charge q when released in free space with an initial separation r_o between them, their separation becomes double in time $'t_o'$. If charge on A is made 2q and on B is made 3q and they were released with initial separation $6r_o$ then time taken to double the initial separation is kt_o. What is k?

18. Two isolated conducting spheres of external radii r and 3r have wall thickness $\frac{r}{20}$. At their centres are point charges q and 2q as shown. The expression for the amount of work done by an external agency to slowly exchange the position of the charges is $\frac{-q^2}{10x\pi\in_o r}$ where x= ______________ (approximately) (Assume gaps shown in diagram are negligible)



19. A hollow hemisphere of uniform charge Q_1 is found to produce same electric field at its centre of curvature as does a solid non-conducting hemisphere of uniform charge Q_2 (distributed over its volume). Radii of both spheres is 'R' each. Then $\frac{Q_1}{Q_2}=$

20. A large conducting plate of surface area A and thickness d $(\sqrt{A} >> d)$ is placed perpendicular to a uniform Electric field E. The amount of electrostatic energy stored within the conductor is $\frac{x}{2}\in_o E^2Ad$ where x is __________.