Sample Paper-02
Physics (Theory)
Class – XI

Time allowed: 3 hours **Maximum Marks: 70**

General Instructions:

a) All the questions are compulsory.
b) There are **26** questions in total.
c) Questions **1** to **5** are very short answer type questions and carry **one** mark each.
d) Questions **6** to **10** carry **two** marks each.
e) Questions **11** to **22** carry **three** marks each.
f) Questions **23** is value based questions carry **four** marks.
g) Questions **24** to **26** carry **five** marks each.
h) There is no overall choice. However, an internal choice has been provided in one question of two marks, one question of three marks and all three questions in five marks each. You have to attempt only one of the choices in such questions.
i) Use of calculators is **not** permitted. However, you may use log tables if necessary.
j) You may use the following values of physical constants wherever necessary:
k)

$c = 3x10^{8} m/s$

$h = 6.63x10^{-34} Js$

$e = 1.6x10^{-19} C$

$\mu_o = 4\pi x10^{-7} TmA^{-1}$

$\frac{1}{4\pi\varepsilon_0} = 9x10^{9} Nm^{2}C^{-2}$

$m_e = 9.1x10^{-31} kg$

1. Find the angular velocity of the hour hand of clock.
2. Write down the value of Stefan's constant in SI units if its value in CGS system is 5.67 x 10^{-5} erg s^{-1} cm^{-2} K^{-4}.
3. Give the unit and dimension of moment of inertia?
4. Why a man standing near the top of an old wooden step-ladder feels unstable?
5. What happens to the potential energy of the spring when it is compressed or stretched?
6. If breaking stress of steel = 8.0 x 10^{8} Nm^{-3}, density of steel = 8.0 x 10^{3} kg m^{-3} and g=10 ms^{-2}, find the greatest length of steel wire that can hang vertically without breaking.

   Or

   A steel wire 0.72 m long has a mass of 5.0 x 10^{-3}kg. If the wire is under a tension of 60 N, then what is the speed of the transverse waves on the wire?
7. What will be the ratio of the moments of masses if one of the mass is 'n' times as heavy as the other, have equal K.E?
8. A boy is swinging in the sitting position. How will the period of the swing be changed if he stands up?
9. If the mass of a box measured by a grocer's balance is 2.3 kg and two gold pieces of masses 20.15 g and 20.17 g are added to the box, then calculate
   (a) The total mass of the box.

(b) The difference in the masses of the pieces to correct significant figures.

10. What is the angle of projection at which the H_{max} and range are equal?
11. A Carnot engine whose heat sink is at 27^0C has an efficiency of 40%. By how many degrees should the temperature of source be changed to increase the efficiency by 10% of the original efficiency?

Or

A flask contains argon and chlorine in the ratio 2:1 by mass. The temperature of the mixture is 27^0C. Obtain the ratio of

(i) Average K.E. per molecule

(ii) Root mean square speed v_{max} of the molecules of the two gases.

Given: Atomic mass of argon = 39.9 u; Molecular mass of chlorine = 70.9 u.

12. Find the pressure required to compress a gas adiabatically at atmospheric pressure to one fifth of its volume (Given: ϒ = 1.4)
13. If a block of mass M is placed on a frictionless, inclined plane of angle Θ. Determine

(a) The acceleration of the block after it is released

(b) The force exerted by the incline on the block

14. Calculate the rms speed of oxygen molecules at 1092 K, if the density of oxygen at STP = 1.424 kg m^{-3}.
15. Find the centre of mass of the remaining disc, if a circular hole of radius 1 m is cut off from a disc of radius 6 m and the centre of the hole is 3 m from the centre of the disc.
16. If a block of mass 2 kg is pulled up on a smooth incline of angle 30^0 with horizontal and the block moves with an acceleration of 1 $ms/^2$, then

(a) Find the power delivered by the pulling force at a time 4 seconds after motion starts.

(b) What is the average power delivered during these four seconds after the motion starts?

17. Show the variation of potential energy, K.E and the total energy of a body freely on earth from a height 'h' by using a graph.
18. An automatic manufacturer claims that its super-deluxe sports car will accelerate from rest to a speed of 42.0 ms^{-1} in 8.0 s assuming that the acceleration is constant.

(a) Determine the acceleration of car in ms^{-2}

(b) Find the distance the car travels in 8.0 s

(c) Find the distance the car travels in 8^{th} second.

19. A monkey of mass 40 kg climbs on a rope which stands a maximum tension of 600 N. In which of the following cases will the rope break.

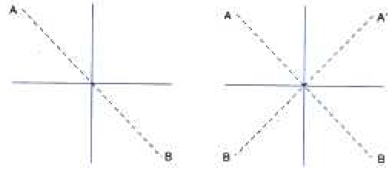
(i) When the monkey climbs up with an acceleration of 6 ms^{-2}

(ii) When the monkey climbs down with an acceleration 4 ms^{-2}

(iii) When the monkey climbs up with a uniform speed of 5 ms^{-1}

(iv) When the monkey falls down the rope nearly freely under gravity

20. Find the moment of inertia of the system about the bisector line AB when two uniform thin identical rods, each of mass m and length L are joined so as to form a cross as shown in the diagram?



21. Deduce an expression for the orbital velocity of a satellite revolving around the earth in a circular orbit at a height 'h' above earth surface.

22. A thermodynamic system is taken an original state to an intermediate state by the linear process shown in the diagram. If its volume is then reduced to the original value from E to F by an isobaric process, then calculate the total work done by the gas from D to E to F.
23. Rishi was discussing about science to his elder sister Shri in the dining room and so their mother came who was cooking in the kitchen shouted at them. All of a sudden, he saw his mother sweating and feeling hot inside the kitchen. Rishi opened the door of the refrigerator thinking that this might relieve her from heat. But, his sister immediately rushed towards him and closed the door. She then made him understand that opening of refrigerator would increase the temperature of the room.
   (a) What values of Shri do you appreciate?
   (b) Why a room cannot be cooled by opening the door of refrigerator?
   (c) If the temperature inside an ideal refrigerator is 285 K, then how much heat is delivered to room for every one joule of work done on working substance when room temperature is 320 K?
24. (i) Show that work done by a stretching force to produce certain extension in the wire is W = ½ stretching force x extension.
   (ii) A wire that obeys Hooke's law is of length l_1 when it is in equilibrium under a tension F_1. Its length becomes l_2 when the tension is increased to F_2. Calculate the energy stored in the wire during this process.

Or

A cubical block of steel of density 7.8 g cm^{-3} floats on mercury (density 13.6 g cm^{-3})with its sides vertical. Assume the side of the cube to be 10cm.
   (a) What length of the block is above the mercury surface?
   (b) If water is poured on the mercury surface, what will be the height of the water column, when the water surface just covers the top of the mercury surface?
25. (a) What causes variation in velocity of a particle?
   (b) A car travels first half of a length S with velocity v_1. The second half is covered with velocities v_2 and v_3 for equal intervals. Find the average velocity of the motion.

Or

   (a) Define centripetal acceleration. Give examples.
   (b) If the length of the seconds hand is 4 cm, calculate
   (c) The speed of the tip of the second's hand.
   (d) The angular speed of the second's hand of a clock.
26. Four identical cylindrical column of steel support a big structure of mass 50000kg. The inner and outer radii of each column are 30 cm and 40 cm respectively. Assuming the load distribution to be uniform, calculate the compressional strain of each column. The Young's modulus of steel is 2.0×10^{11} Pa.

Or

Determine the velocity of water at a point where the diameter is 4 cm when water flows through a horizontal pipe of varying cross section at the rate of 20 L per minute.

Sample Paper-02
Physics (Theory)
Class – XI

Answers

1. $\Omega = 2\pi/12$ hour $= 2\pi/12 \times 3600$ rad/sec
2. $\sigma = 5.67 \times 10^{-8} Js^{-1} m^{-2} K^{-4}$.
3. (a) Unit – kg m^2
   (b) Dimension – $[M^1L^2T^0]$
4. The point of contact of the ladder with the ground is the point about which the ladder can rotate. When the man is at the top of the ladder, the lever arm of force is large.
5. When a spring is compressed or stretched, the potential energy of the spring increases in both the cases due to work done by us in compressing as well as stretching.
6. Let 'L' be the maximum length of the steel wire which can be hang vertically without breaking. In such a case the stretching force is equal to the own weight of wire. If 'A' be the cross-section area of wire and ρ its density,
   Mass of the wire M = ALP
   Stretching force F = mg = ALPg
   Maximum Stress $\sigma_{max} = \frac{Weight}{A} = \frac{ALPg}{A} = LPg$
   $$L = \frac{\sigma_{max}}{\rho g} = \frac{8.0x10^8}{8.0x10^3x10} = 10^4 m$$

Or

   Mass per unit length of the wire, $\mu = \frac{5.0 \times 10^{-3}}{0.72} = 6.9 \times 10^{-3}$ kg/m
   The speed of wave on the wire, $\upsilon = \sqrt{\frac{T}{\mu}} = 93$ m/s
7. $p = \sqrt{2mE_k}$
   $p \alpha \sqrt{m}$
   $$\frac{p_1}{p_2} = \frac{\sqrt{nm}}{\sqrt{m}} = \frac{\sqrt{n}}{1}$$
   $p_1 : p_2 = \sqrt{n} : 1$
8. We can use the concept of simple pendulum. We know that the time period of a simple pendulum is given by,
   $$T = 2\pi\sqrt{\frac{l}{g}}$$
   When the boy stands up, the distance between the point of suspension and the centre of mass of the swinging body will decrease, so T will decrease.
9. (a) Total mass of the box = (2.3 + 0.0217 + 0.0215) kg = 2.3422 kg
   Since the least number of decimal places is 1, the total mass of the box = 2.3 kg
   (b) Difference of mass = 2.17 – 2.15 = 0.02 g
   Since the least number of decimal places is 2, so the difference in masses to the correct significant figures is 0.02 g

10. $\frac{u^2 \sin^2\theta}{2g} = \frac{u^2 \sin 2\theta}{g}$

$\sin^2\theta = 2 \times 2 \sin\theta \cos\theta$

$\sin\theta = 4 \cos\theta$

$\tan\theta = 4$

$\theta = \tan^{-1}(4)$

11. $T_2 = 27^0C = 27 + 273 = 300$ K

$\eta = 40\%$. $T_2 = ?$

$\eta = 1 - \frac{T_2}{T_1}$

$\frac{T_2}{T_1} = 1 - \eta = 1 - \frac{40}{100} = \frac{60}{100} = \frac{3}{5}$

$T_1 = \frac{5}{3} T_2 = \frac{5}{3} \times 300 = 500K$

Increase in efficiency = 10% of 40 =4%

New efficiency η' = 40 + 4 = 44%

Let T_1' be the new temperature of the source,

$\eta' = 1 - \frac{T_2}{T_1'}$

$\frac{T_2}{T_1'} = 1 - \eta' = 1 - \frac{44}{100} = \frac{56}{100}$

$T_1' = \frac{100}{56} T_2 = \frac{100}{56} \times 300 = 535.7K$

Increase in temperature of source = 535.7 – 500 = 35.7 K

Or

The important point to remember is that the average K.E of any gas is always equal to (3/2) k_BT. It depends only on temperature and is independent of the nature of the gas.

(i) Since argon and chlorine both the same temperature in the flask, the ratio of average K.E of the two gases is 1:1

(ii) Now ½ m v_{max}^2 = average K.E per molecule = (3/2)k_BT, where m is the mass of molecule of the gas.

$\frac{(V^2_{rms})_{Ar}}{(V^2_{rms})_{Cl}} = \frac{(m)_{Cl}}{(m)_{Ar}} = \frac{(M)_{Cl}}{(M)_{Ar}} = \frac{70.9}{39.9} = 1.77$

Where M denotes the molecular mass of the gas, taking square root on both sides,

$\frac{(V_{rms})_{Ar}}{(V_{rms})_{Cl}} = 1.33$

Note that the composition of the mixture by mass is quite irrelevant to the above calculation. Any other proportion by mass of argon and chlorine would give the same answer (i) and (ii) provided the temperature remains unaltered.

12. P_1 = 1 atm.

V_1 = x cc and $V_2 = \frac{x}{5}$ cc

Υ = 1.4 and P_2 =?

Using the relation $P_1V_1^{\Upsilon} = P_2V_2^{\Upsilon}$

$P_2 = P_1 = \left(\frac{V_1}{V_2}\right)^{\gamma} = 1\left(\frac{x}{\frac{x}{5}}\right)^{1.4} = (5)^{1.4}$

Taking log both sides, we get

Log P_2 = 1.4 log 5 =1.4 x 0.6990

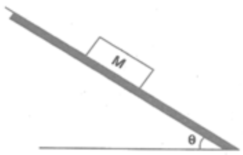
= 0.97860

P_2 = 9.519 atm.

13. When the block is released, it will move down the incline.

Let its acceleration be a.

As the surface is frictionless, so the contact force will be normal to the plane. Let it be N.



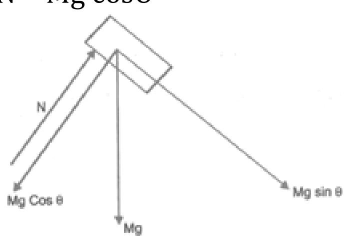
Here for the block we can apply equation for motion along the plane and equation for equilibrium perpendicular to the plane.

Mg sin Θ = Ma

a = g sin Θ

Mg cosΘ - N = 0

N = Mg cosΘ



14. First calculate the root-mean square speed of oxygen at STP

P_0 = 0.76 m of Hg = 1.01 x 10^5 Nm^{-2}

P_0 = 1.424 kg m^{-3}

The root-mean square speed at 0^0C is given by,

$$c_0 = \sqrt{\frac{3P_0}{\rho_0}}$$

$$c_0 = \sqrt{\frac{3 \text{ x } 1.01 \text{ x } 10^5}{1.424}} ms^{-1} = 4.61 \text{ x } 10^2 ms^{-1}$$

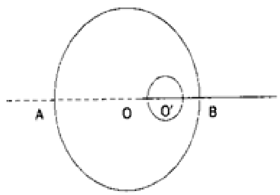
$$c_{rms} = \sqrt{\frac{3kT}{m}}$$

$$\frac{c_{rms}}{c_0} = \sqrt{\frac{T}{T_0}}$$

T_0 = 273 K and T = 1092 K

$$c_{rms} = c_0\sqrt{\frac{T}{T_0}} = 4.61 \text{x } 10^2 \text{ x} \sqrt{\frac{1092}{273}} = 9.22 \text{ x } 10^2 ms^{-1}$$

15. Let O be the centre of the disc and O' that of the hole. To find the centre of mass, we use the fact that a body balances at this point. The algebraic sum of the moments of the weights about the centre of gravity is zero. The weight W_1 of the disc acts at point O. The hold can be regarded as a negative weight W_2acting at O'. If X is distance of the centre of gravity of the combination from point O then



$$x = \frac{W_1 x\ O + (-W_2) x 3}{W_1 + (-W_2)}$$

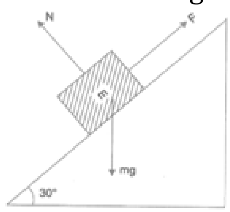
$W_1 = \rho\pi x (6)^2 = 36\rho\pi$

$W_2 = \rho\pi\ x\ (1)^2 = \rho\pi$

where ρ is the mass per unit area of the disc. by passing the value of W_1 and W_2 we get,

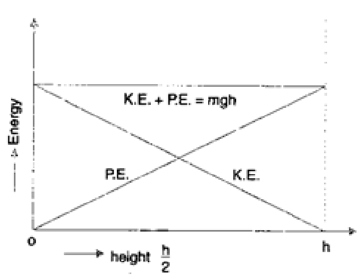
$$x = \frac{-\rho\pi\ x\ 3}{36\ \rho\pi - \rho\pi} m = \frac{-3}{35} m$$

16. The force acting on the block are presented in the diagram



Resolving the forces parallel to incline
F – mg sin Θ = ma
F = mg sin Θ + ma
= 2 x 9.8 x sin 30^0 + 2 x 1= 11.8 N
The velocity after 4 seconds = u + at
= 0 + 1 x 4= 4 m/s
Power delivered by force at t =4 seconds
= force x velocity
= 11.8 N x 4 s = 47.2 W
The displacement during 4 seconds is given by
$v^2 = u^2 + 2\ a\ s$
= 0 + 2 x 1 x s
s =8 m
The work done in 4 seconds = force x distance
11.8 x 8 = 94.4 J
Average power delivered = work done / time
= 94.4 / 4 = 23.6 V

17.



Graphs depicting variations of (i) gravitational potential energy (P.E) (ii) K.E and (iii) the total sum of potential and Kinetic energies for a freely falling body are shown in the diagram.

(i) Gravitational potential energy decease as the body falls downwards and is zero at earth.
(ii) Kinetic energy increase as the body falls downwards and will be at maximum when the body just strikes the ground.
(iii) The sum of kinetic and potential energy remains constant at all during its free fall.

18. (a) Given that u =0 and velocity after 8 s is 42 m/s. So, acceleration

$$a = \frac{v - u}{t}$$

$$= \frac{42.0 - u}{8.0} = 5.25 ms^{-2}$$

(b) Distance travelled in 8 s

$s = ut + ½ at^2$

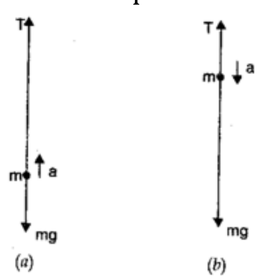
$= 0 + ½ \times 5.25 \times 8^2 = 168$ m

(c) Distance travelled in 8^{th} second

$$S_n = u + (2n - 1)\frac{a}{2}$$

$$= (2 \times 8 - 1) \times \frac{5.25}{2} = 39.375 \text{ m}$$

19. (i) When the monkey climbs up with an acceleration a, then T - mg = ma
Where T represents the tension
T = m g + ma = m (g + a)
T' = 40kg (10 + +6) ms^{-2} = 640 N
But the rope can withstand a maximum tension of 600 N. so the rope will break.



When the monkey is climbing down with an acceleration then mg – T = ma
T = mg – ma = m (g – a)
T = 40 kg x (10 – 4) ms^{-2} = 240 N
The rope will not break
(i) When the monkey climbs up with uniform speed
T = mg = 40 kg x 10 ms^{-2} = 400 N
The rope will not break.
(ii) When the monkey is falling freely, it would be state of weightlessness. So tension will be zero and the rope will not break.

20. Take a bisector line A'B' perpendicular to bisector line AB.
Moment of inertia about an axis perpendicular to the plane and passing through the point of intersection is

$$2x\frac{ML^2}{12} or \frac{ML^2}{6}$$

Applying theorem of perpendicular axis we get

$$\frac{ML^2}{6} = I_{AB} + I_{A'B'}$$

$$2I = \frac{ML^2}{12}$$

21. Consider the satellite of mass m revolving around the earth at a height h from its surface so that radius of its orbit r = R + h. If v_0 be the orbital velocity of satellite then centripetal force needed by it for its uniform circular motion is

$$F = \frac{mv_0^2}{r}$$

This value of centripetal force is provided by the gravitational pull of the earth acting on the satellite.

$$F = \frac{GMm}{r^2}$$

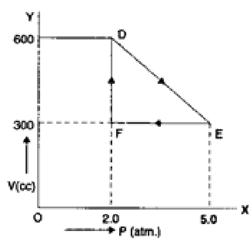
$$\frac{mv_0^2}{r} = \frac{GMm}{r^2}$$

$$v_0 = \sqrt{\frac{GM}{r}} = \sqrt{\frac{GM}{(R+h)}}$$

$$g = \frac{GM}{R^2}$$

$$v_0 = \sqrt{\frac{gR^2}{(R+h)}} = R\sqrt{\frac{g}{(R+h)}}$$

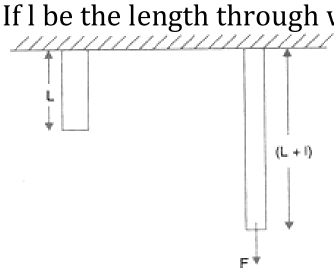
22.



Change in pressure Δ P = EF = 5.0 – 2.0 = 3.0 atm = 3.0×10^5 Nm^{-2}
Change in volume Δ V = DF = 600 – 300 = 300 cc = $300 \times 10^{-6} m^3$
Work done by the gas from D to E to F = area of Δ DEF
W = ½ x DF x EF
= ½ x $(300 \times 10^{-6}) \times (3.0 \times 10^5)$ = 45 J

23. (a) She is sensible and has scientific knowledge.
(b) This is because a refrigerator rejects heat from inside to the air in the room and so the room temperature increases gradually.
(c) By substituting values in $\beta = \frac{Q_2}{W} = \frac{T_2}{T_1 - T_2}$, we get
Q_1 = 6.9 J and Q_2 = 7.9 J

24. Consider a wire of length L and area of cross-section A. Let a force F be applied to stretch the ire. If l be the length through which the wire is stretched, then



Longitudinal strain = $\frac{l}{T}$ and tensile stress = $\frac{F}{A}$

Young's modulus of elasticity

$$Y = \frac{stress}{strain} = \frac{F/A}{l/L} = \frac{FL}{Al}$$

$$F = \frac{YAl}{L} \quad \text{...} \text{ (i)}$$

If the wire is stretched through a length dl, then work done is given by

$$dW = Fdl = \frac{YAl}{L}dl \quad \text{...} \text{ (ii)}$$

Total work done to stretch the wire through length l can be calculated by integrating equation (ii) between the limits l = 0 to l = l

$$\int dW = \int_0^l \frac{YA}{L} ldl$$

$$W = \frac{YA}{L}\frac{l^2}{2} = \frac{1}{2}\left(\frac{YAl}{L}\right)xl$$

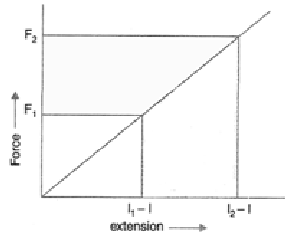
W = ½ F x l

Work done = ½ stretching force x extension

W_1 = ½ $F_1(l_1 - l)$ and W_2 = ½ $F_2(l_2 - l)$

U = W_2-W_1 = ½ $F_2(l_2 - l)$ – ½ $F_1(l_1 - l)$

= ½ [$F_2 l_2 - F_1 l_1 + (F_1 - F_2) l$]



$$\frac{F_1}{F_2} = \frac{l_1 - l}{l_2 - l}$$

(F_2-F_1)l =$F_2 l_1$ – $F_1 l_2$

$$I = \frac{F_2 l_2 - F_1 l_2}{F_2 - F_1}$$

$$U = \frac{1}{2}\left[F_2 l_2 - F_1 l_1 + (F_1 - F_2)\frac{F_2 l_1 - F_1 F_2}{F_2 - F_1}\right]$$

$$U = \frac{1}{2}[F_2 l_2 - F_1 l_1 - F_2 l_1 + F_1 l_2]$$

$$U = \frac{1}{2}[(F_2 + F_1) l_2 - (F_2 + F_1) l_1]$$

$$U = \frac{1}{2}[(F_2 + F_1)(l_2 - l_1)]$$

Or

(a) Volume of the steel block = 10 x 10 x 10 = 1000 cm^3

Weight of the steel block = 1000 x 7.8 g

Volume of the block below the surface is (10 – l_1) x 100 where l_1 is the length of the block above the surface of mercury.

The weight of mercury displaced by the block = (10 – l_1) x 100 x 13.6 g

According to Archimedes principle, this must be equal to the weight of the block.

$(10 - l_1)$ x 100 x 13.6 = 7800

l_1 = 4.26 cm

(b) Let l_2 be the height of the water column

Weight of the block = weight of water displaced + weight of mercury displaced

7800 = l_2 x 100 x 1 + $(10 - l_2)$ x 100 x 13.6

l_2 = 4.6 cm

25. (a) Change in magnitude of velocity. Change in direction of motion of the motion and change in magnitude as well as direction of the motion.

(b) Average velocity,

$$v = \frac{\text{Total Displacement}}{\text{Total time taken}}$$

Time taken to cover the first half of the length $= \frac{S}{2v_1}$

Time taken to cover the second half of the length = 2t

$$v = \frac{S}{\frac{S}{2v_1} + 2t}$$

Second half is divided equally into two parts with equal time

$\frac{S}{2}$ = $v_2t + v_3t$

= $(v_2 + v_3)$ t

$$2t = \frac{S}{(v_2 + v_{3)}}$$

$$v = \frac{S}{\frac{S}{2v} + \frac{S}{(v_2 + v_3)}}$$

$$v = \frac{2v_1(v_2 + v_1)}{(v_2 + v_3 + 2v_1)}$$

Or

(a) Acceleration needed for a particle to undergo uniform circular motion is called "centripetal acceleration". It is directed along the radius of circular path towards its centre. Two common examples are:

(i) An electron revolving around the nucleus of an atom in a uniform circular motion experiences a centripetal acceleration on account of Coulombian electrostatic force on electron due to nucleus.

(ii) A satellite revolving around the earth in a circular orbit experiences a centripetal acceleration on account of gravitational force due to the earth

(b) Second's hand of a clock completes one rotation in 60 second's

T = 60 s, $\theta = 2\pi$ rad

Angular speed $\omega = \frac{\theta}{T} = \frac{2\pi rad}{60s}$

$$\omega = \frac{\pi}{30} rads^{-1}$$

Length of the second's hand R = 4 cm

Speed of the tip of second's hand is

$$v = \omega R = \frac{\pi}{30} \text{ x } 4 = \frac{2\pi}{15} cms^{-1}$$

26. M = 50000 kg; r_1 = 0.30m; r_2= 0.40m; Y =2.0 x 10^{11} Pa.

Area of cross section of each column,

$a = \pi (r^2_2 - r^2_1) = \pi[(0.4)^2 - (0.3)^2]$

$= \pi \times 0.07\ m^2$

Whole weight of the structure = Mg = 50000 x 9.8 N

This weight is equally shared by four columns,

Compressional force on one column,

$$F = \frac{5000 \times 9.8}{4} N$$

$$Y = \frac{F/a}{\text{compressionalstrain}}$$

$$\text{Compressional strain} = \frac{F}{aY}$$

$$= \frac{50000 \times \frac{9.8}{4}}{(\pi \times 0.07) \times 2.0 \times 10^{11}} = 2.785 \times 10^{-6}$$

Or

V = 20 L/min = 1/3 x $10^{-3} m^3 s^{-1}$

R = 4/2 = 2 cm = 0.02 m

$$A = \pi r^2 = \frac{22}{7} \times (0.02)^2 m^2$$

Now, V = av

Substituting we get,

$$v = \frac{7 \times 10^{-3}}{3 \times 22 \times (0.02)^2}$$

= 0.2639 m/s