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 $\sigma_{\max} = \frac{Weight}{A} = \frac{ALPg}{A} = LPg$
   $$L = \frac{\sigma_{\max}}{\rho g} = \frac{8.0 \text{x} 10^8}{8.0 \text{x} 10^3 \text{x} 10} = 10^4 m$$

   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

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

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

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

$\tan \theta = 4$

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

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

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

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

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

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

Increase in efficiency = 10% of 40 = 4%

New efficiency $\eta' = 40 + 4 = 44\%$

Let T_1' be the new temperature of the source,

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

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

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

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.

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

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 $V_2 = \dfrac{x}{5}$ cc

$\Upsilon = 1.4$ and $P_2 = ?$

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

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

Taking log both sides, we get

Log P_2 = 1.4 log 5 =1.4 x 0.6990

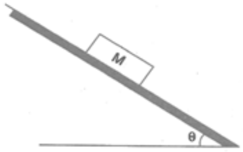
= 0.97860

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.



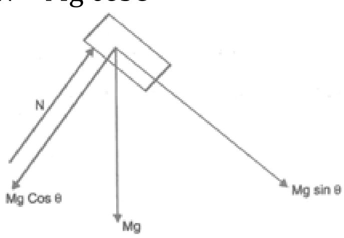
Here for the block we can apply equation for motion along the plane and equation for equilibrium perpendicular to the plane.

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,

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

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

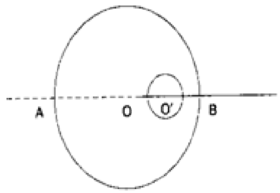
$c_{rms} = \sqrt{\frac{3kT}{m}}$

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

T_0 = 273 K and T = 1092 K

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

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



$$x=\frac{W_1 x\ O+(-W_2)x3}{W_1+(-W_2)}$$

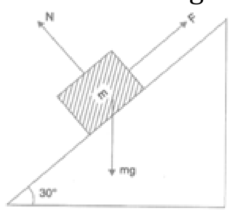
$W_1=\rho\pi x(6)^2=36\rho\pi$

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

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

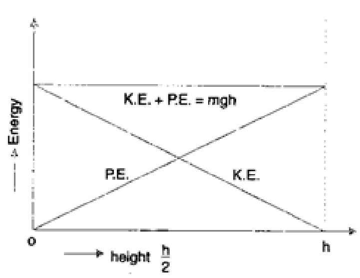
$$x = \frac{-\rho\pi\ x\ 3}{36\ \rho\pi - \rho\pi} m = \frac{-3}{35} m$$

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



Resolving the forces parallel to incline
$F - mg \sin \Theta = ma$
$F = mg \sin \Theta + ma$
$= 2 \times 9.8 \times \sin 30^0 + 2 \times 1 = 11.8$ 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.

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(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

$s = ut + ½ at^2$

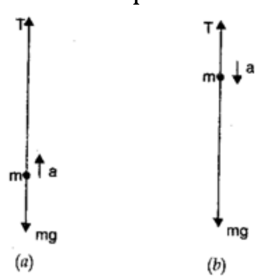
$= 0 + ½ \times 5.25 \times 8^2 = 168$ m

(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

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

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

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.

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

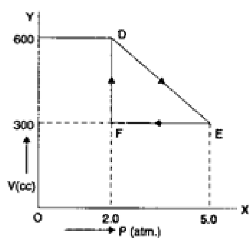
$$\frac{mv_0^2}{r} = \frac{GMm}{r^2}$$

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

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

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

22.



Change in pressure $\Delta P = EF = 5.0 - 2.0 = 3.0$ atm $= 3.0 \times 10^5\ Nm^{-2}$

Change in volume $\Delta V = DF = 600 - 300 = 300$ cc $= 300 \times 10^{-6} m^3$

Work done by the gas from D to E to F = area of Δ DEF

$W = \frac{1}{2} \times DF \times EF$

$= \frac{1}{2} \times (300 \times 10^{-6}) \times (3.0 \times 10^5) = 45$ J

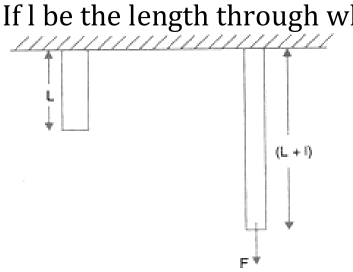
23. (a) She is sensible and has scientific knowledge.

(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



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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

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

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

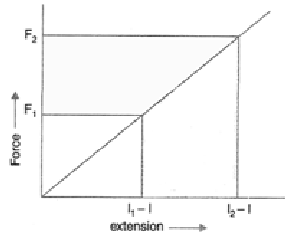
W = ½ F x l

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, θ = 2π 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

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

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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, $V = a\,v$

Substituting we get,

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

= 0.2639 m/s

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