Sample Paper-01
Physics (Theory)
Class – XI

Answers

1. This is not always true because heat content of a body depends on mass of the body, its specific heat and temperature.
2. The apparent weight of the floating block is equal to zero because the weight of the block acting vertically downwards is balanced by the buoyant force acting on the block upwards.
3. (a) 7.776×10^{4}
   (b) 1.06×10^{-16}
4. If impurity is mixed in liquid, the surface tension of the liquid decreases.
5. Yes. When two bodies move in opposite direction then the relative velocity of each is greater than the individual velocities.
6. $u\cos\theta=\frac{u}{2}$

   $\cos\theta=\frac{1}{2}\Rightarrow\theta=60^\circ$

   Horizontal range =R = $\frac{u^2\sin 2\theta}{g}$

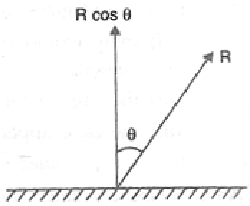
   R = $\frac{u^2\sin 2\times 60^\circ}{8}$

   $=\frac{u^2\sin 120^\circ}{g}=\frac{\sqrt{3}u^2}{2g}$
7. Let the ball fall from height h then,
   Kinetic energy of ball at the time of just striking the ground = Potential energy of ball at height h,
   K = mgh
   Similarly, on rebounding the ball moves to a maximum height h’, then kinetic energy will be K’ = mgh’
   Loss of kinetic energy K – K’ = mgh – mgh’ = mg (h –h’)
   = mg (h – 80/100h) = mgh x (0.2)
   Fractional loss in K.E. of ball in each re-bounce = K –K’/K
   = mgh x (0.2)/mgh = 0.2
   = 0.2 x 100% = 20%
8. $T=2\pi\sqrt{\frac{l}{g}}$

   $g=4\pi\frac{l}{T^2}$

   $\frac{\Delta g}{g}=\frac{\Delta l}{l}+2\frac{\Delta T}{T}$

   % of error in g = 1% + 2 x 2% = 5%
9.



Let R represents the reaction offered by the ground. The vertical component $R\cos\theta$ will balance the weight of the person and the horizontal component $R\sin\theta$ will help the person to walk forward.

Normal reaction = $R\cos\theta$

Friction force = $R\sin\theta$

Coefficient of friction

$$\mu = \frac{R\sin\theta}{R\cos\theta} = \tan\theta$$

In along step, θ is more and tan θ is more. But μ has a fixed value. So, there is danger of shipping in along step.

10. $K=\frac{PV}{\Delta V}$

$\Delta V=\frac{PV}{V}$

P= $5\times10^{8}\,Nm^{-2}$

$V=\frac{4}{3}\pi r^3=\frac{4}{3}\pi(0.1)^3 m^3$

$V=4.19 \text{ x } 10^{-3}m^3$

$K=3.14 \text{ x } 10^{11}Nm^{-2}$

$\Delta V=\frac{5 \text{ x } 10^8 \text{ x } 4.19 \text{ x } 10^{-3}}{3.14 \text{ x } 10^{11}}=6.67 \text{ x } 10^{-6}m^3$

Or

(a) Here,

Volume of wood body outside water = $\frac{v}{4}$

Volume of wood body inside water = $V - \frac{V}{4}$

Now, weight of water displaced by wood = $\frac{3V}{4} \text{ x } 10^3 g$

Therefore, Vρg = $\frac{3V}{4} \text{ x } 10^3 g$

Then, ρ = 750 kg/m^3

(b) This is because the lives saving jackets have air in them which keeps us afloat if we accidently fall into water.

11. $T_2 = 27°C$ = 27 + 273 = 300 K

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

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

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

$T_1 = \frac{5}{3}, \; T_2 = \frac{5}{3} \times 100$

=500K

Increase in efficiency = 10% of 40 =4%

New efficiency η' = 40 + 4 = 44%

Let T_1' be the new temperature of the source,

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

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

$T_1' = \frac{100}{56} T_2 = \frac{100}{56}$ x 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 $\left(\frac{3}{2}\right) k_B T$.

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 $\frac{1}{2} m v_{\max^2}$ = average K.E per molecule = $\left(\frac{3}{2}\right) k_B T$, where m is the mass of molecule of the gas.

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

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

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

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

γ = 1.4 and P_2 =?

Using the relation $P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$

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

$$=1\left(\frac{x}{\frac{x}{5}}\right)^{1.4} = (5)^{1.4}$$

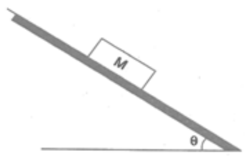
Taking log both sides, we get

$Log P_2 = 1.4 \log 5 = 1.4 \times 0.6990$

$= 0.97860$

$P_2 = 9.519$ 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.



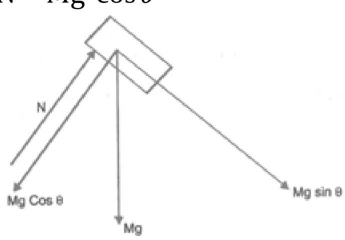
Here for the block we can apply equation for motion along the plane and equation for equilibrium perpendicular to the plane.

Mg $\sin\theta$ = Ma

a = g $\sin\theta$

Mg $\cos\theta$ - N = 0

N = Mg $\cos\theta$



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

P_0 = 0.76 m of Hg = $1.01 \times 10^5\ Nm^{-2}$

P_0 = 1.424 kg m^{-3}

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

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

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

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

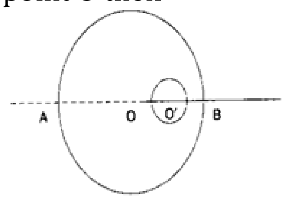
$$\frac{c_{ms}}{c_0} = \sqrt{\frac{T}{T_0}}$$

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_2 acting at O'. If X is distance of the centre of gravity of the combination from point O then



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

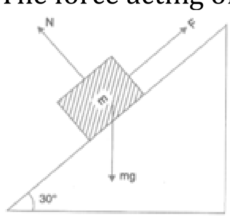
$$W_1=\rho\pi x(6)^2=36\rho\pi$$

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

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

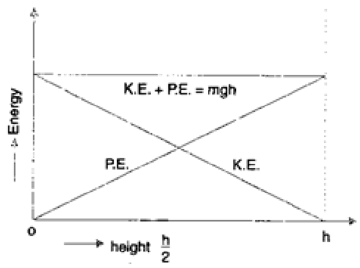
$$x = \frac{-\rho\pi\ x\ 3}{36\ \rho\pi - \rho\pi} m = \frac{-3}{35} m$$

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
= $2\times9.8\times\sin 30°+2\times1=11.8$ N
The velocity after 4 seconds = u + at
$=0+1\times4=4\ m/s$
Power delivered by force at t =4 seconds
= $force\times velocity$
= $11.8N\times4s$ = 47.2 W
The displacement during 4 seconds is given by
$v^2=u^2+2as$
$=0+2\times1\times s$
s =8 m
The work done in 4 seconds = $force\times distance$
11.8×8 = 94.4 J
Average power delivered = $\frac{work\ done}{time}$
= 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

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

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

(a) Distance travelled in 8 s

$$s = ut + \frac{1}{2}at^2$$

$$= 0 + \frac{1}{2} \times 5.25 \times 8^2$$

=168 m

(b) Distance travelled in 8th second

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

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

= 39.375 m

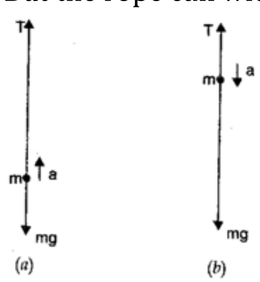
19. (i) When the monkey climbs up with an acceleration a, then T - mg = ma

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.



(ii) When the monkey is climbing down with an acceleration then mg – T = ma

T = mg – ma = m (g – a)

T = $40kg \times (10 - 4) ms^{-2}$ = 240 N

The rope will not break

(iii) When the monkey climbs up with uniform speed

$T = mg = 40kg \times 10ms^{-2} = 400$ N

The rope will not break.

(iv) 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.

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

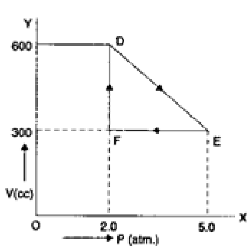
$$\frac{mv_0^2}{r} = \frac{GMm}{r^2}$$

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

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

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

22.



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

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

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

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

$= \frac{1}{2}\times\left(300\times10^{-6}\right)\times\left(3.0\times10^{5}\right) = 45$ J

23. (a) She has presence of mind and is helpful in nature.

(b) She has used linear expansion of solids.

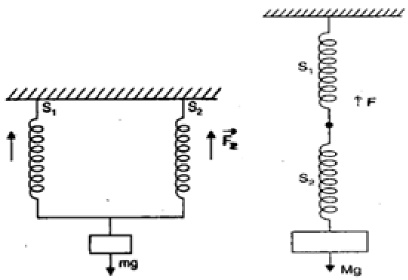
(c) Here,

$L_1 = 6.231$ m, $L_2 = 6.243$ m, $T_1 = 27^0C$

Using the formula, $\alpha = \frac{L_2 - L_1}{L_1(T_2 - T_1)}$

We get $T_2 = \frac{6.243 - 6.231}{6.243 \text{ x } 1.2 \text{ x } 10^{-5}} + 27 = 187^0C$

24.



Consider the body of mass M suspended by two springs connected in parallel. Let K_1 and K_2 be the spring constants of two springs.

Let the body be pulled down so that each spring is stretched through a distance y. Restoring F_1 and F_2 will be developed in the springs S_1 and S_2.

According to Hooke's law $F_1 = - K_1y$ and $F_2 = - K_2y$

Since both the forces acting in the same direction, total restoring force acting on the body is given by

$F = F_1 + F_2 = - K_1 y - K_2 y = - (K_1 + K_2)y$

Acceleration produced in the body is given by

$a = \frac{F}{M} = - \frac{(K_1+K_2)Y}{M}$ ……………………………. (i)

Since $\frac{(K_1+K_2)}{M}$ is constant $a = - y$

Hence motion of the body is SHM

The time period of body is given by

$T = 2\pi\sqrt{\frac{y}{|a|}} = 2\pi\sqrt{\frac{M}{K_1+K_2}}$ ……………………… (ii)

$K_1 = K_2 = K$

$T = 2\pi\sqrt{\frac{M}{2K}}$

For series:

Consider the body of mass M suspended by two springs S_1 and S_2 which are connected in series. Let k_1 and k_2 be the spring constants of spring S_1andS_2.

At any instant the displacement of the body from equilibrium position is y in the downward direction. If y_1 and y_2 be the extension produced in the springs S_1 and S_2.

$y = y_1 + y_2$ ……………………….... (i)

Restoring the forces developed in S_1 and S_2 are given by,

$F_1 = -k_1 + y_1$ ……………………………… (ii)

$F_2 = -k_2 + y_2$ …………………………….. (iii)

Multiplying the equation (ii) by k_2 and equation (iii) by k_1 and adding we get,

$K_2F_1 + k_1F_2 = -k_1k_2(y_1+y_2) = -k_1k_2\, y$

Since both the springs are connected in series.

$F_1 = F_2 = F$

$F(k_1 + k_2) = -k_1k_2y$

$$F = \frac{k_1k_2}{(k_1 + k_2)\,y}$$

If 'a' be the acceleration produced in the body of mass 'M' then,

$$a = \frac{F}{M} = \frac{k_1k_2y}{(k_1+k_2)M} \quad \text{………………………. (iv)}$$

Time period of the body is given by,

$$T = 2\pi\sqrt{\frac{y}{|a|}} = 2\pi\sqrt{\frac{(k_1+k_2)M}{k_1k_2}}$$

$$T = 2\pi\sqrt{\left(\frac{1}{k_1}+\frac{1}{k_2}\right)M}$$

Or

Let the frequency of the first tuning fork be n. as last fork is octave of the first therefore frequency of the last fork = 2n

As each fork gives 4 beats / seconds with the preceding one,

Therefore, frequency of 2nd fork = n + 4

Frequency of the 3rd fork = n +8 = n +4(2) = n + 4(3-1)

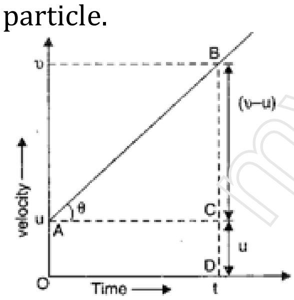
Proceeding in this way, frequency of 24th fork = n + 4(24 -1) = n +92

2n = n + 92 or n = 92 Hz.

Frequency of the last fork = 2n = 2 x 92 = 184 Hz.

25. Uniformly accelerated motion, we can drive some simple equation that relate displacements (x), time taken (f), initial velocity (u), final velocity (v) and acceleration (a).

(i) Velocity attends after time t: the velocity-time graph for positive constant acceleration of a particle.



Let u be the initial velocity of the particle at l =0 and v is the final velocity of the particle after time t. consider two points A and B on the curve corresponding to t=0 and t =t.

Draw ZBD perpendicular to time axis. Also draw AC perpendicular to BD.

OA = CD = u

BC = (v – u) and OD = t

Now,

Slope of v – t graph = acceleration (a)

a = slope of v – t graph

$\tan\theta = \frac{BC}{AC} = \frac{BC}{OD}$

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

v – u = at

v = u + at

(ii) Distance travelled in time t will be,

x_0 = position of the particle at t = 0 from the origin

x = position of the particle at t = t from the origin

$(x - x_0)$ = S = distance travelled by the particle in the time interval (t - 0) = t

Distance travelled by a particle in the given time

Interval = area under velocity-time graph

$(x - x_0)$ = area OABD

= area of Trapezium OABD

= ½ [Sum of parallel sides **x** perpendicular distance between parallel sides]

= ½ (OA + BZD) x AC

= ½ (u + v) x t

v = u + at

$(x - x_0)$ = ½ (u + u + at) x t

= ½ (2u + at) x t

= $ut + \frac{1}{2}at^2$

$x - x_0 = S$

$S = ut + \frac{1}{2}at^2$

(iii) Velocity attained after travelling a distance S:

Distance travelled by a particle in time t is equal to the area under velocity-time graph. The distance (s) travelled by a particle during time interval t is given by

S = area under v – t graph

S = area of Trapezium OABD

= ½ (sum of parallel sides) x perpendicular distance between these parallel sides

S = ½ (OA + OD) x AC ……………………… (i)

Acceleration a = slope of v – t graph

$A = \frac{BC}{AC} = \frac{BD - CD}{AC} = \frac{v - u}{AC}$

$AC = \left(\frac{v - u}{a}\right)$ ……………………… (ii)

OA = u and BD = v …………………………… (iii)

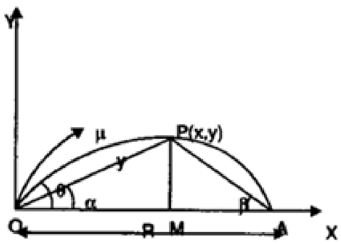
From equation (i), (ii) and (iii) we get

$S = \frac{1}{2}(v+u)\frac{(v-u)}{a}$

$S = \frac{v^2 - u^2}{2a}$

$v^2 - u^2 = 2aS$

Or



From the $\tan\alpha = \dfrac{y}{x}$ where R is horizontal range.

$$\tan\beta = \frac{y}{MA} = \frac{y}{R-x}$$

$$\tan\alpha + \tan\beta = \frac{y}{x} + \frac{y}{R-x}$$

$$= \frac{(R-x+x)y}{x(R-x)} = \frac{yR}{x(R-x)}$$

$$\tan\alpha + \tan\beta = \frac{yR}{x(R-x)} \quad \text{.......................................} \text{ (i)}$$

$$x = (u\cos\theta)t \quad \text{..} \text{ (ii)}$$

$$y = (u\sin\theta)t - \frac{1}{2}gt^2 \quad \text{...................................} \text{ (iii)}$$

From equation (ii) and (iii),

$$y = x\tan\theta\left[1 - \frac{xg}{2u^2\cos^2\theta\tan\theta}\right]$$

Substituting, $R = \dfrac{2u^2\sin\theta\cos\theta}{g}$

$$y = x\tan\theta\left[1 - \frac{xg}{2u^2\cos\theta\sin\theta}\right]$$

$$y = x\tan\theta\left[1 - \frac{x}{R}\right]$$

$$\frac{y}{x} = \tan\theta\left(\frac{R-x}{R}\right) \quad \text{.................................} \text{ (iv)}$$

Putting (iv) in (i) we get,

$$\tan\alpha + \tan\beta = \frac{yR}{x(R-X)} = \tan\theta$$

$$\tan\alpha + \tan\beta = \tan\theta$$

26. The second stone will catch up with the first stone when the distance covered by it in (t – n) second will equal the distance covered by the first stone in t second.

The distance covered by the first stone in t second = ½ gt^2 and distance covered by the second stone in (1 –n) second.

u (t –n) + ½ g $(t-n)^2$

½ gt^2 = u (t – n) + ½ g $(t-n)^2$

½ g [t^2 – $(t-n)^2$] = u (t –n)

½ g [(2t –n) n] = u (t –n)

gnt – ½ gn^2 = ut –un

t (gn – u) = (½ gn –u)n

$$t = \frac{n\left(\frac{1}{2}gn - u\right)}{(gn-u)}$$

The distance covered by the first stone in this time

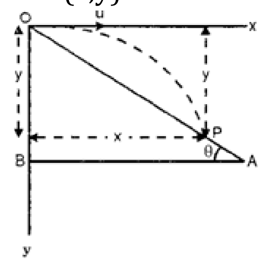
$$h = \frac{1}{2}gt^2 = \frac{1}{2}g\left[\frac{n\left(\frac{1}{2}gn - u\right)}{(gn - u)}\right]$$

Thus the second stone will overtake the first at distance

$$\frac{1}{2}g\left[\frac{n\left(\frac{gn}{2} - u\right)}{(gn - u)}\right]^2$$

Or

Let the particle projected from O strike the inclined plane OA at P after time t and coordinates of P be (x,y).



Taking motion of projectile from O to P along x-axis we have
$x_0 = 0$, $x = x$, $u_x = u$, $a_x = 0$, $t = t$
Using the relation $x = x_0 + u_x t + ½ a_x t^2$
We get x = ut or i =x/u
Taking motion of projectile along y – axis
$y_0 = y$, $y = y$, $u = 0$, $a_y = g$, $t = t$
Using the relation $y = y_0 + u_y t + ½ a_y t^2$

$$y = 0 + 0 + \frac{1}{2}gt^2 = \frac{1}{2}gt^2 = \frac{1}{2}g\frac{x^2}{u^2}$$

$y = x \tan \Theta$, so $gx^2 / 2u^2 = x \tan\Theta$

$$x = \frac{2u^2\tan\theta}{g}$$

And $y = x\tan\Theta = \dfrac{2u^2\tan^2\theta}{g}$

Distance OP = $\sqrt{x^2 + y^2}$

$$= \frac{2u^2\tan\theta}{g}\sqrt{1+\tan^2\theta}$$

$$= \frac{2u^2\tan\theta\sec\theta}{g}$$