Nagaland Board
Class XI
Physics
Sample Paper 1 – Solution

1. (ii)There are seven positions along the medium which have vibrations between a large positive and a large negative displacement

2. (ii) As period of oscillator depends upon inertia factor and spring factor which in turn are independent of amplitude. So, the period of simple harmonic oscillator would remain the same on doubling the amplitude

3. (iv) A frame of reference is a set of coordinate axes that helps to determine the position of a body in space at any instant of time.

4. (iv) In a refrigerator, external work is done by the compressor for the transfer of heat from the cold cooling coils to warm surroundings. Hence, the second law of thermodynamics is not violated and this process is favoured.

5. (i)Decreasing the temperature of a liquid, decreases the average K.E. of the molecules, thus bringing them closer and binding them tightly; due to which the liquid changes into a solid.

6. Dimension of ɑ = dim of F × dimension of x
As dimension of LHS = dimension of RHS (each term)
ɑ = $[ML^2T^{-2}]$

7. No, it is not possible. In order to change the state of motion of a body, some net external force must act on the body.

8. Impulse and change in momentum are along the same direction. Therefore, angle between these two vectors is zero degree

9. Work is done by the winning team. It is equal to the product of the resultant force applied by the two teams and the displacement that the losing team suffers.

10. Since in case of a parachute fall, appreciable work is done against the non-conservative force of friction, Bernoulli's equation as such cannot be applied

11.

$$1 \text{ light year} = 9.46 \times 10^{15}\,\text{m}$$
$$1 \text{ par sec} = 3.08 \times 10^{16}\,\text{m}$$
$$\therefore 1 \text{ light year} = \frac{9.46 \times 10^{15}}{3.08 \times 10^{16}}$$
$$= 0.307 \text{ par sec}$$
$$\text{Distance of Alpha centauri}$$
$$= 4.29 \times 0.307 \text{ par sec}$$
$$= 1.32 \text{ par sec}$$

12. No, the bomb will not hit the target. At the time the bomb is released, it has horizontal velocity same as that of the bomber. Due to this velocity (say u) it will fall a distance $u=\sqrt{2h/g}$ ahead of the target, where h is the height of the bomber when the bomb is dropped.

13. Speed of a moving body is defined as the rate of change of position of the body with respect to time. It is measured by the distance travelled by the body in a unit time. $\text{speed} = \dfrac{\text{Distance travelled by the body}}{\text{Time taken}}$

Velocity of a moving body is defined as the rate of change of position of the body along a particular direction with respect to time.

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

Or

Damped oscillations are oscillations in which dissipative forces act as additional restoring forces to continuously decrease the amplitude of oscillation.

Forced oscillations are oscillations whose amplitude is maintained by an external periodic force which compensates for the energy loss in damped oscillations.

Resonant oscillations are those forced oscillations in which the frequency of driver force matches with the natural frequency of the system resulting in large increase in amplitude.

14.

$$\begin{aligned}
K.E &= \frac{1}{2}mv^2 \\
&= \frac{1}{2}m\,(\vec{v}.\vec{v}) \\
&= \frac{1}{2}m\,(2\hat{i}+5\hat{j}).(2\hat{i}+5\hat{j}) \\
&= \frac{1}{2}\times\frac{120}{1000}(4+25)\,J \\
&= 1.74\,J
\end{aligned}$$

15.

$\alpha = 3.6\,rad/s^2$

$\omega_o = 4.0\,rad/s,$

$\theta = ?\ t = 1s$

Using $\theta = \omega_o t + \frac{1}{2}\alpha t^2$

$= 4\times1 + \frac{1}{2}\times.36\times1$

$= 4 + 1.8 = 5.8\,rad$

Again $\omega = \omega_o + \alpha t = 4 + 3.6\times1$

$= 7.6\,rad/s$

Or

We know, $g = \frac{GM}{R^2}$ ....(i)

$g' = \frac{GM'}{(R')^2}$ ....(ii)

From (i) and (ii) we have,

$g'/g = \left(\frac{M'}{M}\right)\left(\frac{R}{R'}\right)^2$

$= \frac{1}{2}\times2^2 = 2$

$g' = 2g$

16. An open organ pipe is open at both the ends. The air molecules at the ends can easily move out into the open space and are thus free to vibrate with maximum amplitude. Therefore, when the air within the pipe vibrates in resonance, an atinode is formed at each end of the pipe.

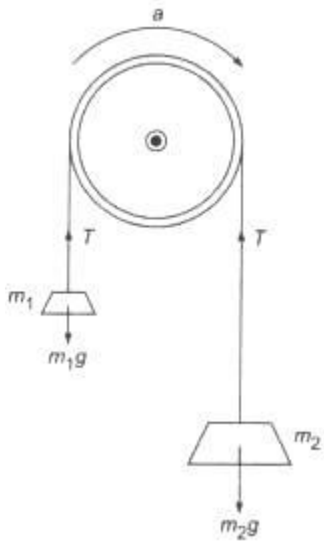
Or

In any satellite orbiting the Earth (in any orbit), the condition of weightlessness exists (i.e. effective g = 0). Hence, the pendulum does not oscillate and its period is therefore infinity.

17.

(a) It is meaningful, if both the scalars represent the same physical quantities.
(b) It is not permissible as the vector can only be added to another vector.
(c) It is permissible, e.g. mass multiplied with velocity.
(d) It is permissible, e.g. volume multiplied by density equals mass.
(e) It is permissible, if both the vectors represent the same physical quantity, otherwise not. For example we can add the forces, but not force and velocity.
(f) It is permissible.

18.



The pulley system with mass m_1 and m_2 is shown in the figure above. The tension T is same throughout.

For mass m_1: $T - m_1g = m_1a$ (i)

For mass m_2: $m_2g - T = m_2a$ (ii)

Adding (i) and (ii), we have,

$$(m_2 - m_1)g = (m_1 + m_1)a$$

or $$a = \left(\frac{m_2 - m_1}{m_2 + m_1}\right)g \quad \text{(iii)}$$

Putting this value in (i) we get,

$$T = m_1g + m_1\left(\frac{m_2 - m_1}{m_2 + m_1}\right)g$$

$$= \frac{[m_1(m_2 - m_1) + m_1(m_2 - m_1)]}{(m_2 - m_1)}$$

$$T = \frac{2m_1m_2\,g}{(m_2 + m_1)} \quad \text{(iv)}$$

$\therefore$ Thrust on the pulley is given by,

$$2T = \frac{4m_1m_2\,g}{(m_2 + m_1)}$$

19. Yes, the expression K.E = 1/2 mv^2 holds for a variable force also. Suppose some variable force F acts on a body producing displacement S along the direction of the applied force. Then, the work done by the force which measures the kinetic energy of the body is given by

$$W = K.E = \int F\,ds$$
$$= \int m a\,ds \;(\because F = ma)$$
$$= \int m \frac{dv}{dt} dS \left(\because a = \frac{dv}{dt}\right)$$
$$= \int m \left(\frac{dv}{dS}\right)\left(\frac{dS}{dt}\right) dS$$
$$= \int m v \frac{dv}{dS} dS = \int mv\,dv$$
$$= m\int v\,dv$$

If the velocity of the body increase from u to v.

$$K.E = m\int_u^v v\,dv = m\frac{(v^2 - u^2)}{2}$$

for $u = 0$, $K.E = \frac{1}{2}mv^2$

This agrees with the espression.

Or

(i) Kelvin's statements: It is impossible to obtain a continuous supply of energy by cooling a body below the coldest of its surrounding.

(ii) Clausius' statement: It is impossible for a self-acting machine, unaided by any external agency, to transfer heat from a body at a lower temperature to a body at a higher temperature.
In other words, heat cannot by itself (i.e. without the performance of work by an external agency) pass from a cold to a hot body.

(iii) Planck's statement: It is impossible to construct an engine which, operating in a cycle will produce an effect other than extracting heat from a reservoir and performing an equivalent amount of work.

20. Let the thermal conductivity of brass be K.
Thermal conductivity of copper = 4 K.
Length of each rod = x
Suppose θ is the temperature of the junction of the two rods in equilibrium.
Rate of flow of heat energy through brass = rate of flow of heat energy through copper

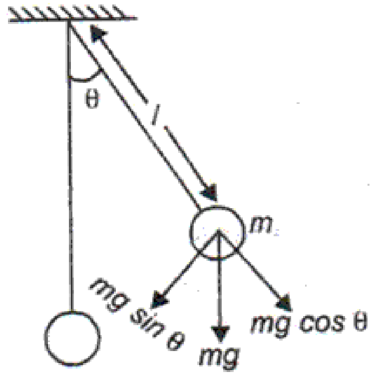
$$\frac{K.A.(100-\theta)}{x} = \frac{4K.A.(\theta - 0)}{x}$$

Or $(100-\theta) = 4(\theta - 0)$

Or $5\theta = 100$

$$\theta = \frac{100}{5} = 200°C$$

Or



Restoring force is provided by the portion $mg\sin\theta$ of gravitational force.

Since it acts perpendicular to length l, the restoring torque= $-mg\sin\theta l$

Also, $\tau = I\alpha = ml^2\alpha$

$\therefore ml^2\alpha = -mg\sin\theta l$

$$\alpha = -\frac{g\sin\theta}{l}$$

For small oscillations, $\sin\theta \cong \theta$

$$\therefore \alpha = -\frac{g}{l}\theta$$

$$\frac{d^2\theta}{dt^2} = -\frac{g}{l}\theta \quad \text{i.e.,} \quad \frac{d^2\theta}{dt^2} + \omega^2\theta = 0$$

giving $\omega = \sqrt{\frac{g}{l}}$ and $T = 2\pi\sqrt{\frac{l}{g}}$

Time period doesn't depend on mass of bob.

21. In case of a soap bubble, there are two free surfaces.

Work done in blowing a soap bubble of radius R

is given by, $W = 2\times 4\pi R^2\sigma$

where σ is the surface tension of the soap solution.

Here, $R = 0.1\text{m}$, $\sigma = 0.06\ \text{Nm}^{-2}$

$$W = 8\pi(0.1)^2\times 0.06\text{J} = .0151\text{J}$$

Similarly, work done in forming a bubble of radius 0.2m is,

$$W' = 8\pi(0.2)^2\times 0.06\text{J} = .0603\text{J}$$

Additional work done in doubling the radius of the bubble is given by
W' - W = 0.0603 J - 0.0151 J = 0.0452 J

22.

Here $y = 5\cos(3\pi t + \frac{\pi}{3})$ cm

Therefore, $\upsilon = \frac{dy}{dt} = -15\pi \sin(3\pi t + \frac{\pi}{3})$ cm/s

and $a = \frac{d\upsilon}{dt} = -45\pi^2 \cos(3\pi t + \frac{\pi}{3})$ cm/s^2

Now $y(t=3) = 5\cos(9\pi + \frac{\pi}{3})$cm $= -5\cos(\frac{\pi}{3})$cm $= -2.5$cm

Therefore, $\upsilon(t=3) = -15\pi\sin(9\pi + \frac{\pi}{3})$cm/s

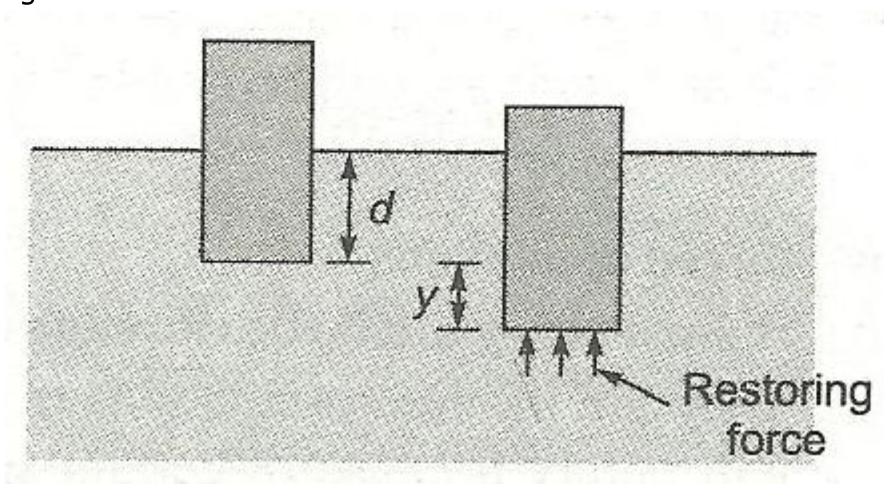
$= 15\pi \sin\frac{\pi}{3}$cm/s $= \frac{15\pi\sqrt{3}}{2}$cm/s

and $a(t=3) = -45\pi^2\cos(9\pi + \frac{\pi}{3})$cm/s^2

$= 45\pi^2 \cos(\frac{\pi}{3})cm/s^2 = \frac{45\pi^2}{2}$cm/s^2

Or

Consider a cylindrical wooden block of the area of cross-section A, floating up right when immersed to a depth d in a liquid of density ρ as shown in the figure.



In the equilibrium position, the weight of the block is balanced by the upthrust. From the state of equilibrium, the block is slightly depressed by distance y and released. The mass of the displaced liquid is A y ρ.

It gives rise to an additional upthrust A y ρ g due to which the resulting motion is simple harmonic. The restoring force = weight of the displaced liquid

or $F = -A\, y\, \rho\, g$

or force $= -(A\rho g)\,y = -Ky$, where $K = A\rho g$

The time–period of oscillation of the block is given by,

$$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{m}{A\rho g}}$$

Frequency of oscillation of the block is given by,

$$n = \frac{1}{2\pi}\sqrt{\frac{A\rho g}{m}}$$

23. Thermal radiations are radiations emitted by a body (that has temperature above 0 Kelvin) on account of its temperature. Thermal radiations are also called infrared radiations as their wavelength ranges from 8 x 10^{-7} m to 4 x 10^{-4} m.

Basic characteristics of thermal radiations are:

i. They require no medium to propagate. They can travel through vacuum.
ii. They travel in straight lines with the speed of light.
iii. They do not heat the intervening medium through which they pass.
iv. Their intensity varies inversely as the square of the distance from the source.
v. They show the phenomena of interference, diffraction, reflection, refraction and polarization like light radiations.

Or

Let the thermal conductivity of brass be K.

Hence, thermal conductivity of copper = 4 K

Length of each rod = x

Suppose θ is the temperature of the junction of the two rods in equilibrium.

Rate of flow of heat energy through brass = rate of flow of heat energy through copper

$$\frac{K.A.(100-\theta)}{x} = \frac{4K.A.(\theta-0)}{x}$$

$$\text{Or} \quad (100-\theta) = 4(\theta-0)$$

$$\text{Or} \quad 5\theta = 100$$

$$\theta = \frac{100}{5} = 20\,^{\circ}\text{C}$$

24. Radius of sphere = 10 cm
Change in volume, ΔV = 0.2 cc
Pressure on the sphere = 100 atm = 1.013 x 10^6 dyne cm^{-2}
We know that,

$$K = -\frac{V\Delta p}{\Delta V}$$

$$K = \left(-\frac{4}{3}\pi(10)^3\right)\frac{1.013\times10^6}{-0.2}$$

$$K = 2.12\times10^{12}\ \text{dyne cm}^{-2}$$

25.

(a) She has inquisitiveness; she wants know the scientific reason behind the various phenomena.

(b) The surface tension of water is more than that of oil, therefore when oil is poured over water, the greater value of surface tension of water, pulls the oil in all directions. On the other hand, when water is poured over oil, it does not spread over it because surface tension of oil is less than that of water.

26. Here L=Iω = constant

Kinetic energy of rotation, K = (1/2)I ω^2

$$K = \frac{1}{2I} I^2\omega^2 = \frac{L^2}{2I}$$

As L is constant, $K \propto \frac{1}{I}$

When moment of inertia (I) decreases, kinetic energy of rotation (K) increases. Thus kinetic energy of rotation is not conserved.

27. Since the swimmer dive the river normal to the flow of river, therefore time taken by swimmer to cross the river

$$t = \frac{d}{v_m} = \frac{1\ km}{4\ km/hr} = \frac{1}{4} hr = 15\ min$$

28.

(i) The body having a large reflectivity (or bright surface) is a poor absorber of heat radiations. The poor absorbers are poor radiators. Therefore, a body with a large reflectivity is a poor emitter.

(ii) Brass is a good conductor of heat. When we touch the brass tumbler, the heat is quickly transferred from the fingertips to the tumbler. Thus, we feel colder touching the brass (or any other) tumbler on a chilly day.

(iii) The temperature of the red hot iron in the oven is given by $E_1 = \sigma T^4$. However, when the iron is taken out in the open (T_o), then its radiant energy is given by $E_2 = \sigma\left(T^4 - T_0^4\right)$. Therefore, the pyrometer will measure a low value for the red hot iron in the open.

(iv) The atmosphere acts as a blanket over the earth and does not allow earth's heat to be radiated during the night.

(v) Because steam contains more heat in the form of latent heat (540 cal/g) than water.

Or

For each spring, spring constant is k

In series spring constant is $\frac{k}{2}$

In parallel spring constant is 2k.

$$T_{\text{series}} = 2\pi\sqrt{\frac{m}{k/2}} = 2\pi\sqrt{\frac{2m}{k}}$$
$$T_{\text{Parallel}} = 2\pi\sqrt{\frac{m}{2k}} = 2\pi\sqrt{\frac{m}{2k}}$$
$$T_{\text{series}} = 2T_{Parallel}$$

29.

(i) The action on the floor by the man in case (i) is given by

$R = m_1g + m_2g = (m_1 + m_2)g$
where m_1 = 25 kg (mass required to be lifted)
And m_2 = 50 kg (mass of man)
R = (75 × 9.8) N = 735 N
The action on the floor by the man in case (ii) is given by
$R = m_2g - m_1g = (m_2 - m_1)$ g
= (50 - 25) g = (25 × 9.8)
R = 245 N
Since the action of the man on the floor in case (ii) is less than in case (i) and since the floor can yield a normal force of 700 N, therefore, the man should prefer mode (ii) to lift the weight.

(ii)

(a) The tension developed in string when the animal climbs up with an acceleration of 6 ms^{-2} is given by
T = m (g + a)
= 40 (10 + 6) = 640 N

(b) The tension developed in the string when the animal climbs down with an acceleration of 4 ms^{-2} if given by
T = m (g - a)
= 40 (10-4) = 240 N

(c) When the animal climbs up with a uniform speed of 5 ms^{-1}, acceleration is zero and the tension developed is given by
T = mg = 40 × 10 = 400 N

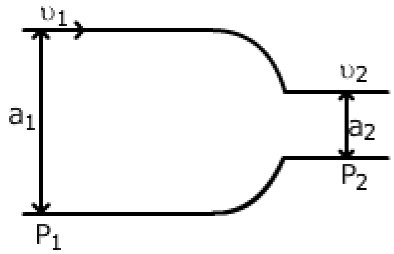
(d) As the animal falls down the rope nearly under gravity, the tension in the string is given by

T = m (g - a)
But a = g, for free fall
T = m (g - g) = 0

Since the string can withstand a maximum tension of 600 N, hence the rope will break only in the first case (a).

Or

Laminar flow occurs when a fluid flows in parallel layers, with no disruption between the layers.



$P_1 + \frac{1}{2}\rho v^2{}_1 = P_2 + \frac{1}{2}\rho v^2{}_2$ and $a_1 v_1 = a_2 v_2$

Therefore, $P_2 = P_1 + \frac{1}{2}\rho\left(v_1^2 - v_2^2\right)$

$$= P_1 + \frac{1}{2}\rho\left[v_1^2 - \left(\frac{a_1}{a_2}\right)^2 v_1^2\right]$$

$$= P_1 + \frac{1}{2}\rho v_1^2\left[1 - \left(\frac{a_1}{a_2}\right)^2\right]$$

$$= 4\times10^4 + \frac{1}{2}\times10^3\times4\left[1 - \frac{4\times10^{-4}}{1\times10^{-4}}\right]$$

$$= 4\times10^4 - 0.6\times10^4$$

$$= 3.4\times10^4 \ P_a$$

30.

(a) Presence of mind and concern for his friend.

(b) Suppose the two stones collide at a distance h from the top

Equation of motion of falling stone is

$$h = 0\times t + \frac{1}{2}gt^2 = \frac{1}{2}gt^2 \qquad \text{(i)}$$

Equation of motion of stone thrown vertically up is

$$100 - h = 25t - \frac{1}{2}gt^2 \qquad \text{(ii)}$$

From equations (i) and (ii), we get

$$100 = 25t$$
$$\therefore t = 4\ \text{s}$$

Thus, from equation (i), we get

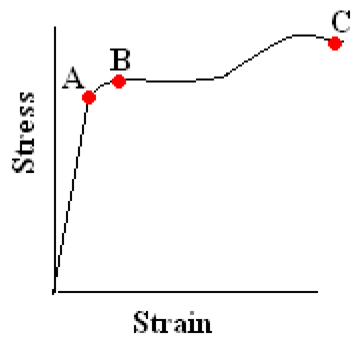
$$h = \frac{1}{2} \times 9.8 \times 4^2 = 78.4\ \text{m}$$

Therefore, height from the ground is

$$\text{Height} = 100 - 78.4 = 21.6\ \text{m}$$

Or

Hooke's law states that for small deformations, stress is directly proportional to the strain.



In the region from O to A, the curve is linear. The strain is directly proportional to the stress. Beyond the point A, known as the proportional limit, the relation between stress and strain is not linear.

The point B on the graph is known as the elastic limit. Up to this point stress and strain are not directly proportional but the body returns to its original dimensions if the stress is removed.

Fracture point corresponds to point C on the graph at which the material breaks.