CBSE Board
Class XI Physics
Sample Paper-3 Solution

1.
Yes. Example is angle

2.
Motion of a body thrown vertically/obliquely under constant g

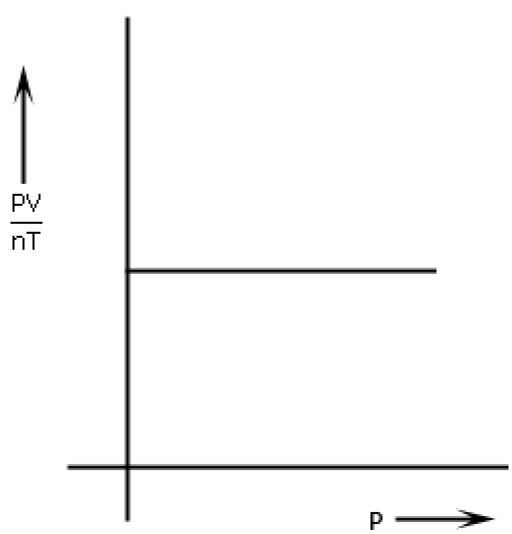
3.
- x-axis

4.
Work

5.
Since $\vec{\tau} = \vec{r} \times \vec{F}$, larger arm means larger $\vec{r}$ which requires less $\vec{F}$ for same $\vec{\tau}$.

6.
3

7.



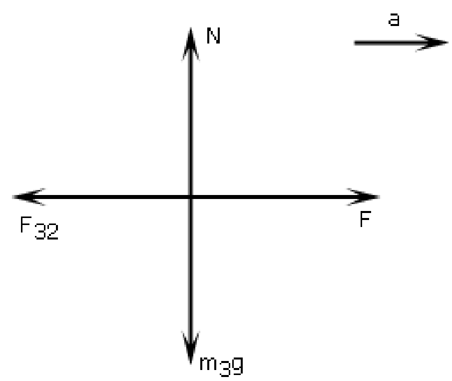
8.
No process is possible whose sole result is the absorption of heat from a reservoir and the conversion of all of this heat into work.

9.

Systematic Errors	Random Errors
1. Errors in which the deviation from true value tends to have fixed size and sign. 2. They can be attributed to a fixed cause and can be eliminated.	Deviation from true value is irregular in size as well as sign. Irregular pattern does not allow them to be attributed to any fixed cause and hence cannot be eliminated, only minimized.

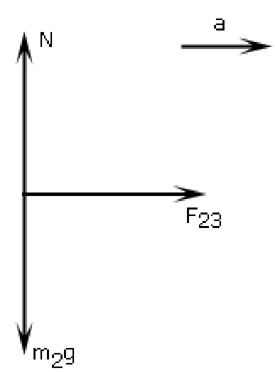
10.

For 3 kg:



$F - F_{32} = m_3a$ (i)

For 2 kg:



$F_{23} = m_2a$ (ii)

But from Newton's third law

$\Rightarrow F_{23} = F_{32}$

Therefore, from (i) and (ii), $F - m_2a = m_3a$

$F = (m_2 + m_3)a$

$\Rightarrow a = \frac{5}{5} = 1\ m/s^2$

Therefore, $F_{32} = m_2a = 2.1 = 2N$ (1/2)

OR

The two ways are:
1. Friction adjusts its **direction** to be always opposite to applied force.
2. Friction adjusts its **magnitude** up to a certain limit, to be equal to the applied force.

$$F_{ms} = \mu_s N = \mu_s mg = 0.2 \times 2 \times 10 = 4\,N$$

Since, applied force < F_{ms}, the static friction acting = f_s = 2 N.

11.

We know that

$$p = \sqrt{2mk}$$

and $p' = \sqrt{2mk'} = \sqrt{2m\left(k + \frac{21}{100}k\right)} = \frac{11}{10}\sqrt{2mk} = \frac{11}{10}p$

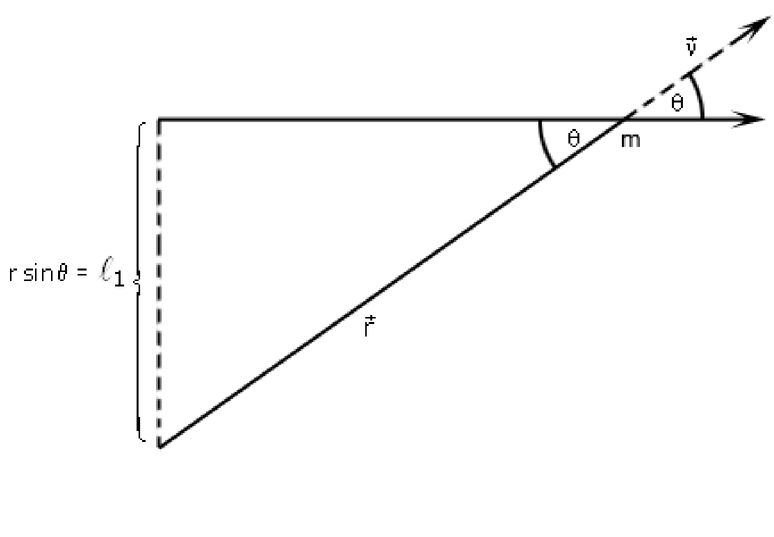
Therefore, $\frac{\Delta p}{p} = \frac{\frac{11}{10}p - p}{p} = \frac{1}{10}$

$$\frac{\Delta p}{p} \times 100 = 10\%$$

12.

$\left|\vec{\ell}\right| = r\,p\sin\theta = \ell mv$

Direction of $\vec{r} \times \vec{p}$ = direction of $\vec{\ell}$



13.

Polar satellites - Their orbit is perpendicular to the orbit of geostationary satellites. These are used for communication purpose. Also, the height above the Earth's surface is lower.
Negative sign of total energy indicates attractive nature of force between the satellite and the Earth.

14.

The stress required to fracture a material whether by compression, tension, or shear is called breaking stress.

Yes, the wire is under stress as its own weight acts as load.

15.

For adiabatic expression PV^{γ} = const.

Therefore, $PV^{\gamma} = P'V'^{\gamma} \Rightarrow 1600\ V^{5/3} = P'(8V)^{5/3} = 2^5 P'V^{5/3}$

Or $P' = \frac{1600}{32} = 50 P_a$

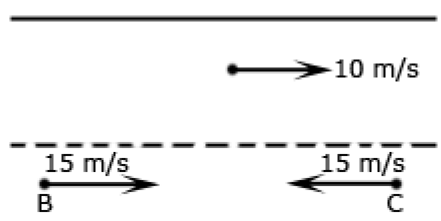
Therefore, fall in pressure = 1600 – 500 = 1550 P_a

16.

(i) For isothermal expansion ΔT = 0, hence ΔU = 0

(ii) For adiabatic expansion ΔU = ΔQ – ΔW = -ΔW = -PΔV as ΔQ = 0.

17.



$$v_A = 36\ km/h = \frac{36 \times 1000}{60 \times 60} = 10\ m/s$$

$$|v_A| = |v_C| = 54\ km/h = 15\ m/s$$

$$v_{BA} = v_B - v_A = 15 - 10 = 5\ m/s$$

$$v_{CA} = v_C - v_A = 15 - (-10) = 25\ m/s$$

Time taken by C to cover 1 km = $\frac{1000}{25} = 40s$

To avoid accident, B should cover 1 km is less than 40s.

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

$$\Rightarrow 1000 = 5 \times 40 + \frac{1}{2}a\,.\,(40)^2$$

$$= 200 + 800a$$

800a = 1000 – 200 = 800

$\Rightarrow$ a = 1 m/s^2

18.

$a = -kx$

$$a = v\frac{dv}{dx} = -kx$$

$$v\,dv = -kx\,dx$$

Integrating both sides, we get

$$\int_u^v v\,dv = -\int_o^x kx\,dx$$

$$\frac{1}{2}(v^2 - u^2) = -\frac{1}{2}kx^2$$

or $$\frac{1}{2}m(v^2 - u^2) = -\frac{1}{2}m\,kx^2$$

Therefore, loss in K.E. = $\frac{1}{2}m\,kx^2$

19.

(a) During free fall acceleration of thief = g = acceleration of load

So that load is unable to apply any force.

Let the force by load be N.

mg – N $\Rightarrow$ N = 0 = force applied by load on man

(b) Along horizontal direction, $\sum \overrightarrow{F_{ext}} = 0$. Net linear momentum is conserved.

Before firing, the system is at rest.

Therefore, 0 = $m_b v_b + m_g v_g$

$$v_g = -\frac{m_b}{m_g}v_b$$

So, to conserve linear momentum, the gun recoils.

(c) The sand yields but the cemented floor doesn't.

Hence, the time taken by man to come to rest increases in case of sand.

Since, $\frac{\Delta p}{\Delta t} = F$, force on man is less.

20.

We know that

$$Q = \frac{KA(T_1 - T_2)t}{x}$$

A = area of 6 faces = 6 × $(3 \times 10^{-1})^2$ = 54 × 10^{-3}

$$m\,L = \frac{KA(T_1 - T_2)t}{x}$$

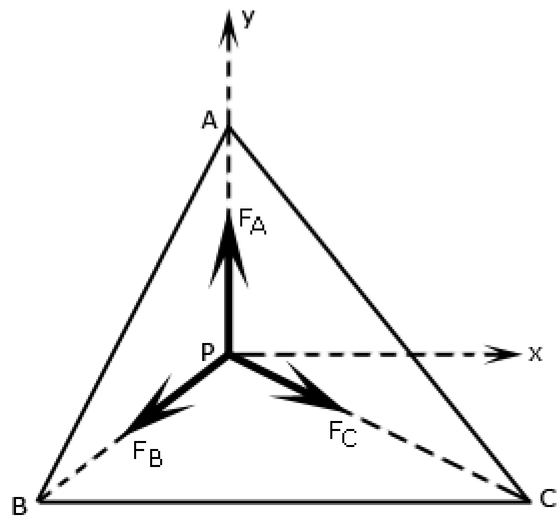
or $$m = \frac{KA(T_1 - T_2)t}{xL}$$

$$= \frac{0.01 \times 54 \times 10^{-2}(45 - 0) \times 6 \times 3600}{5 \times 10^{-2} \times 335 \times 10^{3}}$$

= 0.313 kg

Therefore, mass left = 4 - 0.313 = 3.687 kg

21.



$$\vec{F}_A = \frac{Gm\,.\,2m}{1}\hat{j} = 2\ Gm^2\hat{j}$$

$$\vec{F}_B = \frac{Gm\,.\,2m}{1}(-\hat{i}\cos 30^\circ - \hat{j}\sin 30^\circ) = 2Gm^2\left(-\frac{\sqrt{3}}{2}\hat{i} - \frac{1}{2}\hat{j}\right)$$

$$\vec{F}_C = \frac{Gm\,.\,2m}{1}(\hat{i}\cos 30^\circ - \hat{j}\sin 30^\circ) = 2Gm^2\left(\frac{\sqrt{3}}{2}\hat{i} - \frac{1}{2}\hat{j}\right)$$

$$\vec{F} = \vec{F}_A + \vec{F}_B + \vec{F}_C = 2Gm^2\hat{j} + 2Gm^2\left(-\frac{\sqrt{3}}{2}\hat{i} - \frac{1}{2}\hat{j} + \frac{\sqrt{3}}{2}\hat{i} - \frac{1}{2}\hat{j}\right)$$

$$= 2Gm^2\hat{j} - 2Gm^2\hat{j} = 0$$

22.

(a) $E = \frac{3}{2}NkT = \frac{3}{2}nRT$

$$= \frac{3}{2}(2)(8.31)(293)$$

$$= 7.3 \times 10^{3}\,J$$

(b) Average kinetic energy per molecule

$$= \frac{3}{2}(1.38 \times 10^{-23})(292)$$

$$= 6.07 \times 10^{-21}\,J$$

OR

(a) Average speed is

$$\vec{v} = \frac{5.00 + 8.00 + 12.00 + 12.00 + 14.00 + 14.00 + 17.00 + 20.00}{9}$$

$= 12.70$ m/s

(b) $$v^2 = \frac{(5.0)^2 + (8.0)^2 + (12.0)^2 + (12.0)^2 + (14.0)^2 + (14.0)^2 + (17.0)^2 + (20.0)^2}{9}$$

$= 178\ m^2/s^2$

Therefore, $v_{rms} = \sqrt{\overline{v^2}} = \sqrt{178} = 13.3\ m/s$

(c) 3 out of 9 have speed 12 m/s, 2 have 14 m/s and the rest have different speeds. So, most probable speed is 12 m/s.

23.

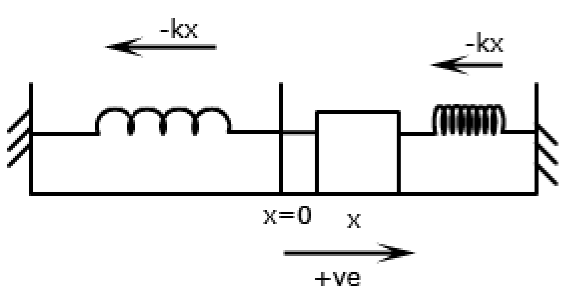
(a) Frequency remains constant as it depends on the source emitting the wave.

(b) 2π corresponds to path difference λ.

Therefore, $\frac{3\pi}{4}$ corresponds to path difference $\frac{\lambda \times \frac{3\pi}{4}}{2\pi} = \frac{3\pi}{8}$

(c) Both waves should not have frequency difference greater than 16 Hz.

24.



If the block is pulled to straight by distance x, restoring force in each spring is –kx.
Therefore, for block F = ma

$$\Rightarrow -kx - kx = m\frac{d^2x}{dt^2}$$

or $$m\frac{d^2x}{dt^2} + 2kx = 0$$

or $$\frac{d^2x}{dt^2} + \frac{2k}{m}x = 0$$

which is in form $\frac{d^2x}{dt^2} + \omega^2 x = 0$

Hence, the motion is SHM.

Also $T = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{\frac{2k}{m}}}$

$$= 2\pi\sqrt{\frac{m}{2k}}$$

25.

(a) No, it is in conformity with the law of conservation of energy.

(b)

(i) There is no indication available as regards the direction in which the change takes place.

(ii) It does not give any idea about the extent to which the change takes place.

26.

(a) Radha takes care of things and has concern for others. She is practical in finding the solutions to problems.

(b) When the thin wheel is rolling upright, it possesses some angular momentum in the horizontal direction along the axis of the wheel. As angular momentum is conserved in magnitude as well as direction (in the absence of external torque) the wheel cannot fall from its upright position. However, when external torque due to friction reduces angular velocity of the wheel to zero, (i.e. when the wheel becomes stationary) it falls from its upright position at the slightest disturbance, on account of moment of force due to its weight.

27.

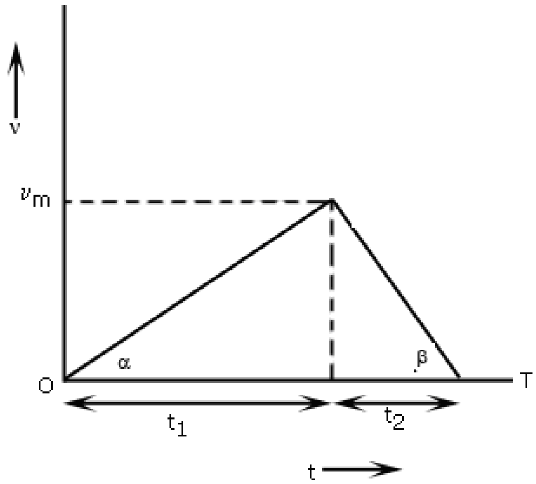
$x \propto t^3$

$$\Rightarrow x = kt^3$$

$$\Rightarrow v = \frac{dx}{dt} = 3kt^2$$

$$\Rightarrow a = \frac{dv}{dt} = 6kt$$

Therefore, acceleration is non-uniform ($a \propto t$)



Slope of ν– t graph = acceleration

Therefore, $\alpha = \frac{\nu_m}{t_1}$, $\beta = \frac{\nu_m}{t_2}$

$$\frac{1}{\alpha} = \frac{t_1}{\nu_m}, \frac{1}{\beta} = \frac{t_2}{\nu_m}$$

$$\frac{1}{\alpha} + \frac{1}{\beta} = \frac{t_1 + t_2}{\nu_m} = \frac{\alpha + \beta}{\alpha\beta}$$

$$\nu_m = \frac{(t_1 + t_2)\alpha\beta}{\alpha + \beta} = \frac{\alpha\beta T}{\alpha + \beta}$$

OR

(a)

(i) Both at same time since vertical motion of both are identical $\nu_y = 0$, $a_y = g$ and $S_y = H$

(ii) Second ball will strike with more speed

$$\nu_1 = \sqrt{2gH} \text{ but } \nu_2 = \sqrt{u^2 + 2gH}$$

(b) For max range θ = 45°.

At highest point = $v = v_x = u\cos 45° = \frac{u}{\sqrt{2}}$

(c) $R = \frac{u^2 \sin 2\theta}{g}$

$$= n \cdot \frac{u^2 \sin^2\theta}{2g} = nH$$

$$2\sin\theta\cos\theta = \frac{n\sin^2\theta}{2}$$

$$\frac{\sin\theta}{\cos\theta} = \frac{4}{n}$$

$$\theta = \tan^{-1}\frac{4}{n}$$

28.

(a) No, because action and reaction cannot act on the same body.

(b) No effect

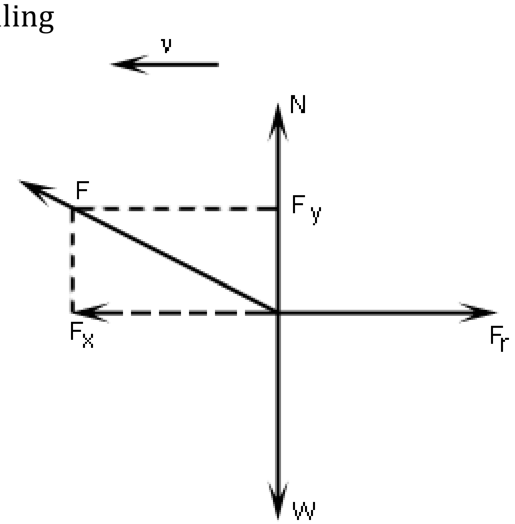
(c) The sideways friction between the road and car tyres.

(d) The angle by which the outer edge of a curved road is raised over the inner edge.

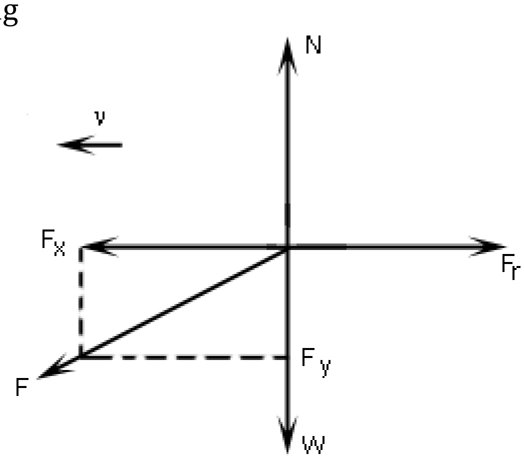
(e) Banking results in additional contribution to centripetal force by a component of normal reaction. So, the vehicles can negotiate a turn at a higher speed without skidding.

OR

(a) Pulling



Pushing



In case of pushing, vertical component of applied force F adds to the weight, thus increasing the friction $F_r = \mu N = \mu\ (F_y + W)$

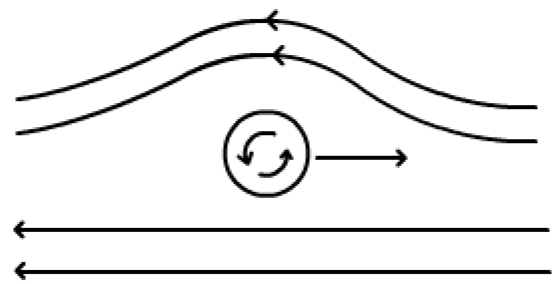
But in case of pulling, vertical component of applied force reduces the downward force, thus decreasing the friction $F = \mu N = \mu(W - F_y)$

(b) Because it changes sliding friction to rolling friction which is smaller.

(c) (i) Car tyres have grooves to increase the friction and hence their grip on the road for perfect rolling.

(ii) To enable walking on slippery ice, sand is sprinkled to increase friction.

29.



Magnus effect: If a moving ball is given a spin, the air layers at the top acquire higher velocity than those at the bottom. So, as per Bernoulli's theorem, pressure below the ball becomes greater than that at the top. Due to net upward force, the ball follows a curved path.

Viscosity is a measure of the resistance of a fluid which is being deformed by either shear stress or extensional stress.

Dimension: $[ML^{-1}T^{-1}]$
SI unit: Poiseulli/decapoise

Depends on: 1. Temperature
2. Nature of liquid

OR

Stokes' Law is written as

$$F_d = 6\pi\mu \, Vd$$

Where F_d is the drag force of the fluid on a sphere, m is the fluid viscosity, V is the velocity of the sphere relative to the fluid, and d is the diameter of the sphere.

Reason: The viscous drag $F_v \propto v$, hence it increases as the body falls. At a certain instant the weight gets neutralized by the buoyant force and the viscous drag. Hence, in absence of any net force, the speed becomes constant.

Terminal speed depends on:
1. Radius of the body
2. Coefficient of viscosity of the fluid
3. Density of body
4. Density of fluid.

Positive terminal velocity ($+v_t$): motion of parachute.
Negative terminal velocity ($-v_t$): motion of air bubbles in water.