TOPPER SAMPLE PAPER 5

PHYSICS –XI

Q. No	Value Points	Marks

Ans1. The alloy is least affected by temperatures variations. It is non-corrosive and so does not wear out easily. (1)

Ans2. Coefficient of restitution is defined as the ratio of relative velocity of separation of the two bodies after collision to the relative velocity of approach before collision. It is denoted by 'e'. (1)

Ans3. No. Radius of gyration depends on axis of rotation and distribution of mass. (1)

Ans4. Ploughing of fields is essential as ploughing breaks the fine capillaries in the soil hence saving the loss of excess water which rises in the capillaries and evaporates. (1)

Ans5. When a ball is thrown and given a spin, then the path of the ball is curved. The velocity of air above the ball relative is large and below it is small. This difference in the velocities of air results in the pressure difference between the lower and upper faces and this provides a upward force on the ball. This dynamic lift due to spinning is called Magnus effect. (1)

Ans6. In an adiabatic process work done by gas results in decrease in its internal energy. (1)

Ans7. At 50cm (1)

Ans8. Internal energy and volume (1/2 + 1/2)

Ans9. The average length of the rod is: 12.99/4 = 3.247 = 3.25 (Rounding off to two decimal points)

$$\Delta L_1 = 3.25 - 3.23 = 0.02m$$
$$\Delta L = 3.25 - 3.25 = 0.00m$$
$$\Delta L = 3.25 - 3.27 = -0.02m$$
$$\Delta L = 3.25 - 3.22 = 0.03m$$
$$Absolute\ Error = \frac{\sum|\Delta L|}{3} = \frac{0.02 + 0 - 0.02 + 0.03}{3} = \frac{0.03}{3} = 0.01m$$
$$Correct\ length = 3.26 \pm 0.01m$$

(1)

$$Z \pm \Delta Z = (A \pm \Delta A) + (B \pm \Delta B)$$
$$= (A + B) + (\Delta A \pm \Delta B)$$
$$= Z \pm (\Delta A + \Delta B)$$
$$\Delta Z = (\Delta A + \Delta B)$$

Hence, the absolute possible error in the sum of two quantities is equal to the sum of the absolute errors in the individual quantities. (1)

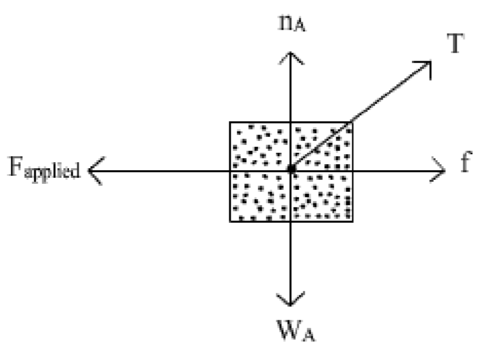
Ans10. Physically, speed and velocity are different in the sense that the former is scalar, whereas the latter is a vector.

However, in terms of magnitude, in this case, both are equal.

∴ Magnitude of velocity = speed = (20+5)/5 = 11 ms^{-1}

This is because the bug happens to move along a straight line and does not turn back, in other words, does not change direction during its travel from A to C.

Ans11. Free body diagram of block A



Forces on block A are:

(i) W_A = Weight of the block, acting downward

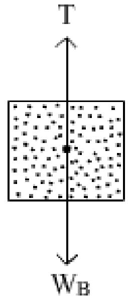
(ii) n_A = Normal reaction force from surface, acting vertically upward.

(iii) T = Tension of chord

(iv) $F_{applied}$ = Applied force

(v) f = Frictional force, acting against the applied force (1)

Free body diagram of Forces on block B are:



T = Tension in chord, acting vertically upward

W_B = Weight of the body, acting vertically downward (1)

Ans12. If a body of mass m is released from the top of a smooth inclined plane of height h, it gains speed at the bottom given by

$$V^2 - 0^2 = 2gh \text{ or}$$

$$v = \sqrt{2gh}$$ (1)

Kinetic energy acquired by the body at the bottom of inclined plane is

$$\frac{1}{2}mv^2 = \frac{1}{2}m \times 2gh = mgh$$

Clearly the work done by the gravitational force does not depend on the angle of inclination or path of the falling body. It depends on the initial and final position of the body. This proves that gravitational force is a conservative force. (1)

Ans13. Sea star is a polar satellite. (1/2)

Polar satellites are used for

1. Getting cloud images,
2. Atmospheric data,
3. To detect the ozone hole. (1/2 for each point)

Ans14. Smoothening the surface beyond a certain limit increases the friction because the area of actual contact increases. Increase in the area of actual contact increases the cohesion between the surfaces. (2)

Ans15.

$$Force, F = \frac{-dU}{dx} = -3kx^2$$

$$Max.force = F_{max} = -3kx^2 = -m\omega^2 a \quad (1)$$

$$\omega^2 = \frac{3ka^2}{ma} = \frac{3ka}{m}$$

$$\frac{4\pi^2}{T^2} = \frac{3ka}{m}$$

$$\Rightarrow T^2 \propto \frac{1}{a}$$

$$\Rightarrow T \propto \frac{1}{\sqrt{a}} \quad (1)$$

Ans16.

$$E = C_v.1.T = \frac{3}{2}RT \quad (1)$$

$$C_v = \frac{3}{2}R$$

$$C_p = C_v + R = \frac{3}{2}R + R = \frac{5}{2}R = 2.5R \quad (1)$$

Ans17.

$$90\, vibrations\, in\, 60\, seconds\, means\, frequency, f = 1.5Hz \quad (1)$$

$$According\, to\, diagram\, 1.5Hz\, is\, covered\, in\, 6m \therefore\, wavelength, \omega = 4m$$

$$We\, have\, speed, v = f \times \lambda = 1.5 \times 4 = 6m/s \quad (1)$$

Ans18.

The reduced mass of the system

$$m_o = \frac{m_1 \times m_2}{m_1 + m_2} = \frac{3\times 2}{3+2} = 6/5\,Kg \qquad (1)$$

Inertia factor $= 6/5$

Spring constant, $k = 200\,Nm^{-1}$

$$Frequency\ \upsilon = \frac{1}{2\pi}\sqrt{\frac{spring\ factor}{inertia\ factor}} \qquad (1)$$

$$= \frac{1}{2\pi}\sqrt{\frac{200}{6/5}} \qquad (1)$$

$$= 2.05Hz$$

Ans19. We know that horizontal range and maximum heights are independent of the mass of bodies. Therefore

Horizontal range of body A,

$$R_A = \frac{u^2\sin(2\times 30^0)}{g} = \frac{u^2\sqrt{3}}{2g}$$

(1/2)

And for body B,

$$R_B = \frac{u^2\sin(2\times 60^0)}{g} = \frac{u^2\sqrt{3}}{2g} \qquad (1/2)$$

That is

$$R_A = R_B$$

$$or\ \frac{R_A}{R_B} = 1:1 \qquad (1/2)$$

Now maximum height for body A,

$$h_A = \frac{u^2\sin^2 30^0}{2g} = \frac{u^2}{8g} \qquad (1/2)$$

$$h_B = \frac{u^2\sin^2 60^0}{2g} = \frac{3u^2}{8g} \qquad (1/2)$$

$$\therefore h_A : h_B = 1:3 \qquad (1/2)$$

Ans20. We are given here,

Mass of the gun=M

Mass of the bullet=m
Velocity of the bullet=v
Recoil velocity of the gun=V

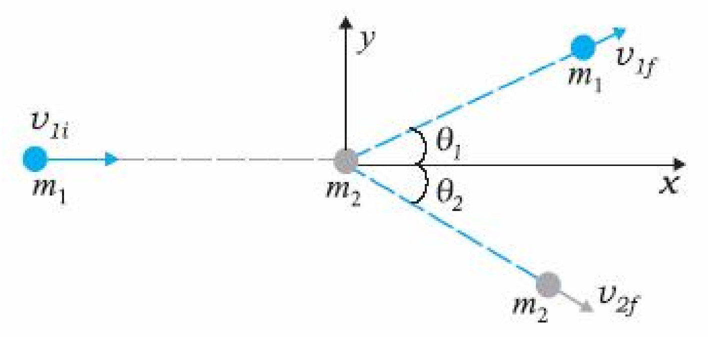
As initially both the bullet and gun are at rest, then applying principle of conservation of momentum, we get (1)

Total momentum of gun + bullet before firing= Total momentum of gun+ bullet after firing (1)

$$0 = MV + mv$$

$$V = -\frac{m}{M}v \qquad (1)$$

Ans21. Consider two masses m_1 and m_2.Let the particle $m_1$is moving with initial speed v_{1i} and $m_2$be at rest.



(1)

In case of an perfectly inelastic collision in one dimension, $\theta_1 = \theta_2 = 0$

Applying law of conservation of momentum, we get

$$m_1 v_{1i} = (m_1 + m_2)v_f$$

$$v_f = \frac{m_1}{m_1 + m_2} v_{1i} \qquad (1)$$

where v_f is the final velocity of the combined mass (m_1 + m_2).

The loss in kinetic energy on collision is

$$\Delta K = \frac{1}{2}m_1 v_{1i}^2 - \frac{1}{2}(m_1 + m_2)v_f^2$$
$$= \frac{1}{2}m_1 v_{1i}^2 - \frac{1}{2}(m_1 + m_2)\left(\frac{m_1}{m_1 + m_2}v_{1i}\right)^2$$
$$= \frac{1}{2}m_1 v_{1i}^2 - \frac{1}{2}\frac{m_1^2}{m_1 + m_2}v_{1i}^2$$
$$= \frac{1}{2}m_1 v_{1i}^2\left[1 - \frac{m_1}{m_1 + m_2}\right]$$
$$= \frac{1}{2}\frac{m_1 m_2}{m_1 + m_2}v_{1i}^2$$

(1)

This is a positive quantity.

Ans22.

Before changing the masses and distance,

$$F = \frac{Gm_1 m_2}{r^2}$$ (1)

After changing the masses and distance,

$$m_1 = 2m_1$$
$$m_2 = 3m_2$$
$$r = 2r$$
$$F' = \frac{G \times 2m_1 \times 3m_2}{(2r)^2}$$ (1)
$$F' = \frac{6}{4} \times \frac{Gm_1 m_2}{r^2}$$
$$\frac{F}{F'} = \frac{\frac{Gm_1 m_2}{r^2}}{\frac{6}{4} \times \frac{Gm_1 m_2}{r^2}} = \frac{4}{6} = \frac{2}{3}$$
$$\frac{F}{F'} = \frac{2}{3}$$ (1)

Ans23. Radius -R = 100 m, θ = 30°, μ = 0.5

At the optimum speed, the normal reaction's component is enough to provide the needed centripetal force, and the frictional force is not needed. (1)

So, the optimum speed is given by

$$v_o = \sqrt{Rg\tan\theta}$$
$$= 100 \times 9.8 \times \frac{1}{\sqrt{3}}$$
$$= 23.84\, m/s$$
(1)

The maximum permissible speed is given by

$$v_{max} = \sqrt{Rg\left(\frac{\mu_s + \tan\theta}{1 - \mu_s \tan\theta}\right)}$$
$$= \sqrt{100 \times 9.8\left(\frac{0.5 + 0.58}{1 - 0.5 \times 0.58}\right)}$$
$$= 38.5\, m/s$$
(1)

Ans24.
Thermal radiations are radiations emitted by every body (that has temperature above 0 Kelvin) on account of its temperature. Thermal radiations are also called infra red radiations as their wavelength ranges from 8 x 10 -7 m to 4x 10-4 m. (1/2)

Basic characteristics of thermal radiations are

i. Thermal radiation requires no medium to propagate. They can travel through vacuum.

ii. Thermal radiations 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. Thermal radiations show the phenomena of interference, diffraction, reflection, refraction and polarization like light radiations.

(1/2 for each point)

Ans25.

In equilibrium, the total energy is equally distributed in all possible energy modes, with each mode having an average energy equal to 1/2kT. This is the law of equipartition of energy. (1)

A diatomic molecule that can be taken as a rigid rotator with 5 degrees of freedom: 3 translational and 2 rotational. Using the law of equipartition of energy the total internal energy of a mole of such a gas is given by

$$U = \frac{5}{2}kT \times N = \frac{5}{2}RT \qquad (1)$$

Then molar specific heat at constant volume $C_V = \frac{5}{2}R$

and molar specific heat at constant pressure $C_P = \frac{7}{2}R$

Hence $\frac{C_P}{C_V} = \frac{7}{5}$ (1)

Ans26.

$$Given\ C_1 = x\,m/s$$

$$T_1 = 273K,$$

$$Let\quad V_1 = V$$

$$At\ constant\ pressure, the\ gas\ is\ heated\ so\ that$$

$$V_2 = 4V$$

$$According\ to\ Charle's\ law$$

$$\frac{V_2}{T_2} = \frac{V_1}{T_1} \qquad (1)$$

$$T_2 = T_1\frac{V_2}{V_1} = 273\times\frac{4V}{V} = 1092K$$

$$Now\ \frac{C_2}{C_1} = \sqrt{\frac{T_2}{T_1}} \qquad (1)$$

$$\Rightarrow \quad \frac{C_2}{x} = \sqrt{\frac{1029}{273}} = \sqrt{4} = 2$$

$$C_2 = 2x\,m/s \qquad (1)$$

Ans27.

Work-energy theorem states that the work done on a particle by a resultant force is equal to the change in its kinetic energy. (1)

$$W = \int F.ds = \int F.\frac{ds}{dt}.dt \quad (1)$$

$$= \int F.v.dt = \int \frac{dK}{dt}.dt = \int dK$$

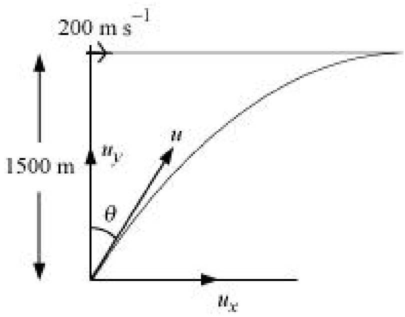
$$W = K_2 - K_1 \quad (1)$$

Ans28.

Height of the fighter plane = 1.5 km = 1500 m

Speed of the fighter plane, v = 720 km/h = 200 m/s

Let θ be the angle with the vertical so that the shell hits the plane. The situation is shown in the given figure.



(1)

Muzzle velocity of the gun, u = 600 m/s

Time taken by the shell to hit the plane = t

Horizontal distance travelled by the shell = $u_x t$

Distance travelled by the plane = vt

The shell hits the plane. Hence, these two distances must be equal.

$$u_x t = vt \quad (1)$$

$$u \sin\theta = v$$

$$\sin\theta = \frac{v}{u}$$

$$= \frac{200}{600} = \frac{1}{3} = 0.33$$

$$\theta = \sin^{-1}(0.33)$$

$$= 19.5° \quad (1)$$

In order to avoid being hit by the shell, the pilot must fly the plane at an altitude (H) higher than the maximum height achieved by the shell.

$$\therefore H = \frac{u^2 \sin^2(90-\theta)}{2g}$$

$$= \frac{(600)^2 \cos^2\theta}{2g}$$ (1)

$$= \frac{360000 \times \cos^2 19.5}{2 \times 10}$$

$$= 18000 \times (0.943)^2$$

$$= 16006.482 \text{ m}$$

$$\approx 16 \text{ km}$$ (1)

OR

Speed of the cyclist, $v = 27 \text{ km/h} = 7.5 \text{ m/s}$

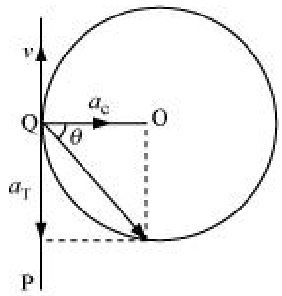
Radius of the circular turn, r = 80 m

Centripetal acceleration is given as:

$$a_c = \frac{v^2}{r}$$

$$= \frac{(7.5)^2}{80} = 0.7 \text{ m/s}^2$$ (1)

The situation is shown in the given figure:



(1)

Suppose the cyclist begins cycling from point P and moves toward point Q. At point Q, he applies the breaks and decelerates the speed of the bicycle by 0.5 m/s^2.

This acceleration is along the tangent at Q and opposite to the direction of motion of the cyclist. (1)

Since the angle between a_c and a_T is 90°, the resultant acceleration a is given by:

$$a = \sqrt{a_c^2 + a_T^2}$$
$$= \sqrt{(0.7)^2 + (0.5)^2}$$
$$= \sqrt{0.74} = 0.86 \ \text{m/s}^2$$

$$\tan\theta = \frac{a_c}{a_T}$$ (1)

Where θ is the angle of the resultant with the direction of velocity

$$\tan\theta = \frac{0.7}{0.5} = 1.4$$

$$\theta = \tan^{-1}(1.4)$$
$$= 54.46°$$ (1)

Ans29. Disc - Radii of the ring and the disc, r = 10 cm = 0.1 m

Initial angular speed, ω_0 =10 π rad s^{-1}

Coefficient of kinetic friction, μ_k = 0.2

Initial velocity of both the objects, u = 0

Motion of the two objects is caused by frictional force. As per Newton's second law of motion, we have frictional force, f = ma

μ_k mg= ma

Where, a = Acceleration produced in the objects, m = Mass

$\therefore a = \mu_k g$ ... (i) (1)

As per the first equation of motion, the final velocity of the objects can be obtained as: $v = u + at$

$= 0 + \mu_k gt$

$= \mu_k gt$ ... (ii)

The torque applied by the frictional force will act in perpendicularly outward direction and cause reduction in the initial angular speed.

Torque, $\tau = -I\alpha$

α = Angular acceleration

$\mu_x mgr = -I\alpha$

$$\therefore \alpha = \frac{-\mu_k mgr}{I} \qquad \ldots(iii)$$

(1)

Using the first equation of rotational motion to obtain the final angular speed:

$$\omega = \omega_0 + \alpha t$$

$$= \omega_0 + \frac{-\mu_k mgr}{I} t \qquad \ldots(iv)$$

Rolling starts when linear velocity, $v = r\omega$

$$\therefore v = r\left(\omega_0 - \frac{\mu_k gmrt}{I}\right) \qquad \ldots(v)$$

(1)

Equating equations (ii) and (v), we get:

$$\mu_k gt = r\left(\omega_0 - \frac{\mu_k gmrt}{I}\right)$$

$$= r\omega_0 - \frac{\mu_k gmr^2 t}{I} \qquad \ldots(vi)$$

For the ring: $I = mr^2$

$$\therefore \mu_k g t = r\omega_0 - \frac{\mu_k g m r^2 t}{mr^2}$$

$$= r\omega_0 - \mu_k g m t_r$$

$$2\mu_k g t = r\omega_0$$

$$\therefore t_r = \frac{r\omega_0}{2\mu_k g}$$

$$= \frac{0.1 \times 10 \times 3.14}{2 \times 0.2 \times 9.8} = 0.80 \text{ s} \qquad \ldots(vii)$$

(1)

For the disc: $I = \frac{1}{2}mr^2$

$$\therefore \mu_k g t_d = r\omega_0 \frac{\mu_k g m r^2 t}{\frac{1}{2}mr^2}$$

$$= r\omega_0 - 2\mu_k g t$$

$$3\mu_k g t_d = r\omega_0$$

$$\therefore t_d = \frac{r\omega_0}{3\mu_k g}$$

$$= \frac{0.1 \times 10 \times 3.14}{3 \times 0.2 \times 9.8} = 0.53 \text{ s} \qquad \ldots(viii)$$

Since $t_d > t_r$, the disc will start rolling before the ring. (1)

OR

(a) False; Frictional force acts opposite to the direction of motion of the centre of mass of a body. In the case of rolling, the direction of motion of the centre of mass is backward. Hence, frictional force acts in the forward direction. (1)

(b) True; Rolling can be considered as the rotation of a body about an axis passing through the point of contact of the body with the ground. Hence, its instantaneous speed is zero. (1)

(c) False; when a body is rolling, its instantaneous acceleration is not equal to zero. It has some value. (1)

(d) True; when perfect rolling begins, the frictional force acting at the lowermost point becomes zero. Hence, the work done against friction is also zero. (1)

(e) True; the rolling of a body occurs when a frictional force acts between the body and the surface. This frictional force provides the torque necessary for rolling. In the absence of a frictional force, the body slips from the inclined plane under the effect of its own weight. (1)

30. (a) Radius of the artery, $r = 2 \times 10^{-3}$ m

Diameter of the artery, $d = 2 \times 2 \times 10^{-3}$ m $= 4 \times 10^{-3}$ m (1/2)

Viscosity of blood, $\eta = 2.084 \times 10^{-3}\ \mathrm{P_a\ s}$

Density of blood, $\rho = 1.06 \times 10^{3}\ \mathrm{kg/m^3}$

Reynolds' number for laminar flow, $N_R = 2000$ (1/2)

The largest average velocity of blood is given by the relation:

$$V_{arg} = \frac{N_R \eta}{\rho d}$$ (1/2)

$$= \frac{2000 \times 2.084 \times 10^{-3}}{1.06 \times 10^{3} \times 4 \times 10^{-3}}$$

$$= 0.983\ \mathrm{m/s}$$ (1)

Therefore, the largest average velocity of blood is 0.983 m/s.

(b) Flow rate is given by the relation:

$$R = \pi r^2 V_{avg}$$ (1)

$$= 3.14 \times \left(2 \times 10^{-3}\right)^2 \times 0.983$$
$$= 1.235 \times 10^{-5}\ \text{m}^3\,\text{s}^{-1}$$ (1)

Therefore, the corresponding flow rate is $1.235 \times 10^{-5}\ \text{m}^3\,\text{s}^{-1}$. (1/2)

OR

Terminal speed = 5.8 cm/s; Viscous force = 3.9×10^{-10} N

Radius of the given uncharged drop, r = 2.0×10^{-5} m

Density of the uncharged drop, ρ = 1.2×10^{3} kg m^{-3}

Viscosity of air, $\eta = 1.8 \times 10^{-5}$ Pa s

Density of air ρ_0 can be taken as zero in order to neglect buoyancy of air.

Acceleration due to gravity, g = 9.8 m/s^2 (1)

Terminal velocity (v) is given by the relation:

$$v = \frac{2r^2 \times (\rho - \rho_0)g}{9\eta}$$ (1)

$$= \frac{2 \times \left(2.0 \times 10^{-5}\right)^2 \left(1.2 \times 10^3 - 0\right) \times 9.8}{9 \times 1.8 \times 10^{-5}}$$
$$= 5.807 \times 10^{-2}\ \text{m s}^{-1}$$
$$= 5.8\ \text{cm s}^{-1}$$

Hence, the terminal speed of the drop is 5.8 cm s^{-1}. (1)

The viscous force on the drop is given by:

$$F = 6\pi\eta rv$$ (1)

$$\therefore F = 6 \times 3.14 \times 1.8 \times 10^{-5} \times 2.0 \times 10^{-5} \times 5.8 \times 10^{-2}$$
$$= 3.9 \times 10^{-10}\ \text{N}$$

Hence, the viscous force on the drop is 3.9×10^{-10} N. (1)