Work Power & Energy (Medical)

Exercise I

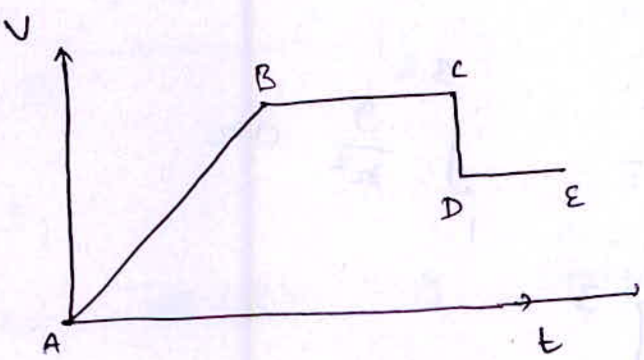
Q1.

Ans. $W = \int \vec{F} \cdot d\vec{s}$

$= \vec{F} \cdot \vec{S} = FS\cos\theta$

(C) does not depend on Initial Velocity

Q2.

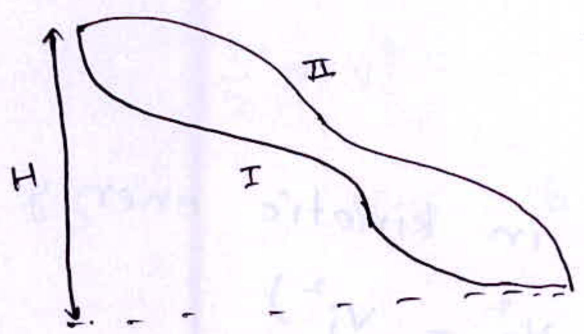


$W_{AB} = \frac{1}{2}m\left(V_B^2 - V_A^2\right)$

$V_B > V_A$

$W_{AB} > 0$

Q3.



For a conservative force work done is path independent it only depends on initial & final point.

$= \frac{1}{2}m\left(V_x^2 + V_y^2\right)$

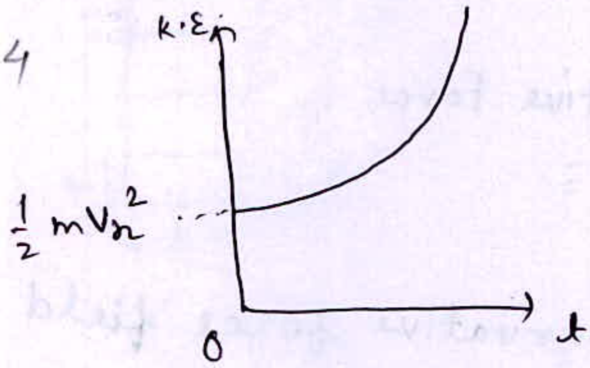
$V_y = 0 + gt$ $\quad$ $K.E. = \frac{1}{2}m\left(V_x^2 + g^2t^2\right)$

Q4. 2

Ans.

work done = change in potential energy.

4



Q12.

Ans.

$$V = \frac{\Delta s}{\Delta t} = \frac{3.6}{1.8 \times 10^{-4}} = 2 \times 10^{4} \text{ m/s}$$

$$K.E. = \frac{1}{2} m_n \times v^2$$

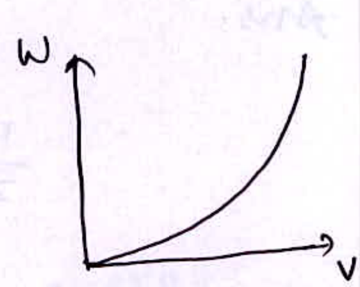
$$= 2.1 \text{ eV}$$

Q13.

Ans.

$$W = \frac{1}{2} m (v^2 - 0^2)$$

$$= \frac{1}{2} m v^2$$



Q14.

Ans.

$$\frac{1}{2} m v^2 = K t \quad \Rightarrow V = \sqrt{\frac{2K}{m}} \times \sqrt{t}$$

$$2 \times \frac{1}{2} m v \frac{dv}{dt} = K$$

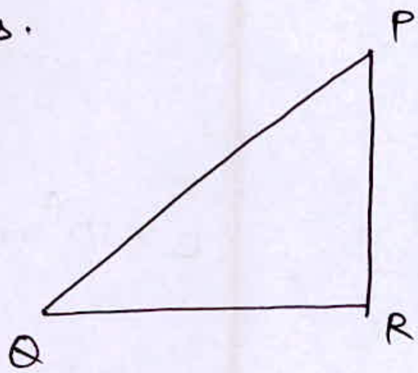
$$a = \frac{dv}{dt} = \frac{K}{m} \times \frac{1}{V}$$

Q7.

Ans. Defination of Conservative Force

Q8.

Ans.



In conservative force field

$$W_{PR} = W_{PQ} + W_{QR}$$

$$= 5 + 2$$

$$= 7 \text{ J}$$

Q9.

Ans. (C) A Conservative Force

Q10.

Ans.

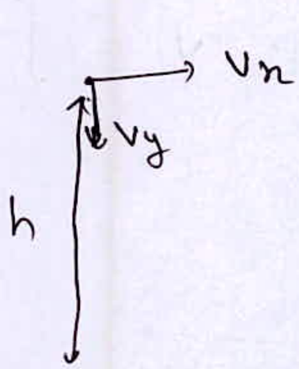
$$K.E. = 3P$$

$$\frac{1}{2} m v^2 = 3 m v$$

$$v = 6$$

Q11.

Ans.



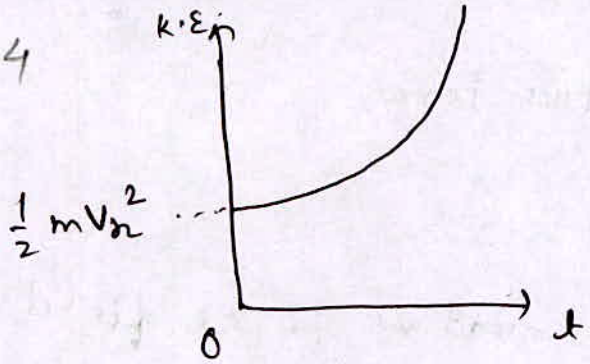
$$K.E. = \frac{1}{2} m v^2$$

$$= \frac{1}{2} m \left(\sqrt{v_x^2 + v_y^2} \right)^2$$

$$= \frac{1}{2} m \left(v_x^2 + v_y^2 \right)$$

$$v_y = 0 + gt$$

$$K.E. = \frac{1}{2} m \left(v_x^2 + g^2 t^2 \right)$$



Q 12.

Ans.

$$V = \frac{\Delta s}{\Delta t} = \frac{3.6}{1.8 \times 10^{-4}} = 2 \times 10^{4} \text{ m/s}$$

$$K.E. = \frac{1}{2} m_n \times v^2$$

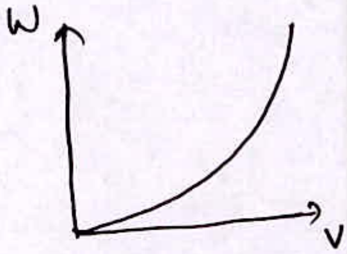
$$= 2.1 \text{ eV}$$

Q 13.

Ans.

$$W = \frac{1}{2} m (v^2 - 0^2)$$

$$= \frac{1}{2} m v^2$$



Q 14.

Ans.

$$\frac{1}{2} m v^2 = K t \Rightarrow v = \sqrt{\frac{2K}{m}} \times \sqrt{t}$$

$$2 \times \frac{1}{2} m v \frac{dv}{dt} = K$$

$$a = \frac{dv}{dt} = \frac{K}{m} \times \frac{1}{v}$$

Q 15.

Ans.

$$-a \propto x$$

$$a = -kx$$

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

$$\int_u^v v\,dv = -\int_0^x kx\,dx$$

$$(v^2 - u^2) = -\frac{k}{2}x^2$$

$$\frac{1}{2}m(v^2 - u^2) = -\frac{k}{4m}x^2$$

$$\Delta KE = -\frac{k}{4m}x^2$$

Q 16.

Ans.

$$\dot{m} = AdV$$

$$K.E. = \frac{1}{2}mV^2$$

$$\frac{d}{dt}(K.E.) = \frac{1}{2}\dot{m}V^2 + \frac{1}{2}m \times 2V\cancel{\frac{dV}{dt}}^{\,0}$$

$$= \frac{1}{2}AdV \cdot V^2$$

$$= \frac{1}{2}AdV^3$$

Q 17. 6

Ans.

$$F \cdot s = \frac{1}{2} m (4^2 - 0) \quad -(1)$$

$$F \cdot x = 2 \times \frac{1}{2} m (4^2 - 0) \quad -(2)$$

$$x = 2s$$

Q 18.

Ans.

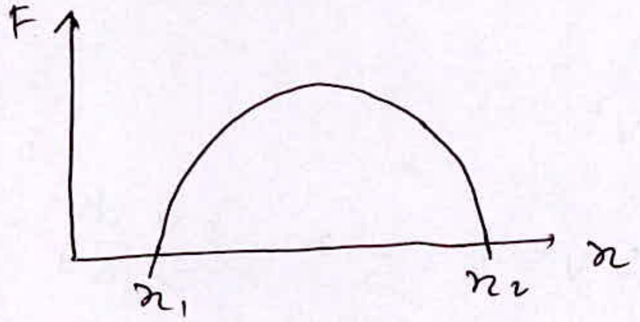
$$F \cdot s = \Delta KE$$

$$\mu \cancel{m} g \cdot s = \frac{1}{2} \cancel{m} (3^2 - 0)$$

$$s = \frac{9}{2 \mu g} = \frac{9}{\cancel{2} \times \frac{1}{\cancel{2}} \times 10} = 0.9 m$$

Q 19.

Ans.



for stable equilibrium

$$F = 0$$

$$\frac{dF}{dx} < 0$$

at $x = x_2$ $F = 0$

and $\left.\frac{dF}{dx}\right|_{x=x_2} < 0$ stable equilibrium

Q 20.

Ans. at equilibrium F must be zero.

U may be or may not be zero.

21.

Ans.

$$\frac{1}{2} K_1 x_1^2 = \frac{1}{2} K_2 x_2^2$$

$$\frac{x_1}{x_2} = \sqrt{\frac{K_2}{K_1}}$$

$$\frac{F_1}{F_1} = \frac{K_1 x_1}{K_2 x_2} = \frac{K_1}{K_2} \times \frac{x_1}{x_2}$$

$$= \frac{K_1}{K_2} \times \sqrt{\frac{K_2}{K_1}}$$

$$= \sqrt{\frac{K_1}{K_2}}$$

Q22.

Ans. Energy stored in spring.

Q23.

Ans.

$$W = \int \vec{F} \cdot d\vec{x}$$

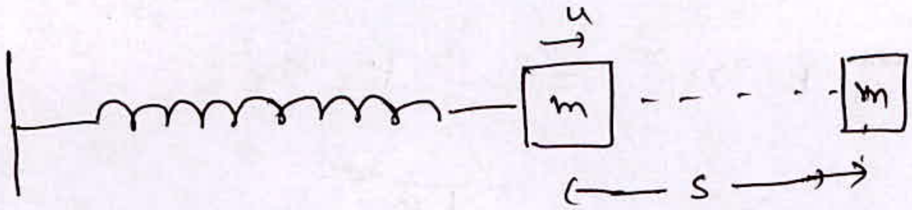
$$= \int_{x_1}^{x_2} K x^2 \times dx \cos 60^\circ$$

$$= \frac{1}{2} \times \frac{K}{3} (x_2^3 - x_1^3)$$

$$= \frac{K}{6} (x_2^3 - x_1^3)$$

Q 24. 8

Ans.



$$\frac{1}{2} m u^2 = \frac{1}{2} K s^2 + \mu m g \cdot s$$

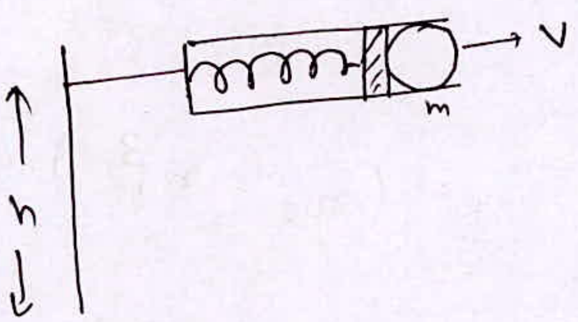
$$s^2 + \frac{2\mu m g}{K} s - \frac{m u^2}{K} = 0$$

$$s = \frac{-\frac{2\mu m g}{K} \pm \sqrt{\frac{4\mu^2 m^2 g^2}{K^2} + \frac{4 m u^2}{K}}}{2}$$

$$= \frac{1}{K}\sqrt{\mu^2 m^2 g^2 + m K u^2} - \frac{\mu m g}{K}$$

Q. 25.

Ans.



$$\frac{1}{2} m v^2 = \frac{1}{2} K x^2$$

$$v = \sqrt{\frac{K}{m}}\, x$$

distance $= v \cdot t$

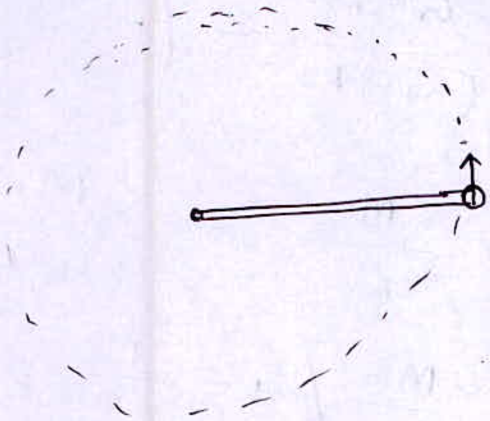
$$t = \sqrt{\frac{2h}{g}}$$

$$= \sqrt{\frac{K}{m}}\, x \cdot \sqrt{\frac{2h}{g}}$$

$$= x\sqrt{\frac{2Kh}{mg}}$$

(26)

Ans.



$$F = m \frac{v^2}{5l/4}$$

$$l/4 = Fl/\lambda$$

$$F = \lambda/4$$

$$\lambda/4 = \frac{4 m v^2}{5l}$$

$$v = \left(\frac{5}{16} \frac{\lambda l}{m}\right)^{1/2}$$

$$K.E. = \frac{1}{2} m v^2 = \frac{5}{8} F l$$

$$\text{elastic stored energy} = \frac{1}{2} \frac{\lambda}{l} \left(\frac{l}{4}\right)^2$$

$$= \frac{2F}{l} \frac{l^2}{16}$$

$$\frac{K.E.}{\text{elastic}} = \frac{5/8\, Fl}{\frac{2F}{l} \frac{l^2}{16}} = 5/1$$

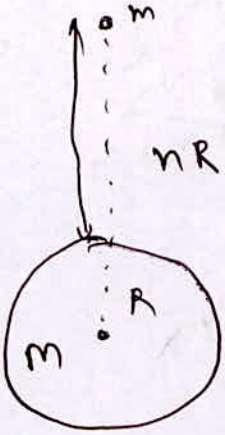
Q. 27.

Ans. $\int \vec{F} \cdot d\vec{x} = m g y_{max}$

$$\frac{1}{2} \times 100 \times 11 = 5 \times 10 \times y_{max}$$

$$y_{max} = 11 \text{ m}$$

(28)



$$\Delta P.E. = \frac{-GMm}{(n+1)R} - \left(-\frac{GMm}{R}\right)$$

$$= \frac{GMm}{R} - \frac{GMm}{(n+1)R}$$

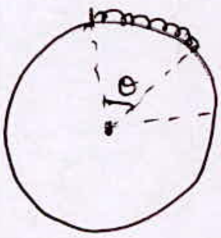
$$= \frac{GMm}{R}\left(1 - \frac{1}{n+1}\right)$$

$$= \frac{GMm}{R}\left(\frac{n}{n+1}\right)$$

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

$$= mgR\left(\frac{n}{n+1}\right)$$

(29)



$$dm = \frac{m}{l} R\, d\theta$$

$$P.E. = \int_0^{l/R} \frac{m}{l} R\, d\theta\, g R\cos\theta$$

$$P.E. = \frac{mR^2 g}{l}\left[\sin\theta\right]_0^{l/R}$$

$$= \frac{mR^2 g}{l}\left[\sin\frac{l}{R} - 0\right]$$

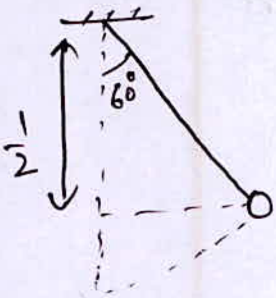
(30)

$$W = \int_r^{r+d} \vec{F}\cdot d\vec{r}$$

$$= \int_r^{r+d} -\frac{G m_1 m_2}{r^2}\, dr = G m_1 m_2\left[\frac{1}{r} - \frac{1}{r+d}\right]$$

$$= \frac{G m_1 m_2 d}{r(r+d)}$$

(31)



$$\Delta K.E. + \Delta P.E = 0$$

$$\frac{1}{2}m(v^2 - 0) = mg\left(\frac{l}{2}\right)$$

$$K.E = 200 \times 10^{-3} \times 10 \times \frac{1}{2}$$

$$= 1\ J$$

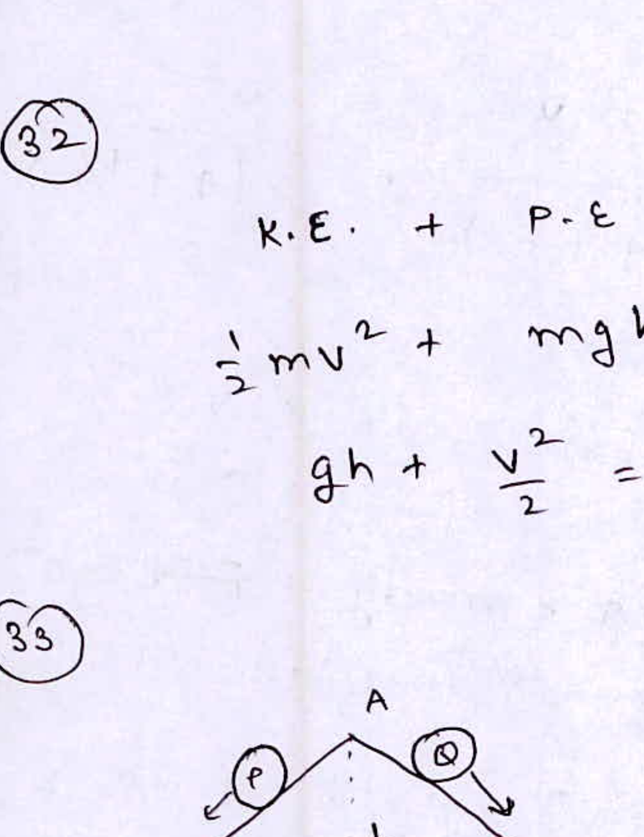
(32)

$$K.E. + P.E = \text{const.}$$

$$\frac{1}{2}mv^2 + mgh = \text{const.}$$

$$gh + \frac{v^2}{2} = \frac{\text{const.}}{m} = K$$

(33)



$$\frac{1}{2}m_P V_P^2 = m_P g h$$

$$\frac{1}{2}m_Q V_Q^2 = m_Q g h$$

$$V_P = V_Q$$

$AC < AB$ & $a_Q > a_P$ so Q will reach the bottom early

(34)

$$\frac{1}{2}\cancel{m}v^2 = \cancel{m}gh$$

$$v = \sqrt{2gh} = 20\ m/s$$

(35)

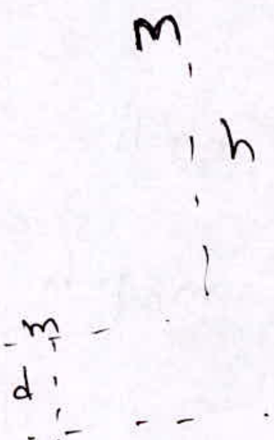
|change in Potential energy| = change in Kinetic energy + change in ~~ee~~ Internal energy

(36)

$$\frac{1}{2} m u^2 - mg\, h_{max} - F\, h_{max} = 0$$

$$h_{max} = \frac{\frac{1}{2} m u^2}{(mg + F)} = \frac{u^2}{2(g + F/m)}$$

(37)



$$M\sqrt{2gh} = (m+M)\,v$$

$$v = \left(\frac{M}{m+M}\right)\sqrt{2gh}$$

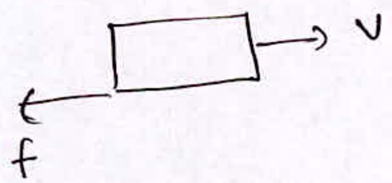
~~$m(d+h)g + mdg - F.d = 0$~~

$$\frac{1}{2}(m+M)\,v^2 + (m+M)\,g\,d = F.d$$

$$F = \frac{1}{2}(m+M)\frac{M^2}{(m+M)^2}\times\frac{2gh}{d} + (m+M)g$$

$$= \frac{M^2 g h}{(m+M)\,d} + (m+M)\,g$$

(38)



$$\frac{dw}{dt} = \text{Power}$$

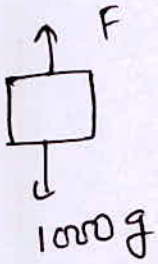
$$= \vec{F}\cdot\vec{V}$$

$$= f v \cos 180^\circ$$

$$= -fv$$

(39)

Power = 3000 W



$F = 1000\,g$

$F \cdot v = 3000$

$v = \frac{3000}{1000 \times 9.8} = .306\,m/s$

(40)

~~$a = \frac{24}{8} = 3\,m/s^2$~~ $a = \frac{24}{8} = 3\,m/s^2$

$K.E. = \frac{1}{2} m v^2$ $\quad V_{avg} = 12\,m/s$

$P = \frac{d(K.E.)}{dt} = \frac{1}{2} m\, 2v \frac{dv}{dt}$

$= \frac{\frac{1}{2} \times 1000 \times 2 \times 12 \times 3}{746}$

$= 48\ hp$

(41)

power $= F \cdot V = (\mu mg\cos\theta + mg\sin\theta)\ 36 \times \frac{5}{18}$

$= mg\left(\frac{1}{\sqrt{3}} \times \frac{2}{\sqrt{5}} + \frac{1}{\sqrt{5}}\right) 36 \times \frac{5}{18}$

$= 1000 \times 9.8 \left(\frac{2.15}{\sqrt{5}}\right) \times 10$

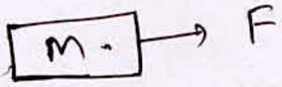
$= 94400\ W$

(42) 14

$$D = bv^2$$

$$\text{Power} = F \cdot V = bv^2 \cdot v = bv^3$$

(43)



$$P = F \cdot V$$

$$a = v\frac{dv}{ds} = \frac{F}{m} = \frac{P}{vm}$$

$$v\frac{dv}{ds} = \frac{P}{vm}$$

$$\int_u^v v^2\,dv = \int_0^s \frac{P}{m}\,ds \Rightarrow v = \left(u^3 + \frac{3PS}{m}\right)^{1/3}$$

(44)

$$w = F^2t^2/2m$$

$$P = \left.\frac{dw}{dt}\right|_{t=T} = \frac{2F^2T}{2m} = \frac{F^2T}{m}$$

$$P_{avg} = \frac{F^2T^2}{2mT}$$

$$P_{instantaneous} / P_{avg} = \frac{F^2T/m}{F^2T/2m} = 2$$

(45)

$$w = \frac{1}{2}mv_0^2$$

$$\frac{dv}{dt} = \frac{v_0 - 0}{t_0}$$

$$v = \frac{v_0}{t_0}t$$

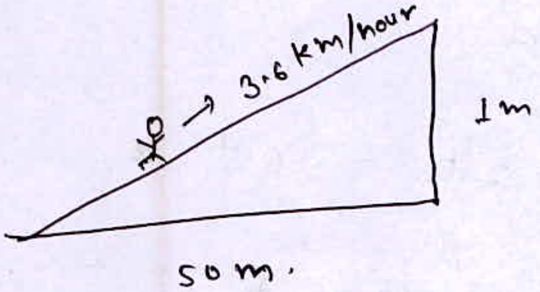
$$P = \frac{dw}{dt} = \frac{1}{2}m \times 2v \times \frac{dv}{dt}$$

$$= m\frac{v_0}{t_0}t \times \frac{v_0}{t_0} = \frac{mv_0^2}{t_0^2}t$$

Exercise 2

Q1.

Ans.



$m = 120\ kg$

$P = F.V$

$= mg \sin\theta \, . \, 3.6 \times \frac{5}{18}$

$= 120 \times 9.8 \times \frac{1}{\sqrt{50^2+1}} \times 3.6 \times \frac{5}{18}$

$= 23.52$ Watt

Q2.

Ans.

$W = \frac{1}{2} K (x+y)^2 - \frac{1}{2} K x^2$

$= \frac{1}{2} K (\cancel{x^2} + 2xy + y^2 - \cancel{x^2})$

$= \frac{1}{2} Ky (2x + y)$

Q3.

$W = \int_0^5 \vec{F} . d\vec{x}$

$= \left[7x - x^2 + x^3 \right]_0^5$

$= [35 - 25 + 125]$

$= 135$ J

Q4.

[illegible]

$x = t^3/3$

$W = \int \vec{F} . d\vec{x}$

$$\frac{dx}{dt} = t^2$$

$$\frac{d^2x}{dt^2} = 2t = a$$

$$F = ma = 3 \times 2t = 6t$$

$$W = \int_0^2 6t \cdot t^2\, dt = \left[6\frac{t^4}{4}\right]_0^2$$

$$= 6 \times 2^4/4 = 24\ J$$

Q5.

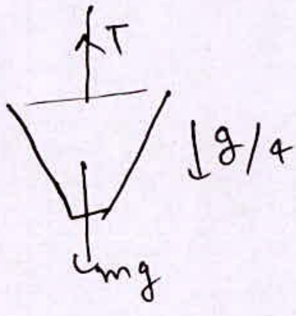
Ans. $P = \vec{F} \cdot \vec{V}$

$= 100 - 60 + 240$

$= 280\ J/s$

Q6.

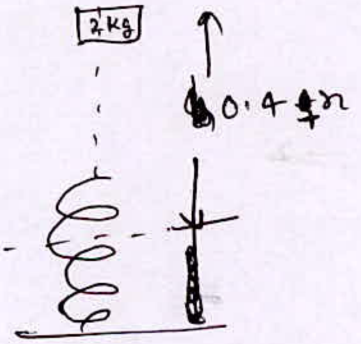
$$T = \frac{3}{4} mg$$



$$W_T = -\frac{3}{4} mg\, d$$

Q7.

Ans.



$$mg(0.4 + x) = \frac{1}{2} K x^2$$

$$2 \times 9.8 \times 0.4 + 2 \times 9.8\, x = \frac{1960}{2} x^2$$

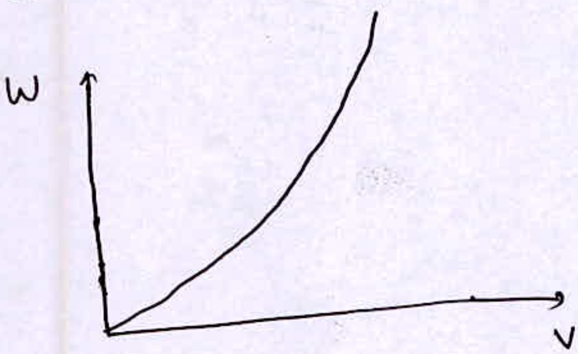
$$100x^2 - 2x - 0.8 = 0$$

$$x = 0.1\ m.$$

Q 8.

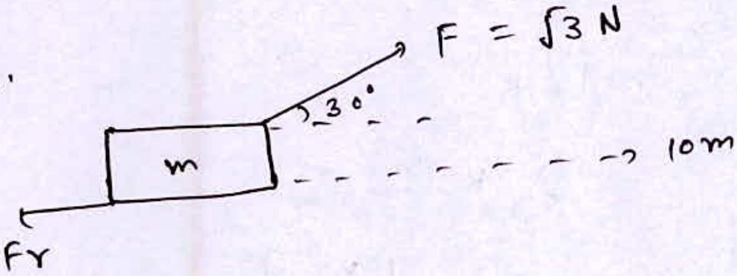
Ans.

$$W = \frac{1}{2} m v^2$$



Q 9.

Ans.



$$W_F = \vec{F} \cdot \vec{s}$$
$$= \sqrt{3} \times 10 \times \cos 30^\circ$$
$$= 15 \text{ J}$$

Q 10.

Ans.

$$U = a/r^2 - \frac{b}{r}$$

$$F = -\frac{dU}{dr} = \frac{2a}{r^3} - \frac{b}{r^2} = 0$$

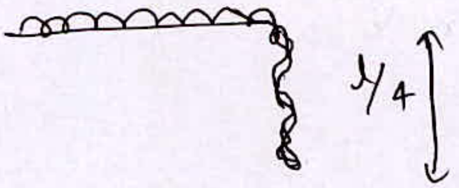
$$2a - b r_0 = 0 \Rightarrow r_0 = \frac{2a}{b}$$

Q 11.

Ans.

$$W_{total} = \int_0^a \vec{F} \cdot d\vec{S_1} + \int_0^a \vec{F} \cdot \vec{S_2}$$
$$= \int_0^a -K(0\hat{i} + x\hat{j})\,(dx\,\hat{i}) + \int_0^a -K(y\hat{i} + a\hat{j})\,dy\,\hat{j}$$
$$= 0 + (-Ka^2) = -Ka^2$$

(12)



$$W = \Delta PE$$
$$= \frac{m}{4} g \frac{l}{8}$$
$$= \frac{mgl}{32}$$

(13)

$$mg = kx_0$$
$$x = mg/k$$
$$\text{energy} = \frac{1}{2} k x_0^2$$
$$= \frac{1}{2} k \left(\frac{m^2 g^2}{k^2}\right)$$
$$= \frac{1}{2} \frac{m^2 g^2}{k}$$
$$= \frac{mg x_0}{2}$$

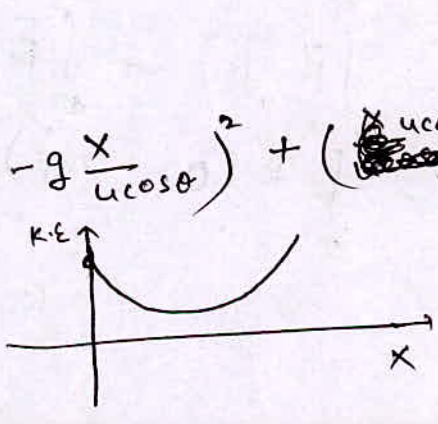
(14)

(a) Conservative system of forces.

(15)

$$x = u\cos\theta\, t$$

$$K.E = \frac{1}{2} m \left[\left(u\sin\theta - g\frac{x}{u\cos\theta}\right)^2 + \left(u\cos\theta\right)^2\right]$$



Q 16.

Ans.

$$\frac{v_1^2}{2g} = \frac{(u \sin 45^\circ)^2}{2g}$$

$$v_1^2 = \frac{u^2}{2}$$

$$\frac{\frac{1}{2} m_1 v_1^2}{\frac{1}{2} m_1 u^2} = \frac{v_1^2}{u^2} = 1/2$$

Q 17.

Ans.

$$K.E = \frac{P_1^2}{2m}$$

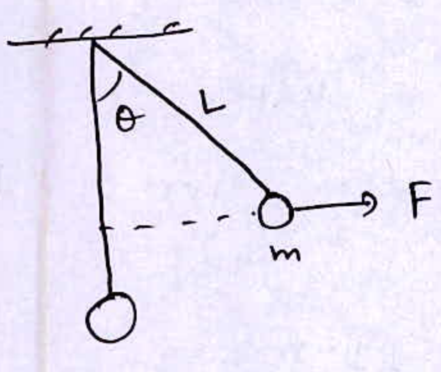
$$4\ K.E. = \frac{P_2^2}{2m}$$

$$4 = \left(\frac{P_2}{P_1}\right)^2 \Rightarrow \frac{P_2}{P_1} = 2$$

Momentum increased by 100 %

Q 18.

Ans.



$$W_F = \Delta P.E.$$

$$= mgl(1-\cos\theta)$$

Q 19. 20

Ans. Work done by internal force is zero

$$T \cdot d - T \cdot d = 0$$

Q 20.

Ans.
$$\frac{1}{2} m v^2 = \frac{1}{2} k x^2 + \frac{1}{2} m \left(\frac{v}{2}\right)^2$$

$$\frac{3}{4} \times \frac{1}{2} m v^2 = \frac{1}{2} k x^2$$

$$k = \frac{3}{4} \frac{m v^2}{x^2}$$

Q 21.

Ans.
$$\frac{1}{2}\left(\frac{1}{2} m v_0^2 + m \times g \times 10\right) = m g \times 10$$

$$v_0^2 = 2 \times g \times 10$$

$$= \sqrt{20 g}$$

$$= 14 \text{ m/s}$$

Q 22.

Ans.
$$m g y_{max} = W_F$$

$$5 \times 10 \times y_{max} = \frac{1}{2} \times 100 \times 11$$

$$y_{max} = 11 \text{ m}$$

(23)

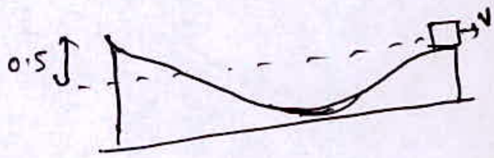
$$\frac{1}{2} m u^2 = m g h$$

$$K.E \text{ at } 3h/4 = \frac{1}{2} m u^2 - m g \frac{3h}{4}$$

$$P.E. \text{ at } 3h/4 = m g \frac{3h}{4}$$

$$\frac{K.E.}{P.E.} = \frac{m g h - m g \frac{3h}{4}}{\frac{3}{4} m g h} = \frac{1}{3}$$

Q 24.



Ans $$m g \times \frac{1}{2} = \frac{1}{2} m v^2$$

$$v = \sqrt{g}$$

$$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 0.5}{g}}$$

$$\text{distance} = \sqrt{g} \times \sqrt{\frac{2 \times 0.5}{g}}$$

$$= 1 \text{ m.}$$

Q. 25 $$K_B = \frac{K_A}{2}$$

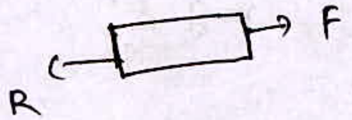
Ans. $$E_1 = \frac{F^2}{2 K_A} = E$$

$$E_2 = \frac{F^2}{2 K_B} = \frac{F^2}{2 \times \frac{K_A}{2}} = 2E$$

$$E_2 = 2E$$

Q 26. 22

Ans.



$$F - R = ma$$

$$F = R + ma$$

$$P = F \cdot v = (R + ma)\, v$$

Q 27.

Ans.

$$P = \vec{F} \cdot \vec{V}$$

$$= 50 - 30 + 120$$

$$= 140 \text{ J}$$

Q 28.

Ans. $P = F \cdot v = 4500 \times 2 = 9 \text{ KW}$

Q 29.

Ans. $P_1 = \frac{mgh_0}{t_1}$ $\quad P_2 = \frac{mgh}{t_2}$

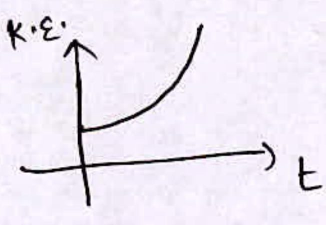
$$P_1 / P_2 = \frac{t_2}{t_1} = \frac{20}{15} = 4/3$$

Q 30.

Ans.

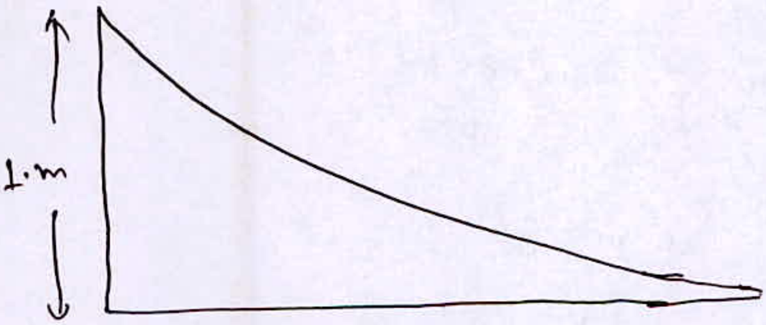
$$K.E. = \frac{1}{2} m (v_x^2 + v_y^2)$$

$$= \frac{1}{2} m (v_x^2 + g^2 t^2)$$



(31)

Ans.



$$mgh = \mu mg \cdot x$$

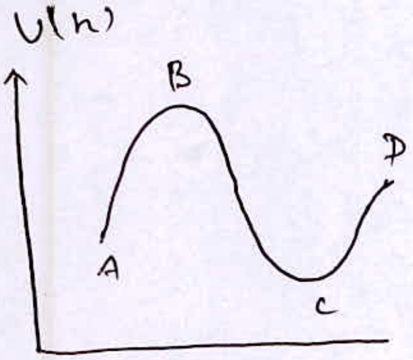
$$x = \frac{h}{\mu}$$

$$= \frac{1}{0.2}$$

$$= 5\text{ m.}$$

Q. (32)

Ans.



$$F = -\frac{dU}{dx}$$

$\frac{dU}{dx} = 0$ at B & C

Q (33)

Ans.

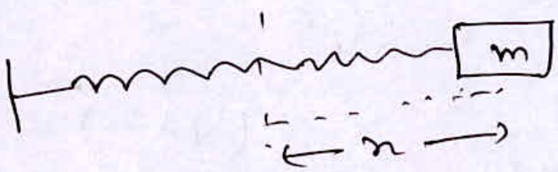
$$W_{PR} = W_{PQ} + W_{QR}$$

$$= 5 + 2$$

$$= 7\text{ J}$$

Q (34)

Ans.



~~[illegible]~~

$$W = \mu mg x + \frac{1}{2} k x^2$$ differentiate w.r.t to x

$$0 = \mu mg + kx$$

$$x = \frac{\mu m g}{K}.$$

$$\frac{1}{2} K x^2 = \frac{1}{2} K \frac{\mu^2 m^2 g^2}{K^2}$$

$$= \frac{\mu^2 m^2 g^2}{2K}$$

Q 35.

Ans.

$$U = \frac{1}{2} m v^2$$

$$m = \frac{2U}{v^2}$$

Q 36.

Ans. Same Q. 29.

Q. 37.

Ans.

$$\frac{\frac{1}{2} m (20^2 - 10^2)}{\frac{1}{2} m (10^2 - 0^2)} = 3$$

Q 38.

$$K.E._2 = \frac{1}{2} m (v+2)^2$$

$$K.E._1 = \frac{1}{2} m v^2$$

$$K.E._2 = 2 K.E._1 \Rightarrow (v+2)^2 = 2v^2$$

$$v + 2 = \pm \sqrt{2} v$$

$$v = \frac{2}{\sqrt{2}-1} \times \frac{\sqrt{2}+1}{\sqrt{2}+1} \qquad v = \frac{-2}{(\sqrt{2}+1)} \times$$

(39)

$$t = \sqrt{x} + 3$$

$$W = \int \vec{F} \cdot d\vec{x}$$

at $t = 6$

$$6 = \sqrt{x} + 3$$

$$x = 9$$

$$t = \sqrt{x} + 3$$

$$1 = \frac{1}{2\sqrt{x}} \frac{dx}{dt}$$

$$dx = 2\sqrt{x}\, dt$$
$$= 2(t-3)\, dt$$

$$\frac{dx}{dt} = 2\sqrt{x}$$

$$\frac{d^2x}{dt^2} = \frac{2}{2\sqrt{x}} \times \frac{dx}{dt} = 2$$

$$F = m\frac{d^2x}{dt^2} = 2m$$

$$W = \int_0^6 2m(t-3)\,dt = 2m\left(\frac{t^2}{2} - 3t\right)_0^6$$

$$= 2m\left(\frac{36}{2} - 3 \times 6\right) = 0$$

(40)

~~$\frac{1}{2}$ K.E ... $= \frac{m_b}{2}$ ... $= \frac{1}{2}mv^2$~~

$$\therefore \frac{1}{2} m v_m^2 = \frac{1}{2} \times \frac{1}{2} \times \frac{m}{2} v_b^2$$

$$2v_m = v_b$$

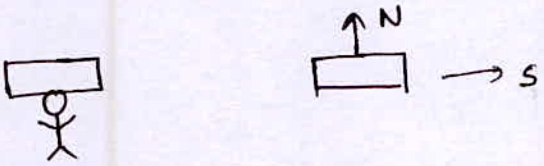
$$\frac{1}{2} m (v_m + 1)^2 = \frac{1}{2} \times \frac{m}{2} \times v_b^2$$

$$v_m + 1 = \frac{v_b}{\sqrt{2}} = \sqrt{2}\, v_m$$

$$v_m = \frac{1}{\sqrt{2} - 1} = \sqrt{2} + 1 \ \text{m/s}$$

Assertion & Reason

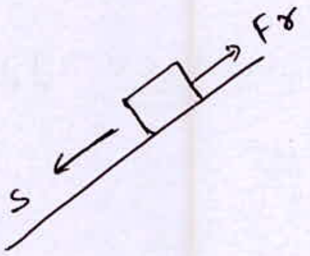
(1)



$\vec{N}$ & $\vec{S}$ are perpendicular.

(2) In Non - ~~Only in~~ Conservative Force Field work done in a round trip is not zero.

(3) angle btw. $\vec{Fr}$ & $\vec{S}$ is 180°



(4) In expansion work done is positive

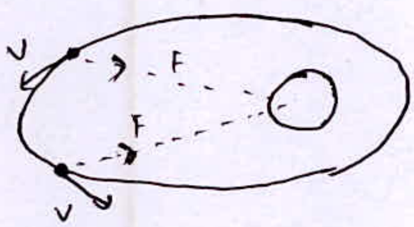
(5) $K.E. = \frac{p^2}{2m} = \frac{1}{2} m v^2$

(6) $P = \vec{F} \cdot \vec{V}$

(7) $W_{net} = \Delta K.E.$

(8) $P.E. = \frac{1}{2} K x^2$

(9)



Gravitational Field is conservative

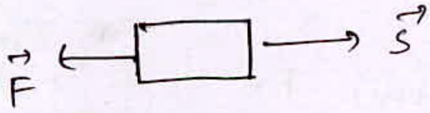
(10) 28

$$\Sigma F_{ext.} = \frac{d\vec{P}_{sys}}{dt}$$

(12)

$$\text{Power } \Delta t = \Delta P.E.$$
$$= mgh$$
$$\text{Power} \cdot \cancel{10} = 100 \times \cancel{10} \times 100$$
$$\text{Power} = 10 \text{ KW}$$

(14)



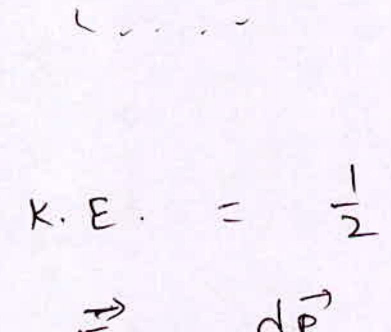
$$\Rightarrow W = \vec{F} \cdot \vec{S}$$

(15) In elastic collision momentum and energy of system is conserved

(16)

$$K.E. = \frac{P^2}{2m}$$

(17)



$$\text{Power} = \vec{F} \cdot \vec{V}$$
$$= (\vec{F}_x + \vec{F}_y)\,\vec{V}$$
$$= \vec{F}_x \cdot \vec{V} + \vec{F}_y \cdot \vec{V}$$
$$= 0 + \vec{F}_y \cdot \vec{V}$$

(18)

$$K.E. = \frac{1}{2} m V^2$$

(19)

$$\vec{F} = \frac{d\vec{P}}{dt}$$ if dt is small $\vec{F}$ will be greater

(20) In Conservative Force Field work done is independent of path.

(23) $P.E. = \frac{1}{2} K x^2$

(24) $E = mc^2$

(25) $P.E = \frac{K q_1 q_2}{r^2}$

(26) $m_b V_b = m_a V_a = P$

$K.E_b = \frac{P^2}{2m_b}$ $\frac{KE_a}{KE_b} = \frac{m_b}{m_a}$

$K.E_a = \frac{P^2}{2m_a}$

(27) $Power = \frac{W}{t}$

$= \frac{n \times \frac{1}{2} m v^2}{1}$

(28) Not for Non conservative Forces

(~~29~~)

Previous Year's Questions

Work Done by Constant Force & Variable Force

Q 1.

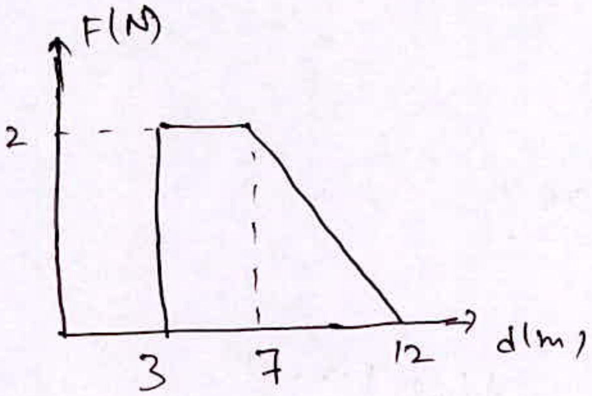
$$W = \vec{F}\cdot\vec{S}$$

$$= (3\hat{i}+\hat{j})\cdot\left[(4\hat{i}+3\hat{j}-\hat{k})-(2\hat{i}+\hat{k})\right]$$

$$= (3\hat{i}+\hat{j})\cdot(2\hat{i}+3\hat{j}-2\hat{k})$$

$$= 9\ J$$

Q 2.



$$W = \int \vec{F}\cdot d\vec{s}$$

$$= 2\times 4 + \frac{1}{2}\times 2\times 5$$

$$= 13\ J$$

Q 3.

$$T = mg + ma = 1000(11) = 11000\ N$$

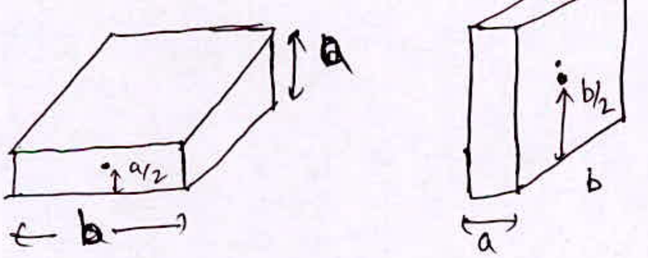
Q 4.

$$W = \vec{F}\cdot\vec{S} = 20\times 9.8\times 20\times \cos 60^\circ$$

$$= 196\times 20\times \frac{1}{2}$$

$$= 1960\ J$$

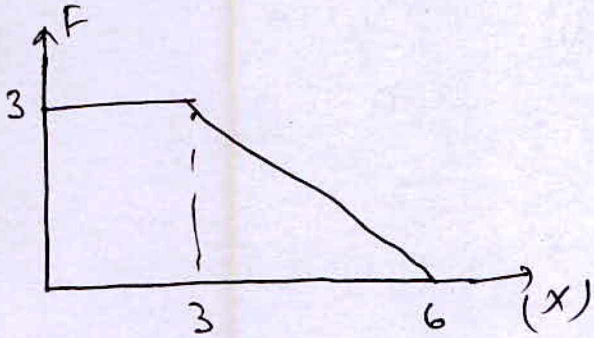
Q 5.



$$W = mg\left(b/2 - a/2\right)$$

$$= mg\left(\frac{b-a}{2}\right)$$

Q 6.



$$W = 3 \times 3 + \frac{1}{2} \times 3 \times (6-3)$$

$$= 13.5 \text{ J}$$

Q 7

Ans.

$$\text{Power} = \frac{746}{4} \text{ Watt}$$

$$W = \frac{746}{4} \times \frac{40}{100} \times \frac{60}{600 \; 10}$$

$$= \frac{746}{100} = 7.46 \text{ J}$$

Q 8.

Ans.

$$W_{gravity} = \frac{1}{2} m \left(v_f^2 - v_i^2 \right)$$

$$= \frac{1}{2} \times 10^{-1} \left(0 - 25 \right)$$

$$= -\frac{2.5}{2} = -1.25 \text{ J}$$

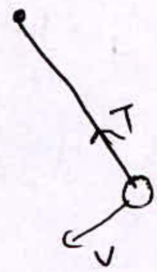
Q 9.

$$W = \frac{1}{2} m \left(v_f^2 - v_i^2 \right)$$

$$= \frac{1}{2} \times 50 \left(20^2 - 0^2 \right)$$

$$= \frac{1}{2} \times 50 \times 400 = 10^4 \text{ J}$$

(10)



$$w = \vec{T} \cdot \vec{v} = TV \cos 90^\circ$$
$$= 0$$

(11)

$$w = \frac{1}{2} m v^2$$
$$= \frac{1}{2} \times 10 \times 10^2 = 500 \text{ J}$$

(12)

$$W_F = 40 \times 2 = 80 \text{ J}$$
$$W_{gravity} = -mgh = -20 \times 2 = -40 \text{ J}$$

(13)

$$w = \frac{1}{2} K (x_f^2 - x_i^2)$$
$$= \frac{1}{2} K (10^2 - 5^2) \times 10^{-4}$$
$$= \frac{1}{2} \times 5 \times 10^3 \times 75 \times 10^{-4}$$
$$= \frac{5 \times 75}{20} = \frac{75}{4} = 18.75 \text{ N-m.}$$

(14)

$$w = mgh + W_{Fr}$$
$$300 = 2 \times 10 \times 10 + W_{Fr}$$
$$W_{Fr} = 100 \text{ J}$$

(15)

$$s = \frac{1}{3} t^2 \qquad \frac{ds}{dt} = \frac{2}{3} t \qquad \frac{d^2 s}{dt^2} = \frac{2}{3}$$
$$F = \frac{2}{3} \times 3 = 2 \text{ N}$$
$$W = F \cdot S = 2 \times \frac{1}{3} \times 2^2 = \frac{8}{3} \text{ J}$$

Q 16.

Ans.

$$F = (-5x - 16x^3)\ N$$

$$W = -\int_{0.1}^{0.2} F\, dx$$

$$= -\int_{0.1}^{0.2} [-5x - 16x^3]\, dx$$

$$= \left[\frac{5x^2}{2} + \frac{16x^4}{4}\right]_{0.1}^{0.2}$$

$$= \frac{5}{2} \times (0.04 - 0.01) + 4(16 - 1)10^{-4}$$

$$= 7.5 \times 10^{-2} + .64 \times 10^{-2}$$

$$= 8.14 \times 10^{-2}\ J$$

Q 17.

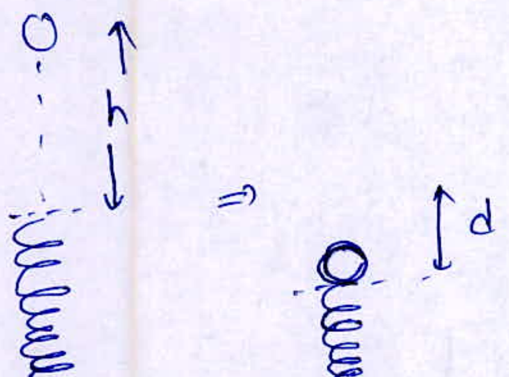
$$W = (P_2 - P_1)V + \rho V g h + \cancel{\tfrac{1}{2}m(v_f^2 - v_i^2)} \to 0$$

$$= (2\times10^5 - 10^5) \times 4 + 1000 \times 4 \times 10 \times 20$$

$$= 4\times10^5 + 8\times10^5$$

$$= 12\times10^5\ J$$

Q 18.



$$W = mg(h+d) - \frac{1}{2}kd^2$$

Q 19.

Ans.

$\vec{F} = 2\hat{i} + 15\hat{j} + 6\hat{k}$

$\vec{s} = 10\hat{j}$

$W = \vec{F}\cdot\vec{s} = 150\ J$

Q 20

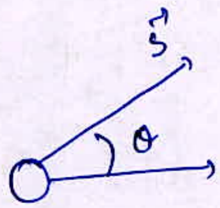
Ans.

$W = \vec{F}\cdot\vec{s}$ $[\vec{s} = 0]$

$= 0$

Q 21.

Ans.



$W = \vec{F}\cdot\vec{s} = F S \cos\theta$

$25 = 5 \times 10 \cos\theta$

$\cos\theta = 1/2$

$\theta = 60^\circ$

Q 22.

Ans.

$v = \cancel{u}^{0} + at$

$V = at$

given $V = v$ at $t = t_1$

$v = a t_1 \Rightarrow a = \frac{v}{t_1}$

$V = \left(\frac{v}{t_1}\right) t$

$W = \Delta K.E. = \frac{1}{2} m \left(v_f^2 - \cancel{v_i^2}^{0}\right)$

$= \frac{1}{2} m \left(\frac{v}{t_1} t\right)^2$

$= \frac{1}{2}\left(\frac{m v^2}{t_1^2}\right) t^2$

(23)

Ans.

$$W = \int_{4}^{-2} \vec{F}\cdot(dx\,\hat{i})$$

$$= \int_{4}^{-2} -6x^3\,dx$$

$$= -\frac{6}{4}\left[x^4\right]_{4}^{-2}$$

$$= -\frac{6}{4}\left[2^4 - 4^4\right]$$

$$= -6\left[4 - 64\right]$$

$$= 360\ J$$

Q24.

Ans.

$$\vec{F} = (6\hat{i} + 2\hat{j})\ N$$

$$\vec{s} = (3\hat{i} - \hat{j})\ m$$

$$W = \vec{F}\cdot\vec{s} = 18 - 2 = 16\ J$$

Q 25

Ans.

$$W_I : W_{II} : W_{III} \equiv mg\,s_I : mg\,s_{II} : mg\,s_{III}$$

$$s_I : s_{II} : s_{III}$$

$$\frac{1}{2}g(1)^2 : \frac{1}{2}g(2^2 - 1^2) : \frac{1}{2}g(3^2 - 2^2)$$

$$1 : 3 : 5$$

Q 26. 36

Ans.

$$F = Cx$$

$$W = \int_0^{x_1} F\,dx$$

$$= \int_0^{x_1} Cx\,dx$$

$$= \frac{1}{2} C x_1^2$$

Q 27.

Ans. Frictional Force

Q 28.

Ans.

$$x = \frac{t^3}{3}$$

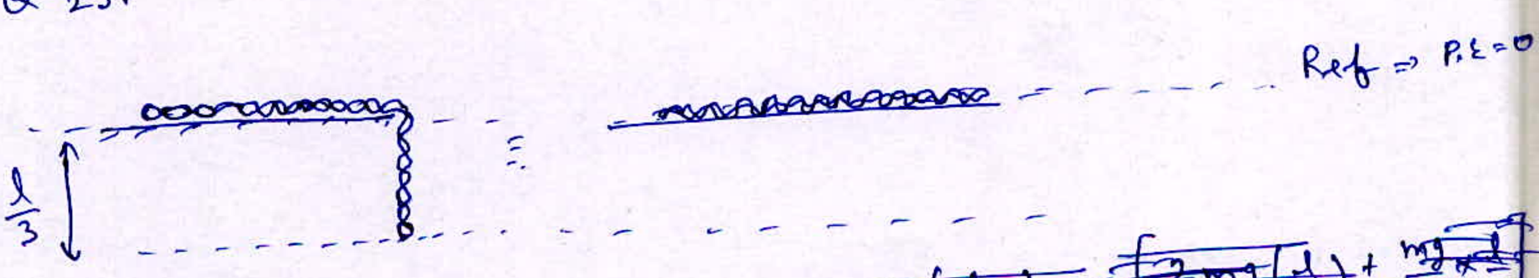
$$\frac{dx}{dt} = t^2$$

$$a = 2t$$

$$ma = 4t$$

$$W = \int_0^2 4t\, t^2\,dt = \frac{4}{4}\left[t^4\right]_0^2 = 16\ J$$

Q 29.



$$W = \Delta P.E = 0 - \left[0 - \frac{m}{3} g \frac{l}{6}\right]$$

$$= \frac{mgl}{18}$$

Energy

Q. 1.

Ans. by the system against a conservative force

Q 2.

Ans.

$$K.E. = \frac{p^2}{2m}$$

$$\frac{K.E_1}{K.E_2} = \frac{m_2}{m_1} = \frac{5}{4}$$

Q 3.

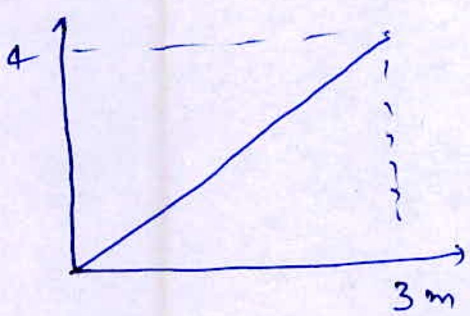
Ans.

$$490 = \frac{490}{2} + mgh$$

$$245 = 5 \times 9.8 \times h$$

$$h = \frac{245}{49} = 5\text{ m.}$$

Q 4.



$$w = -\frac{1}{2} \times 4 \times 3$$

$$= -6\text{ J}$$

$$w = \Delta K.E. = -6\text{ J}$$

Q 5.

~~$\frac{1}{2} M v^2 = (M+m) g h$~~

~~$v = \sqrt{\left(\frac{M+m}{m}\right) 2gh}$~~

$$\frac{1}{2} M_b V_{block}^2 = M_b g h$$

$$V_{block} = \sqrt{2gh}$$

Q 6.

Ans.

$$K.E._{ground} = \frac{1}{2} m u^2$$

$$K.E._{highest\ point} = \frac{1}{2} m (u\cos\beta)^2 \quad -②$$

$$\frac{K.E_h}{K.E_g} = \frac{3}{4} = \cos^2\beta$$

$$\cos\beta = \frac{\sqrt{3}}{2} \Rightarrow \beta = 30^\circ$$

Q 7.

Ans.

$$5 \times 10^3 \times 1.2 = (5 \times 10^3 + 10^3) V$$

$$V = \frac{5 \times 1.2}{6} = 1 \text{ m/s}$$

$$\Delta K.E = \cancel{\frac{1}{2} m (V_f^2 - V_i^2)} \; K.E_2 - KE_1$$

$$= \frac{1}{2} \times 6 \times 10^3 \times 1^2 - \frac{1}{2} \times 5 \times (1.2)^2$$

$$= 3000 - 6100$$

$$= -3100 \text{ J}$$

Q 8.

Ans.

$$K.E. = \frac{1}{2} m V^2$$

$$V = \cancel{u}^{0} + at = \frac{P}{m} t$$

$$K.E. = \frac{1}{2} m \frac{P^2}{m^2} t^2 = \frac{P^2 t^2}{2m}$$

Q 9.

Ans.

$$K.E_1 = \frac{P^2}{2m} \qquad P' = 3/2\, P$$

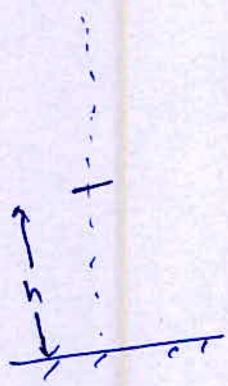
$$K.E_2 = \frac{(3/2\, P)^2}{2m} = \frac{9/4\, P^2}{2m}$$

$$\frac{K.E_2 - K.E_1}{K.E_1} \times 100 = \frac{(9/4 - 1)\frac{P^2}{2m}}{P^2/2m} \times 100$$

$$= 125\ \%$$

Q 10.

Ans.



$$mgh + \frac{1}{2} m V_1^2 = \frac{1}{2} m u^2$$

$$mgh = \frac{1}{2} m V_1^2$$

$$mgh = \frac{1}{4} m u^2$$

$$mgh + \frac{1}{2} m V_2^2 = \frac{1}{2} m (2u)^2$$

$$\frac{1}{4} m u^2 + K.E. = \frac{1}{[illegible]}\ 2 m u^2$$

$$K.E. = \left(2 - \frac{1}{4}\right) m u^2$$

$$P.E. = \frac{1}{4} m u^2 \qquad P.E/_{K.E.} = 1/7$$

$$K.E. = \frac{7}{4} m u^2$$

Q 11.

Ans.

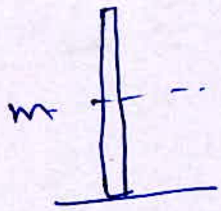
$$mgh + [illegible]\ \frac{490}{2} = 490$$

$$mgh = \frac{490}{2}$$

$$2 \times 9.8\, h = \frac{490}{2} \Rightarrow h = 12.5\,m.$$

Q 12.

Ans.



$$P.E. = mg\frac{l}{2}$$

Q 13.

Ans.

$$a = -kx$$

$$\int_{v_i}^{v_f} \frac{d^2x}{dt^2} = -\int_0^x kx$$

$$\frac{dx}{dt} = -\frac{kx^2}{2}$$

v_f

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

$$\int_{v_i}^{v_f} v\,dv = -\int_0^x kx\,dx$$

$$\frac{1}{2}(v_f^2 - v_i^2) = -\frac{kx^2}{2}$$

$$\frac{1}{2}m(v_f^2 - v_i^2) = -\frac{km}{2}x^2$$

$$\Delta K.E. \propto x^2$$

Q 14.

Ans.

$$-\Delta K.E = \Delta P.E$$

$$-\frac{1}{2}\cancel{m}(\cancel{v_f^2}^{\,0} - v_i^2) = \cancel{m}g(2 - 0.75)$$

$$v_i = \sqrt{2g \times 1.25} = 5\,m/s$$

Q 15.

Ans.

~~$\frac{1}{2} m_A v_A^2$~~ $\frac{p_B^2}{2m_B} = \frac{p_A^2}{2m_A}$

$$\frac{p_B}{p_A} = \sqrt{\frac{m_B}{m_A}} = 1/\sqrt{3}$$

Q 16.

Ans.

$$F \cdot s = mgh$$

$$F = mg\frac{h}{s}$$

Q 17.

Ans.

$$21 \times \frac{28}{100} \times 10^3 = 40 \times 9.8 \times h$$

$$h = \frac{21 \times 7}{9.8} = \frac{147}{9.8} = 15\,m$$

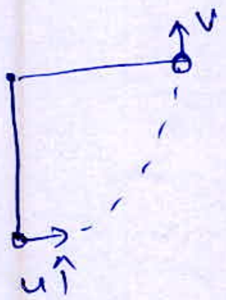
Q 18.

Ans.

$$\frac{K.E._1}{K.E._2} = \frac{m_1 g h}{m_2 g h} = \frac{2}{4} = \frac{1}{2}$$

Q 19.

Ans.



$$\frac{1}{2} m v^2 + 2 m g l = \frac{1}{2} m u^2$$

$$v = \sqrt{u^2 - 2gl}\ \hat{j}$$

~~$v = u$~~

$u - v$ ~~$u - v$~~ $= u\hat{i} - \sqrt{u^2 - 2gl}\ \hat{j}$

$$|u - v| = \sqrt{u^2 + u^2 - 2gl} = \sqrt{2(u^2 - gl)}$$

Q20.

Ans.

$$\frac{\varepsilon_1}{\varepsilon_2} = \frac{\frac{p^2}{2m_1}}{\frac{p^2}{2m_2}} = \frac{m_2}{m_1}$$

$$\frac{\varepsilon_1}{\varepsilon_2} < 1 \Rightarrow \varepsilon_1 < \varepsilon_2$$

Q21.

Ans.

$$F = K_1 x_1$$

$$F = K_2 x_2$$

$$\frac{P.\varepsilon_1}{P.\varepsilon_2} = \frac{\frac{F^2}{2K_1}}{\frac{F^2}{2K_2}} = \frac{K_2}{K_1} = 2/1$$

Q22.

Ans.

$$\frac{K.\varepsilon_0}{2} + mgh = K.\varepsilon$$

$$mgh = \frac{K.\varepsilon}{2} = \frac{1}{4} m \times 4^2$$

$$h = \frac{4}{10} = 0.4\,m.$$

Q23.

Ans.

$$\frac{1}{2} m v_0^2 = \frac{1}{2} 3m v^2 + \frac{1}{2} K x_0^2 \quad \text{—(1)}$$

$$m v_0 = 3 m v \Rightarrow m = \frac{v_0}{3}$$

from (1) $\frac{1}{2} m \left(v_0^2 - \frac{v_0^2}{3} \right) = \frac{1}{2} K x_0^2$

$$K = \frac{2}{3} \frac{m v_0^2}{x_0^2}$$

Q 24.

Ans.

Δ M.E. $=$ Δ K.E. $+$ Δ P.E

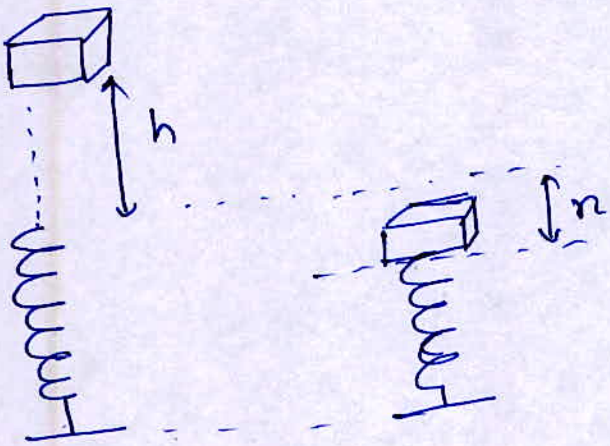
$= \frac{1}{2} m (10^2 - 0^2) + mg(19.5 + .5)$

$= .25 + 5 \times 10^{-3} \times 10 \times 20$

$= 1.25$ J

Q 25.

Ans.

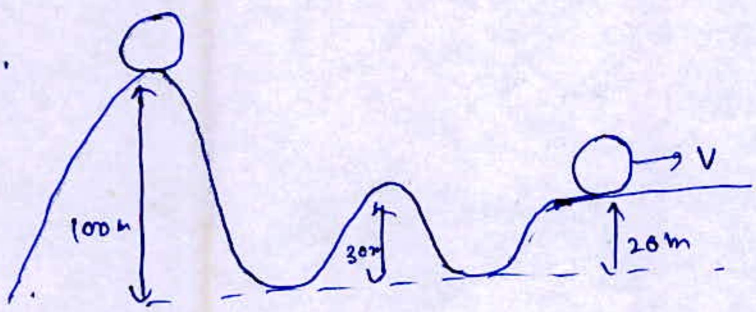


Δ P.E. $= \frac{1}{2} k x^2$

$mg(h + x) = \frac{1}{2} k x^2$

Q 26.

Ans.



$\frac{1}{2} m v^2 = mg(100 - 20)$

$v = \sqrt{2g \times 80}$

$= 40$ m/s

Q 27.

Ans.

$\frac{p^2}{2m} = \frac{1}{2} k L^2$

$p = \sqrt{mk}\ L$

Power

Q 1.

Ans.

$$P = F \cdot V = K$$

$$V^2 \frac{dv}{ds} = \frac{K}{m}$$

$$\int v^2 \, dv = \int \frac{K}{m} \, ds$$

$$\frac{v^3}{3} = \frac{K}{m} s$$

$$\frac{ds}{dt} = \left(\frac{3K}{m}\right)^{1/3} s^{1/3}$$

$$\frac{ds}{s^{1/3}} = K_2 \, dt$$

$$\frac{s^{2/3}}{-2/3} = K_2 t$$

$$s \propto t^{3/2}$$

Q 2.

Ans.

$$P = \tau \cdot \frac{d\theta}{dt}$$

$$= \frac{.15 \times 9.8 \times}{2} 25 \times 10^{-2} \times \frac{2\pi}{2}$$

$$= 115.6 \text{ W}$$

Q3.

Ans. $P = F \cdot V = 0$

Q4.

Ans. $P = \frac{W}{t} = \frac{\frac{1}{2} m (v_f^2 - v_i^2)}{5}$

$= \frac{\frac{1}{2} \times 10^3 \left(\left(54 \times \frac{5}{18}\right)^2 - 0 \right)}{5}$

$= \frac{1}{2} \times 10^3 \times \frac{225}{5}$

$= \frac{45000}{2} = 22500 \, W$

Q5.

Ans. $P = .9 \times mgh = .9 \times 15 \times 10 \times 60$

$= 8.1 \, KW$

Q6.

Ans. $\frac{P_2}{P_1} = \frac{W_1/t_2}{W_2/t} = \frac{W_1}{W_2} = \frac{\frac{1}{2} nm (nv)^2}{\frac{1}{2} m v^2}$

$\frac{P_2}{P_1} = n^3$

Q7.

Ans. $F \cdot V = K$

$\frac{d}{dt}\left(\frac{1}{2} m v^2\right) = K$

$v \frac{dv}{dt} = \frac{K}{m}$

$v^2 = 2K/m \, t$

$$v = \sqrt{\frac{2K}{m}}\, t^{1/2}$$

$$\frac{ds}{dt} = \sqrt{\frac{2K}{m}}\, t^{1/2}$$

$$s \propto K_2\, t^{3/2}$$

$$s^2 \propto t^3$$

Q 8.

Ans. $a_c = k^2 r t^2 \Rightarrow$ ~~$v = \frac{k^2 r t^3}{3}$~~

$$\text{Power} = F \cdot V$$

~~$= m k^2 r t^2$~~

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

$$v = k r t$$

$$a_t = \frac{dv}{dt} = k r$$

$$m a_t = F_t = m k r$$

$$P = F \cdot v = m k r \; k r t$$

$$= m k^2 r^2 t$$

Q 9.

Ans. $\text{Loss} = 75 - 60$

$$= 15\,W$$

Q 10.

Ans.

Power of the engine $\times 0.6 = mgh/t$

$$\text{Power} = \frac{100 \times 10 \times 10}{5 \times 0.6}$$

$= 3.3$ KW

Q 11.

Ans.

$\text{Power} = F \cdot V$

$= ma\,(at)$

$= ma^2 t$

Q 12.

Ans.

max. power from fuel $= 1 \times g s^{-1} \times 2 K cal g^{-1}$

$= 2 \times 4.2$

$= 8.4$ KW

10 KW not valid

Q 13.

Ans.

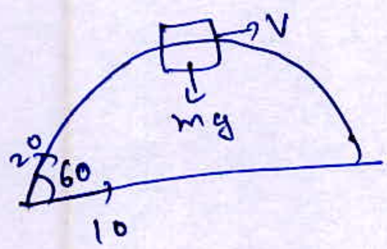
$\text{Power} = (5\hat{i} - 3\hat{j} + 6\hat{k}) \cdot (10\hat{i} + 10\hat{j} + 20\hat{k})$

$= 50 - 30 + 120$

$= 140$ J/s

Q 14.

Ans.



$F \cdot V = 0$

Q 15.

Ans.

$$\text{Power} = \frac{P \cdot V}{t}$$

$$= \frac{2\times10^{4}\times 1\times10^{-6}}{1}$$

$$= 2\times10^{-2}\ W$$

Q 16.

Ans.

$$P_1 = \frac{W}{10} \qquad \frac{P_1}{P_2} = 2$$

$$P_2 = \frac{W}{20}$$

Q 17.

Ans.

$$F \cdot V = P_0$$

$$m v \frac{dv}{dt} = P_0$$

$$\frac{v^2}{2} = \frac{P_0}{m} t$$

$$v = \sqrt{\frac{2P_0}{m}}\ t^{1/2}$$