Name :- Shreyas Srinivasa

ID Number :- 012551187

Homework 6 :- Work and Kinetic Energy

23. Using

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

Substitute 5.0 N for F, 0° for θ and 0.6 m for s in the above expression and solve,

$W = (5.00\ N)(0.600\ m)\cos 0°$

$= (5.00\ N)(0.600\ m)(1)$

$= 3\ J$

Hence the work done by the checkout attendant is 3 J

27. Using $W_{body} = mgh\sin\theta$

Substitute 85.0 kg for m, 9.81 m/s² for g, 4.00 m for h and 20° for θ

$W_{body} = (85.0\ kg)(9.81\ m/s^2)(4.00\ m)\sin 20°$

$= 1140.77\ J$

Using $W_{crate} = F d \cos\theta$

Substitute 500 N for F, 4.00 m for d and 0° for θ

$W_{crate} = (500\ N)(4.00\ m)\cos 0° = 2000\ J$

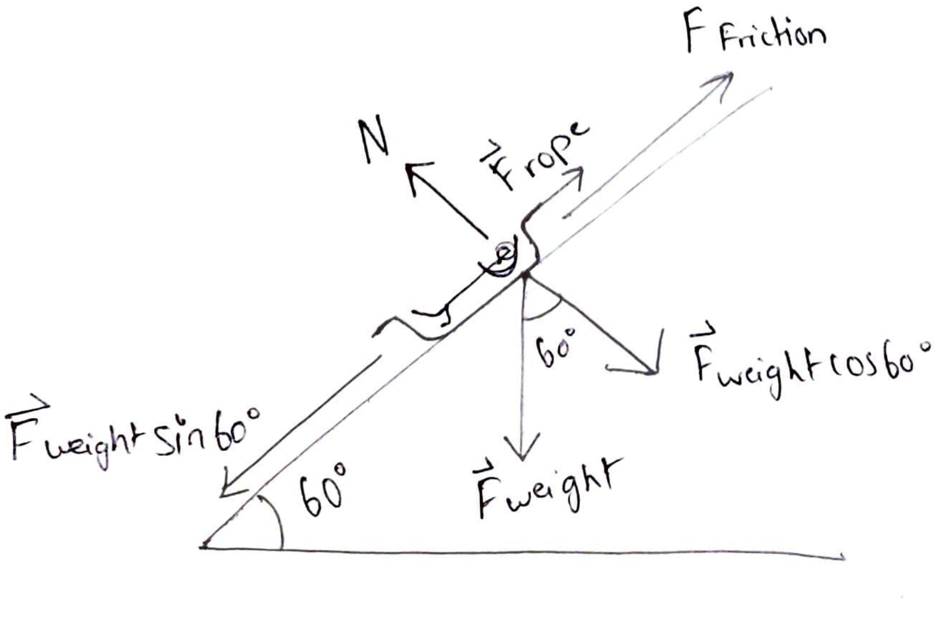
Using $W_{total} = W_{body} + W_{crate}$

Substitute 11~~7~~40.77 J for W_{body} and 2000 J for W_{crate}

$$W_{total} = W_{body} + W_{crate}$$
$$= (1140.77\ J) + (2000\ J)$$
$$= 3140.77\ J = 3141\ J$$

Hence, the work done by the man is 3141 J

30. Free body diagram that represents all the forces acting on the sliding sled is as follows,



(a) Substitute 90.0 kg for m, 9.8 m/s² for a (acceleration due to gravity) in the expression for force and solve,

$$F_{weight} = (90.0\ kg)(9.8\ m/s^2)$$
$$= 882\ N$$

Normal reaction force can be calculated as

$$N = (F_{weight}\ N)\cos 60^\circ$$
$$= (882\ N)(0.5)$$
$$= 441\ N$$

Using $W_{friction}$,

Substitute 44.1 N for F, 180° for θ and 30.0 m for s in the expression for work and solve,

$$W_{Friction} = (44.1N)(30.0m)\cos 180^\circ$$
$$= (44.1N)(30.0\ m)(-1)$$
$$= -1323\ J$$

Hence the work done on the sled by the force of friction is −1323 J

(b) $\vec{F}_{Rope} - \vec{F}_{weight,S} + \vec{F}_{Friction} = 0\,N$

Substitute 882 N for F, 60° for θ in the expression for vertical component of force due to weight and solve,

$$F_{weight,S} = (F_{weight}\ N) \times \sin 60°$$
$$= (882\,N)(0.866)$$
$$= 763.83\,N$$

Substitute 763.83 N for F_{weight} and 44.1 N for $F_{Friction}$ in the expression for F_{Rope} and solve,

$$F_{Rope} = 763.83\,N - 44.1\,N$$
$$= 719.73\,N$$

Substitute 719.73 N for F, 180° for θ and 30.0 m for s in the expression for work and solve,

$$W_{Rope} = (719.73\,N)(30.0\,m)\cos 180°$$
$$= (719.73\,N)(30.0\,m)(-1)$$
$$= -21592\,J$$

Hence the work done by the elevator car by its cable is $-21592\ J$

(c) Substitute $763.83\ N$ for $F_{weight,s}$, $0°$ for θ and $30.0\ m$ for s in the expression for work and solve,

$$W_{Gravity} = (763.83\ N)(30.0\ m)\cos 0°$$
$$= (763.83\ N)(30.0\ m)(1)$$
$$= 22915\ J$$

Hence the work done on the sled by gravitational force is $22915\ J$

(d) $W_{Total} = W_{Rope} + W_{Friction} + W_{Gravity}$

$$= (-21592\ J) + (-1323\ J) + (22915\ J)$$
$$= 0\ J$$

Hence the total work done on the lift is $0\ J$

41. Substitute $a\left[\frac{(x+9)m}{9m} - \left(\frac{9m}{(x+9)m}\right)^2\right]$

for F in the equation $W = \int F\,dx$

$$W = \int \left[a\left[\frac{(x+9)m}{9m} - \left(\frac{9m}{(x+9)m}\right)^2\right]\right] dx$$

$$= \int_0^{16.7m} \frac{a(x+9)m}{9m}\,dx - a\int_0^{16.7} \left(\frac{9m}{(x+9)m}\right)^2 dx$$

$$= \frac{a}{9m}\int_0^{16.7} (x+9)m\,dx - 81a\int_0^{16.7} \left(\frac{1}{(x+9)m}\right)^2 dx$$

$$= \frac{a}{9m}\left[\frac{x^2}{2} + 9x\right]_0^{16.7} - 81a\left[-\frac{1}{(x+9)m}\right]_0^{16.7}$$

Solving further for W

$$W = \frac{a}{9m}\left[\frac{(16.7m)^2}{2} + 9(16.7m)\right] + 81a$$

$$\left[\frac{1}{(16.7m+9)m} - 1/9\right] = 47.68a + 81a[-0.073]$$

$$= 47.68a - 5.913a = 41.76a$$

Rearrange the equation $W = -41.76a$ for a

$$a = \frac{W}{41.76}$$

Now, substitute 22.0 kJ for W in the equation

$$a = \frac{W}{41.76}$$

$$a = \frac{22.0\ \text{kJ}}{41.76} = \frac{22.0 \times 10^3\ \text{J}}{41.76} = 526.8\ \text{N}$$

Hence, the value of the constant is 526.8 N

47. (a) $v = 100\ \text{km/h}$

$$= \left(100\ \frac{\text{km}}{\text{h}}\right)\left(\frac{10^3\ \text{m} \times 1\ \text{h}}{60 \times 60 \times 1\ \text{s} \times 1\ \text{km}}\right)$$

$$= \left(\frac{100 \times 10^3}{3600}\ \frac{\text{m}}{\text{s}}\right)$$

Substitute 2000 kg for mass m, $\frac{100 \times 10^3}{3600}$ m/s for v in the expression for kinetic energy and solve,

$$K = \frac{1}{2}(2000\ \text{kg})\left(\frac{100 \times 10^3}{3600}\ \text{m/s}\right)^2 = 77.16 \times 10^4\ \text{J}$$

Hence, kinetic energy of the automobile is 77.16×10^4 J

(b) Substitute 80.0 kg for mass m, 10.0 m/s for v in the exp. for K and solve,

$$K = 1/2\,(80.0\,kg)\,(10.0\,m/s)^2$$

$$= 4000\,J$$

Hence kinetic energy of automobile is 4000J

(c) Substitute 9.1×10^{-31} for mass m, 2.0×10^{7} m/s for v in the exp. for K and solve,

$$K = 1/2\,(9.1 \times 10^{-31}\,kg)\,(2.0 \times 10^{7}\,m/s)^2$$

$$= 18.2 \times 10^{-17}\,J$$

Hence kinetic energy of an electron is 18.2×10^{-17} J

51. (a) Substitute $v_f = 0$ m/s for final velocity of the car, 900 kg for mass m in the exp. of K and solve,

$$K_f = 1/2\,(900\,kg)\,(0\,m/s)^2 = 0\,J$$

Substitute $v_i = 1.1$ m/s for initial velocity of the car, 900 kg for mass m in the expression of kinetic energy and solve,

$$K_i = \frac{1}{2}(900\ kg)(1.1\ m/s)^2 = 544.5\ J$$

Now, change in kinetic energy can be calculated as,

$$K_f - K_i = 0J - 544.5\ J$$
$$= -544.5\ J$$

Where K_f and K_i represent final and initial kinetic energies of the car respectively.

Substitute $180°$ for θ and 0.200 m for s in the expression of net work and solve,

$$W_{net} = (F\ N)(0.200\ m)(-1)$$
$$= (F\ N)(0.200\ m)(-1)$$
$$= -F\ N \times 0.200\ m$$

Substitute the value of W_{net} from above calculation and $-544.5\ J$ for change in kinetic energy in work energy and solve,

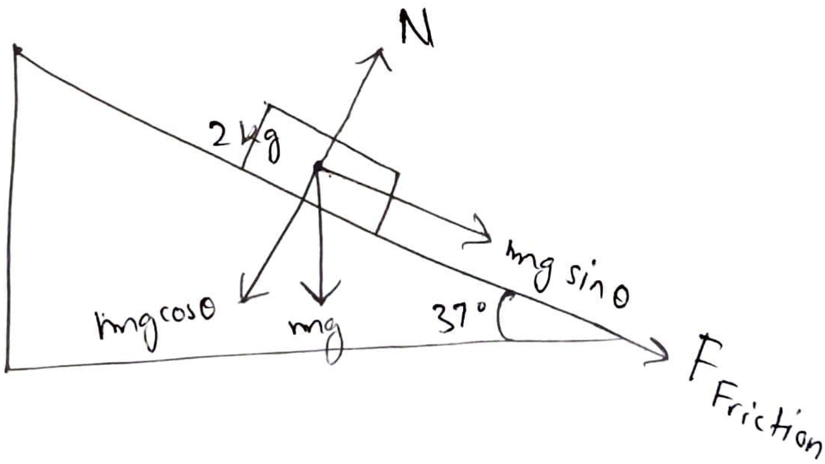
$$-F \times 0.200 = -544.5$$

$$-F = \frac{-544.5}{0.200}$$

$$F = 2722.5\ \text{N}$$

Hence the average force on the bumper is 2722.5 N

60. The free body diagram of the block is:



For final kinetic energy K_f

Substitute 0 m/s for final velocity of the block, 2.0 kg for mass,

$$K_f = \frac{1}{2}(2.0\,\text{kg})(0\,\text{m/s})^2 = 0\,\text{J}$$

For initial kinetic energy K_f,

Substitute 10 m/s for initial velocity of the block, 2.0 kg for mass,

$K_i = \frac{1}{2}(2.0\,kg)(10\,m/s)^2$

$= 100\,J$

$K_f - K_i = 0\,J - 100\,J = -100\,J$

Using $F_H = mg\cos\theta$

Substitute 2.0 kg for m, 9.8 m/s² for g, 37° for θ,

$F_H = (2.0\,kg)(9.8\,m/s^2)\cos 37°$

$= (2.0\,kg)(9.8\,m/s^2)(\cancel{0.8}\;0.8)$

$= 15.65\,N$

$N = 15.65\,N$

Using $|\vec{F}_{friction}| = \mu|\vec{N}|$

Substitute 15.65 N for normal force N, 0.30 for coefficient of kinetic friction,

$F_{friction} = (0.30)(15.65)$

$= 4.7\,N$

Using $W_{friction} = \vec{F}_{friction} \cdot \vec{s} = F_{friction}\, s\cos\phi$

Substitute 4.7 N for force $F_{friction}$, 180° for θ,

$$W_{friction} = (4.7)(s)\cos 180°$$
$$= (4.7)(s)(-1)$$
$$= (-4.7s)\ J$$

Here, $W_{friction}$ represent friction on the block

Using $F_r = mg\sin\theta$

Substitute 2.0 kg for m, 9.8 m/s² for g,

$$F_r = (2.0\ kg)(9.8\ m/sec^2)\sin 37°$$
$$= 11.8\ N$$

Using $W_G = F_r\, s\cos\phi$

Substitute 11.8 N for force F_r, 180° for ϕ in the expression of work and solve,

$$W_G = (11.8\ N)(s)\cos 180°$$
$$= (11.8\ N)(s)(-1)$$
$$= (-11.8s)\ J$$

Here, W_G represents work of force due to gravity or weight on the block.

$W_{net} = W_{Friction} + W_G$

$= (-4.75\,J) + (-11.8s\,J)$

$= (-16.5s)\,J$

$W_{net} = K_f - K_i$

Substitute $(-16.5s)\,J$ for W_{net} and $-100\,J$ for change in kinetic energy,

$(-16.5s)\,J = -100\,J$

$$s = \frac{(-100)\,J}{(-16.5)\,J} = 6.06\,m$$

Hence, the distance traversed by the block up the hill is 6.06 m

(b) $K = \frac{1}{2}mv^2 \quad \ldots (1)$

For K_f, substitute v_f for v and 2.0 kg for m in (1) and solve,

$K_f = \frac{1}{2}(2.0\,kg)(v_f\,m/s)^2$

$= (v_f)^2\,J$

For K_i, substitute 10 m/s for v_i and 2 kg for m in equation (1) and solve.

$K_i = \frac{1}{2}(2.0\,kg)(10\,m/s)^2$

$= 100\,J$

$K_f - K_i = (V_f)^2\,J - 100\,J$

$W_{net} = W_{Friction,\,up} + W_{Friction,\,down}$

Substitute 6.06 m for s in the expression of work of friction and solve,

$W_{net} = (-(4.7 \times 6.06))J + (-(4.7 \times 6.06))J$

$= -56.9\,J$

$W_{net} = K_f - K_i$

Substitute $-56.9\,J$ for W_{net} and $(V_f)^2\,J - 100\,J$ for change in kinetic energy,

$(V_f)^2\,J - 100\,J = -56.9\,J$

$V_f = \sqrt{-56.9 + 100}$

$V_f = 6.56\,m/s$

Hence, the speed of the block when it reaches the bottom of the incline is 6.56 m/s

61. Using $W_{spring} = \frac{1}{2}kx^2$ and $W = Fd$ and $F = \mu mg$

Substitute Fd for W_{spring} and μmg for F in the expression $W_{spring} = \frac{1}{2}kx^2$ and rearrange the equation for μ

$$W_{spring} = \frac{1}{2}kx^2$$

$$Fd = \frac{1}{2}kx^2$$

$$(\mu mg)d = \frac{1}{2}kx^2$$

$$\mu = \frac{kx^2}{2mgd}$$

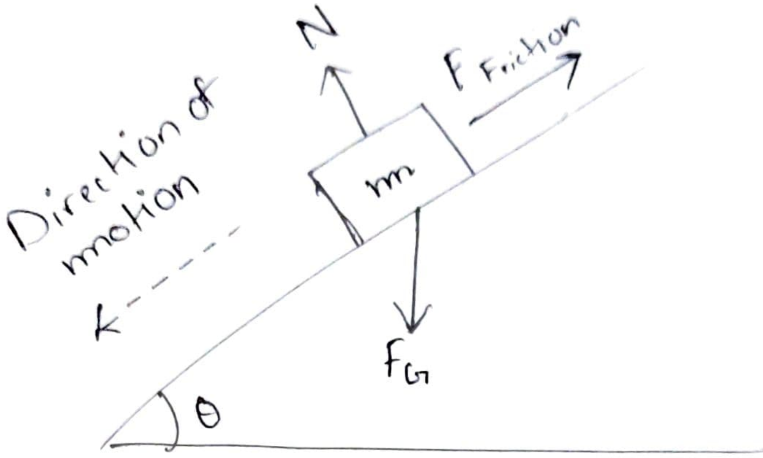
Substitute 3.0 kg for m, 9.8 m/s² for g, 8.0 cm for x, 4.5×10^3 N/m for k, and 2.0 m for d.

$$\mu = \frac{kx^2}{mgd} = \frac{(4.5\times10^3\,\mathrm{N/m})\left(8.0\,\mathrm{cm}\left(\frac{10^{-2}\,\mathrm{m}}{1\,\mathrm{cm}}\right)\right)^2}{(3.0\,\mathrm{kg})(9.8\,\mathrm{m/s^2})(2.0\,\mathrm{m})}$$

$$= 0.25$$

Therefore, the required coefficient of kinetic friction is 0.25

66. Free body diagram of the sled representing all the forces acting on it



Substitute 14 m/s for final velocity of the sled, m kg for mass in the expression of K_f

$$K_f = \frac{1}{2}(m\ \text{kg})(14\ \text{m/s})^2$$

$$= \left(\frac{m \times 196}{2}\right) \text{J}$$

$$= (98\ m)\ \text{J}$$

Substitute 0 m/s for initial velocity of the sled in the expression of K_i

$$K_i = \frac{1}{2}(m\ \text{kg})(0\ \text{m/s})^2 = 0\ \text{J}$$

The change in kinetic energy,

$$K_f - K_i = (98\ m)\text{J} - 0\ \text{J} = (98\ m)\ \text{J}$$

Using $F_G = mg$

Substitute $9.8\ m/s^2$ for g

$F_G = (m\ kg)(9.8\ m/s^2)$

$= 9.8\ m$

Normal reaction can be calculated as

$N = (F_G N)\cos 22°$

Substitute $9.8\ m$ for F_G

$N = (9.8\ m)\cos 22°$

$= (9.8\ m)(0.927)$

$= 9.08\ m$

Substitute $9.08\ m$ for normal force N in the exp. of $F_{Friction}$

$F_{Friction} = (\mu_k)(9.08\ m)$

Substitute $(\mu_k)(9.08\ m)$ for force F, $180°$ for θ and $75\ m$ for s in the expression of work.

$W_{Friction} = (9.08\ m \times \mu_k)(100)\cos 180°$

$= (9.08\ m \times \mu_k)(100)(-1)$

$= -9.08.64\ m\ \mu_k$

Using $F_v = F_G \sin\theta$

Substitute mg for force F_G and $22°$ for θ

$$F_v = (mg)\sin 22°$$
$$= (mg)\,0.374$$

Substitute $(mg)0.374$ for force F, $0°$ for θ and $75\,m$ for s in the expression of work.

$$W_G = ((mg)0.374)(75\,m)\cos 0°$$
$$= ((mg)0.374)(75\,m)(1)$$
$$= (mg)(28.09)$$

Net work is given as sum of work done by all individual forces that do work:

$$W_{net} = W_{Friction} + W_G$$
$$= (-908.64\,m\,\mu_k) + (mg)28.09$$
$$= m(-908.64\,\mu_k + 275.33)$$

Substitute $m(-908.64\,\mu_k + 275.33)$ for W_{net} and $(198\,m)\,J$ for change in Kinetic energy in work energy relation

$$98m = m(-908.64\mu_k + 275.33)$$

$$\mu_k = \frac{(98 - 275.33)}{-908.64}$$

$$\mu_k = 0.195$$

Hence, the coefficient of kinetic friction between the sled and the snow surface is 0.195.

68. Using $E = Pt$,

Substitute 3.00 W for P and 1 year for t to find E.

$$E = \left(3.00\,\text{W}\left(\frac{1\,\text{kW}}{10^3\,\text{W}}\right)\right)\left(1\,\text{year}\left(\frac{365.25\,\text{days}}{1\,\text{year}}\right)\left(\frac{24\,\text{h}}{1\,\text{day}}\right)\right)$$

$$= 26.30\,\text{kWh}$$

Thus, the energy consumed by the electric clock is 26.30 kWh

Using Cost = ER,

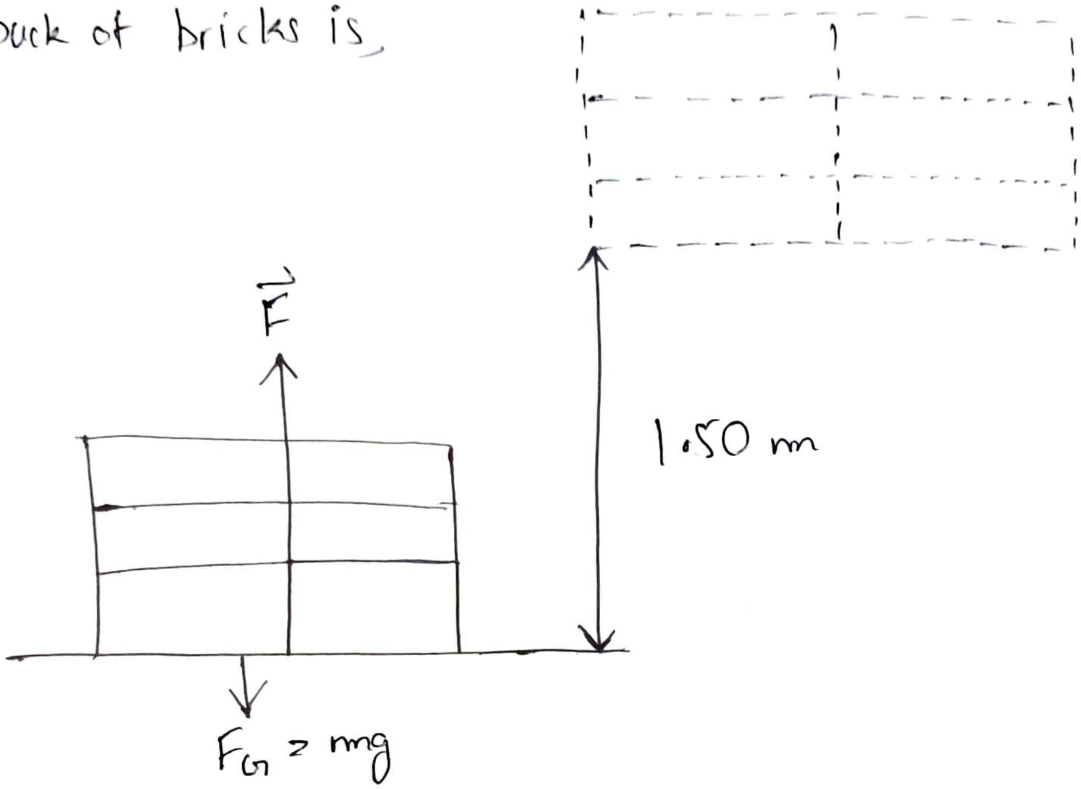
Substitute 26.30 kW·h for E and \$0.0900/kWh for R to find Cost.

$$\text{Cost} = (26.30\,\text{kWh})\left(\frac{\$0.0900}{1\,\text{kWh}}\right)$$

$$= \$2.37$$

Therefore, the cost of operating the electric clock for a year is \$ 2.37

71. Free body diagram of the pack of bricks is,



(a) Work done by the person per second is calculated as,

$$P_{avg} = \frac{\text{work done in 8 hours}}{(8\,h)\left(\frac{3600\,s}{1\,h}\right)}$$

$$= \frac{(6.00 \times 10^6)\,J}{(8 \times 3600)\,s}$$

$$= 208.34\ W$$

Hence average useful power output by the person is 208.34 W

(b) Substitute 2000 kg for m, 9.8 m/s² for acceleration due to gravity in the expression of force and solve,

$$F = (2000\,kg)(9.8\,m/s^2) = 19600\,N$$

Substitute 19600 N for F, 1.50 m for s, 0° for θ in the expression of work done and solve,

$$W = (19600\,N)(1.50\,m)\cos 0^\circ$$

$$= (19600)(1.50)(1)$$

$$= 29400\,J$$

Time required to lift the bricks to a given height is calculated as,

$$T = \frac{\text{Energy required}}{\text{Energy / second available}} = \frac{29400\,J}{208.34\,J/s}$$

$$= 141.1\,s$$

Hence the time taken to perform this task is 141.1 s

79. Using $v^2 = u^2 + 2as$

Rearrange the ~~above~~ above velocity expression in terms of acceleration

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

Substitute 0 for u in the above exp

Substitute 8.4×10^7 m/s for v and 2.5 cm for s in the above exp.

$$a = \frac{(8.4 \times 10^7 \text{ m/s})^2}{2(2.5 \text{ cm})} = \frac{(8.4 \times 10^7 \text{ m/s})^2}{2(2.5 \text{ cm})\left(\frac{1 \text{ m}}{100 \text{ cm}}\right)}$$

$$= 1.412 \times 10^{17} \text{ m/s}^2$$

Using $v_1^2 = u^2 + 2as$

Substitute 1.412×10^{17} m/s^2 for a, 0 for u and 1 cm for s in the above expression

$$v_1^2 = 2(1.412 \times 10^{17} \text{ m/s}^2)(1 \text{ cm})$$

$$= 2(1.412 \times 10^{17} \text{ m/s}^2)(1 \text{ cm})\left(\frac{1 \text{ m}}{100 \text{ cm}}\right)$$

$$= 2.824 \times 10^{15} \text{ m}^2/\text{s}^2$$

Taking square root on both sides,

$$v = \sqrt{2.824 \times 10^{15} \text{ m}^2/\text{s}^2} = 5.3 \times 10^7 \text{ m/s}$$

Using $P = Fv$

Substitute ma for F in the above expression

$P = mav$

Substitute 9.1×10^{-31} kg for m, 1.412×10^{17} m/s^2 and 5.3×10^{7} m/s for v in the above power expression

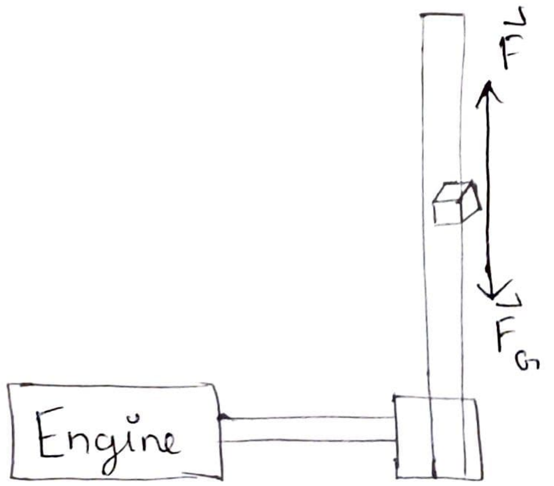
$$P = (9.1 \times 10^{-31}\ \text{kg})(1.412 \times 10^{17}\ \text{m/s}^2)(5.3 \times 10^{7}\ \text{m/s})$$

$$= 6.83 \times 10^{-6}\ \text{W}$$

$$= (6.83 \times 10^{-6}\ \text{W})\left(\frac{1\ \mu\text{W}}{10^{6}\ \text{W}}\right) = 6.83\ \mu\text{W}$$

Hence, power delivered to the electron at the displacement 1 cm is $P = 6.83\ \mu\text{W}$

80.



Using $F = ma$

Substitute $9.8\ m/s^2$ for acceleration due to gravity in the expression of force and solve for mass m.

$$F = (m\ kg)(9.8\ m/s^2)$$

$$= (9.8\ m)\ N$$

Substitute $(9.8\ m)\ N$ for force F, $0°$ for θ and $50\ m$ for s in the expression of work done and solve,

$$W = ((9.8\ m)\ N)(50\ m)\cos 0°$$

$$= ((9.8\ m)\ N)(50\ m)(1)$$

$$= (490\ m)\ J$$

$$W_{net} = (490\ m)\ J$$

$$\text{Joules of energy available per minute} = \frac{500\ J}{(1\ s)\left(\frac{1\ min}{60\ s}\right)}$$

$$= (500 \times 60)\ J/min$$

$$= 30000\ J/min$$

Hence available energy per minute is $30\,000\ J$

Equate the energy required to energy available and Solve,

$$(490\,m)\,J = 30000\,J$$

$$m = \frac{30000\,J}{490} = 61.25\ kg$$

Hence the amount of coal that can be brought to surface per minute is 61.25 kg