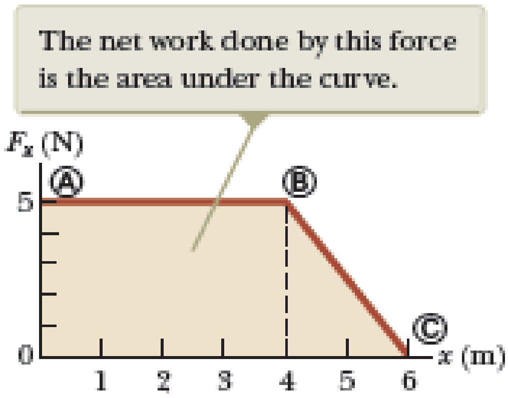
UNIT 5 WORK ENERGY AND POWER

ASSIGMENT SOLUTION

1 A force acting on a particle varies with displacement x as shown in Figure Calculate the work done by the force on the particle as it moves from $x = 0\ to\ x = 6.0\ m$.



[25 J]

SOLUTIONS

Work = area under the graph

$$W = (base\ \times height) + \frac{1}{2} \times b \times h$$

$$W = (4\ \times 5) + \frac{1}{2} \times (6 - 4) \times 5$$

$$W = 20 + \frac{1}{2} \times 2 \times 5$$

$$W = 20 + 5$$

$$W = 25\ \mathrm{J}$$

2 A body of mass 10kg at rest is subjected to a force of 16N. Find the kinetic energy at the end of 10 s. [1280 J]

Data:

$m = 10\ \mathrm{kg}$

$v_i = 0$

$F = 16\ N$

$t = 10\ s$

$k.E = ?$

SOLUTION:

$\Delta P = F\ t$

$\Delta P = (16)\ (10) = 160\ Ns$

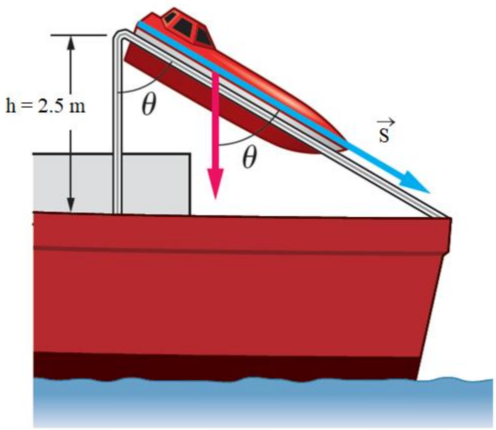
$$K.E = \frac{(\Delta P)^2}{2\ m}$$

$$K.E = \frac{(160)^2}{2\ (10)} = \frac{25600}{20}$$

$$k.E = 1280\ \mathrm{J}$$

3 In a gravity escape system (GES), an enclosed lifeboat on a large ship is deployed by letting it slide down a ramp and then continue in free fall to the water below. Suppose a 4970-kg lifeboat slides a distance of 5.00 m on a ramp, dropping through a vertical height of 2.50 m. How much work does gravity do on the boat?

[1.22 x 10^5]



Data:

$m = 4970\ \text{kg}$

$d = 5.00\ \text{m}$

$h = 2.50\ \text{m}$

$W = ?$

SOLUTION:

$W = F\, d\, \cos\theta$

$W = (mg)\, d\, \cos\theta \quad \ldots\ldots\ldots (i)$

$\cos\theta = \dfrac{\text{base}}{hyp}$

$\cos\theta = 0.500$

Substituting the $\cos\theta = 0.5$ in equation (i)

$W = (4970 \times 9.8)(5.00)\,(0.500)$

$W = 1.22 \times 10^5\ J$

4 **A 10.0 kg mass is dropped from a tall building. During the first second of the fall, what did gravity exert the average power? What was the average power exerted by gravity during the first 5.00 seconds of the fall?**

ata:

$m = 10.0\ kg$

$t = 1s$

$t = 5\ s$

$P = ?$

SOLUTION:

$h = v_i\, t + \dfrac{1}{2}\, g\, t^2$

$h = (0 \times 1) + \dfrac{1}{2}\,(9.8)\,(1)^2$

$h = 4.9\ m$

$P = \dfrac{W}{t} = \dfrac{mgh}{t} = \dfrac{(10.0)(9.8)(4.9)}{1}$

$P = 480.2\ W$

$h = v_i\, t + \dfrac{1}{2}\, g\, t^2$

$h = (0 \times 5.000) + \dfrac{1}{2}\,(9.8)\,(5.00)^2$

$h = 122.5\ m$

$P = \dfrac{W}{t} = \dfrac{mgh}{t} = \dfrac{(10.0)(9.8)(122.5)}{5}$

$P = 2401\ W$

5. **A 4.10-kg box of books is lifted vertically from rest at a distance of 1.60 m with a constant, upward applied force of 52.7 N. Find (a) the work done by the applied force, (b) the work done by gravity, and (c) the final speed of the box.**

Data:

$m = 4.10\ kg$

$h = 1.60\ m$

$F = 52.7\ N$

$W_F = ?$, $W_g = ?$, $v_f = ?$

SOLUTION:

$W_F = F\,S\cos\theta$

$W_F = 52.7\,(1.6)\cos 0^0$

$W_F = 84.3\ J$

$W_g = F_g\,S\cos\theta$

$W_g = mg\,S\cos\theta$

$W_g = (4.10)(9.8)\,(1.6)\cos 180$

$W_g = (4.10)(9.8)\,(1.6)\,(-1)$

$W_g = -64.28\ J$

$$W_{total} = W_{app} + W_{mg} = 84.3\,J - 64.4\,J = 19.9\,J$$

$$W_{total} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = \frac{1}{2}mv_f^2$$

$$v_f = \sqrt{\frac{2W_{total}}{m}} = \sqrt{\frac{2(19.9\,J)}{4.10\,kg}} = 3.12\ m/s$$

6. **It takes a force of 1450 N to keep a 1300-kg car moving with constant speed up a slope of 5.25°. If the engine delivers 4.10×10^4 W to the drive wheels, what is the maximum speed of the car?**

Data:

$F = 1450\ N$

$m = 1300\ kg$

$\theta = 5.25^0$

$P = 4.10 \times 10^4\ W$

$v = ?$

SOLUTION:

$P = F\,v$

$4.10 \times 10^4 = 1450 \times v$

$v = 128.3\ m/s$

7 **A new record for running the stairs of the Empire State Building was set on February 4, 2024. The total of 1576 steps, was run in 9 minutes and 33 seconds. If the height gain of each step was 0.20 m, and the mass of the runner was 70.0 kg, what was his average power output during the climb?**

Data:

$steps(n) = 1576,$

$height\ of\ each\ step(H) = 0.20\ m$

$h = n \times H = 1576 \times 0.20 = 3152\ m$

$t = 9\ min = 9 \times 60 = 540\ s$

$m = 70.0\ s$

SOLUTION:

$$P_{av} = \frac{mgh}{t} = \frac{(70.0)(9.8)(3152)}{540}$$

$P_{av} = 3.77 \times 10^3\ W$

Power measure in horse power

$$P_{av} = \frac{3.77 \times 10^3}{746} = 5.05\ hp$$

8. **A motor pumps the water at the rate of 600 grams/min to the height of 95 m If the motor is 50% efficient then how much input electric power is needed?**

Data:

$$\frac{m}{t} = 600\ g/min$$

$$\frac{m}{t} = \frac{\frac{600}{1000}}{1 \times 60} = 0.01\ kg/s$$

$$h = 95\ m$$

$$\eta = 50\%$$

SOLUTION:

Power out put P_{output}

$$P_{output} = \frac{mgh}{t}$$

$$P_{output} = \frac{m}{t}\,(g\ h)$$

$$P_{output} = 0.01\,(9.8 \times 95) = 9.31\ W$$

$$\eta = \frac{P_{output}}{P_{input}} \times 100$$

$$P_{input} = \frac{P_{output}}{\eta} \times 100$$

$$P_{input} = \frac{9.31}{50} \times 100$$

$$P_{av} = 18.62\ W$$

9. **The mass of the earth is 5.98 x 10^{24} kg and the mass of the sun is 1.99 x 10^{30} kg, and the earth is 160 million km away from the sun, Calculate the GPE of the earth**

Data:

$$m_e = 5.98 \text{ x } 10^{24}\ kg$$

$$m_s = 1.99 \text{ x } 10^{30}\ kg$$

$$R = 160\ million\ km$$

$$R = 160 \times 10^6 \times 10^3 m$$

$$R = 1.60 \times 10^{11}\ m$$

$$GPE = ?$$

SOLUTION:

$$GPE = -\frac{G\,m_e\,m_s}{R}$$

$$GPE = -\frac{6.67 \times 10^{-11}\,(5.98 \text{ x } 10^{24})(1.99 \text{ x } 10^{30}\ kg)}{1.60 \times 10^{11}}$$

$$GPE = -\ 4.96 \times 10^{33} J$$