CSD2301 Practice Solutions
7. Work and Energy Part 1

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Practice Question 1

You push your laptop 1.50 m along a horizontal tabletop with a horizontal force of 2.40 N. The opposing force of friction is 0.600 N. a) How much work does your force do on the laptop? b) What is the work done on the laptop by the friction force? c) What is the total work done on the laptop?

a) (2.40)(1.50) = 3.60 J
b) (-0.600)(1.50) = -0.900J
c) 3.60 – 0.900 = 2.70 J

Practice Question 2

A fisherman reels in 12.0 m of line while pulling in a fish that exerts a constant resisting force of 25.0 N. If the fish is pulled in at constant velocity, how much work is done on it by the tension in the line?

$$(25.0)(12.0) = 300 \text{ J}$$

Practice Question 3

A loaded grocery cart is rolling across a parking lot in a strong wind. You apply a constant force F = (30 N) $\hat{\imath}$ - (40 N) $\hat{\jmath}$ to the cart as it undergoes a displacement s = (-9.0 N) $\hat{\imath}$ - (3.0 N) $\hat{\jmath}$. How much work does the force you apply do on the grocery cart?

$$\begin{aligned}\vec{\boldsymbol{F}} \cdot \vec{\boldsymbol{s}} &= ((30\text{N})\hat{\boldsymbol{i}} - (40\text{N})\hat{\boldsymbol{j}}) \cdot ((-9.0\text{m})\hat{\boldsymbol{i}} - (3.0\text{m})\hat{\boldsymbol{j}}) \\ &= (30\ \text{N})(-9.0\ \text{m}) + (-40\ \text{N})(-3.0\ \text{m}) \\ &= -270\ \text{N} \cdot \text{m} + 120\ \text{N} \cdot \text{m} = -150\ \text{J}\end{aligned}$$

Practice Question 4

You throw a 20-N rock vertically into the air. You observe that when it is 15.0m above, it is travelling at 25.0 m/s upward. Use the work-energy theorem to find a) its speed just as it leaves your hand, and b) its maximum height.

a)

$$W = \Delta KE$$

$$-mgh = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_0^2$$

Work done by gravitational force

$$v_0 = \sqrt{v_f^2 + 2gh}$$

$$= \sqrt{(25.0\,\text{m/s})^2 + 2(9.80\,\text{m/s}^2)(15.0\,\text{m})}$$

$$= 30.3\,\text{m/s}$$

b)

$$W = \Delta KE$$

$$-mgh = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_0^2$$

$$h = \frac{v_0^2 - v_f^2}{2g} = \frac{(30.3\,\text{m/s})^2 - 0^2}{2(9.80\,\text{ms/s}^2)}$$

$$= 46.8\,\text{m}$$

Practice Question 5

A car is stopped by a constant friction force that is independent of the car's speed. By what factor is the stopping distance changed if the car's initial speed is doubled?

$E = \frac{1}{2}mv^2$ $E = fd$

Doubling the speed increases the kinetic energy, and hence the magnitude of the work done by friction, by a factor of four. With the stopping force given as being independent of speed, the distance must also increase by a factor of four.

Practice Question 6

A 6.0 kg box moving at 3.0 m/s on a horizontal, frictionless surface runs into a light spring of force constant 75 N/cm. Find the maximum compression of the spring.

$$W_{\text{tot}} = K_2 - K_1$$

$$K_1 = \frac{1}{2}mv_0^2, \quad K_2 = 0$$

Work is done by the spring force. $W_{\text{tot}} = -\frac{1}{2}kx^2$, where x is the amount the spring is compressed.

$$-\frac{1}{2}kx^2 = -\frac{1}{2}mv_0^2 \quad \text{and} \quad x = v_0\sqrt{m/k} = 8.5\,\text{cm}$$

Practice Question 7

A 20.0 kg rock is sliding on a rough, horizontal surface at 8.00 m/s and eventually stops due to friction. The coefficient of kinetic friction between the rock and the surface is 0.200. What average thermal power is produced as the rock stops?

friction

$$\Sigma F = ma : \mu_k mg = ma$$

$$a = \mu_k g = (0.200)(9.80\,\mathrm{m/s^2}) = 1.96\,\mathrm{m/s^2}$$

a is the acceleration that friction force is providing. Which will be negative.

$$v = v_0 + at$$

$$0 = 8.00\,\mathrm{m/s} - (1.96\,\mathrm{m/s^2})t$$

$$t = 4.08\,\mathrm{s}$$

$$P = \frac{KE}{t} = \frac{\frac{1}{2}mv^2}{t}$$

$$= \frac{\frac{1}{2}(20.0\,\mathrm{kg})(8.00\,\mathrm{m/s^2})}{4.08\,\mathrm{s}} = 157\,\mathrm{W}$$

Practice Question 8

When its 75 kW engine is generating full power, a small single-engine airplane with mass 700 kg gains altitude at a rate of 2.5 m/s. What fraction of the engine power is being used to make the airplane climb? (The remainder is used to overcome effects of air resistance and of inefficiencies in the propeller and engine.)

The power is $P = F \cdot v$. F is the weight, mg, so $P = (700\,\text{kg})\,(9.8\,\text{m/s}^2)\,(2.5\,\text{m/s}) = 17.15\,\text{kW}.$ So, $17.15\,\text{kW}/75\,\text{kW}. = 0.23,$ or about 23% of the engine power is used in climbing.

The End