Ch 8 WS#3 Solutions

P8.13 We use the nonisolated system energy model, here written as $-f_k d = K_f - K_i$, where the kinetic energy change of the sled after the kick results only from the friction between the sled and ice.

$$\Delta K + \Delta U = -f_k d:$$

$$0 - \frac{1}{2}mv^2 = -f_k d$$

$$\frac{1}{2}mv^2 = \mu_k mgd$$

which gives $\boxed{d = \dfrac{v^2}{2\mu_k g}}$

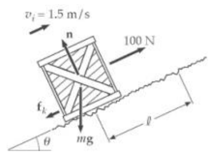
.14 (a) The force of gravitation is

$$(10.0 \text{ kg})(9.80 \text{ m/s}^2) = 98.0 \text{ N}$$

straight down, at an angle of

$$(90.0° + 20.0°) = 110.0°$$

with the motion. The work done by the gravitational force on the crate is



$$W_g = \vec{\mathbf{F}} \cdot \Delta\vec{\mathbf{r}} = mg\ell\cos(90.0° + \theta)$$

$$= (98.0 \text{ N})(5.00 \text{ m})\cos 110.0° = \boxed{-168 \text{ J}}$$

(b) We set the x and y axes parallel and perpendicular to the incline, respectively.

From $\sum F_y = ma_y$, we have

$$n - (98.0 \text{ N})\cos 20.0° = 0$$

so $n = 92.1$ N

and

$$f_k = \mu_k n = 0.400\,(92.1 \text{ N}) = 36.8 \text{ N}$$

Therefore,

$$\Delta E_{\text{int}} = f_k d = (36.8 \text{ N})(5.00 \text{ m}) = \boxed{184 \text{ J}}$$

(c) $W_F = F\ell = (100 \text{ N})(5.00 \text{ m}) = \boxed{500 \text{ J}}$

(d) We use the energy version of the nonisolated system model.

$$\Delta K = -f_k d + \sum W_{\text{other forces}}$$

$$\Delta K = -f_k d + W_g + W_{\text{applied force}} + W_n$$

The normal force does zero work, because it is at 90° to the motion.

$$\Delta K = -184 \text{ J} - 168 \text{ J} + 500 \text{ J} + 0 = \boxed{148 \text{ J}}$$

(e) Again, $K_f - K_i = -f_k d + \sum W_{\text{other forces}}$, so

$$\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = \sum W_{\text{other forces}} - f_k d$$

$$v_f = \sqrt{\frac{2}{m}\left[\Delta K + \frac{1}{2}mv_i^2\right]}$$

$$= \sqrt{\left(\frac{2}{10.0 \text{ kg}}\right)[148 \text{ J} + \frac{1}{2}(10.0 \text{ kg})(1.50 \text{ m/s})^2]}$$

$$v_f = \sqrt{\frac{2(159 \text{ kg}\cdot\text{m}^2/\text{s}^2)}{10.0 \text{ kg}}} = \boxed{5.65 \text{ m/s}}$$

.31 When the car moves at constant speed on a level roadway, the power used to overcome the total friction force equals the power input from the engine, or $P_{\text{output}} = f_{\text{total}}\, v = P_{\text{input}}$. This gives

$$f_{\text{total}} = \frac{P_{\text{input}}}{v} = \frac{175 \text{ hp}}{29 \text{ m/s}}\left(\frac{746 \text{ W}}{1 \text{ hp}}\right)$$

f_{total} = 4500 N

.36 $P = \dfrac{W}{\Delta t}$

older-model: $W = \dfrac{1}{2}mv^2$

newer-model: $W = \dfrac{1}{2}m(2v)^2 = \dfrac{1}{2}(4mv^2) \;\rightarrow\; P_{\text{newer}} = \dfrac{4mv^2}{2\Delta t} = 4\dfrac{mv^2}{2\Delta t}$

$\boxed{\text{The power of the sports car is four times that of the older-model car.}}$

.38 (a) The distance moved upward in the first 3.00 s is

$$\Delta y = \bar{v}\Delta t = \left[\frac{0 + 1.75 \text{ m/s}}{2}\right](3.00 \text{ s}) = 2.63 \text{ m}$$

The motor and the Earth's gravity do work on the elevator car:

$$W_{\text{motor}} + W_{\text{gravity}} = \Delta K$$

$$W_{\text{motor}} + (mg\Delta y)\cos 180° = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

$$W_{\text{motor}} - (mg\Delta y) = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

$$W_{\text{motor}} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 + mg\Delta y$$

$$W_{\text{motor}} = \frac{1}{2}(650 \text{ kg})(1.75 \text{ m/s})^2 - 0 + (650 \text{ kg})g(2.63 \text{ m})$$

$$= 1.77 \times 10^4 \text{ J}$$

Also, $W = \bar{P}\Delta t$ so $\bar{P} = \dfrac{W}{\Delta t} = \dfrac{1.77 \times 10^4 \text{ J}}{3.00 \text{ s}} = \boxed{5.91 \times 10^3 \text{ W}} = 7.92$ hp.

(b) When moving upward at constant speed ($v = 1.75$ m/s), the applied force equals the weight $= (650 \text{ kg})(9.80 \text{ m/s}^2) = 6.37 \times 10^3$ N. Therefore,

$$P = Fv = (6.37 \times 10^3 \text{ N})(1.75 \text{ m/s}) = \boxed{1.11 \times 10^4 \text{ W}} = 14.9 \text{ hp}$$

Ch 8 WS#3 Solutions

47 (a) Given $m = 4.00$ kg and $x = t + 2.0t^3$, we find the velocity by differentiating:

$$v = \frac{dx}{dt} = \frac{d}{dt}\left(t + 2t^3\right) = 1 + 6t^2$$

Then the kinetic energy from its definition is

$$K = \frac{1}{2}mv^2 = \frac{1}{2}(4.00)(1+6t^2)^2 = \boxed{2 + 24t^2 + 72t^4}$$

where K is in J and t is in s.

(b) Acceleration is the measure of how fast velocity is changing:

$$a = \frac{dv}{dt} = \frac{d}{dt}\left(1 + 6t^2\right) = \boxed{12t}$$

where a is in $\mathrm{m/s^2}$ and t is in s.

Newton's second law gives the total force exerted on the particle by the rest of the universe:

$$\sum F = ma = (4.00\ \mathrm{kg})(12t) = \boxed{48t}$$

where F is in N and t is in s.

(c) Power is how fast work is done to increase the object's kinetic energy:

$$P = \frac{dW}{dt} = \frac{dK}{dt} = \frac{d}{dt}\left(2.00 + 24t^2 + 72t^4\right) = \boxed{48t + 288t^3}$$

where P is in W [watts] and t is in s.

Alternatively, we could use $P = Fv = 48t(1.00 + 6.0t^2)$.

(d) The work-kinetic energy theorem $\Delta K = \sum W$ lets us find the work done on the object between $t_i = 0$ and $t_f = 2.00$ s. At $t_i = 0$ we have $K_i = 2.00$ J. At $t_f = 2.00$ s, suppressing units,

$$K_f = [2 + 24(2.00\ \mathrm{s})^2 + 72(2.00\ \mathrm{s})^4] = 1250\ \mathrm{J}$$

Therefore the work input is

$$W = K_f - K_i = 1\,248\ \mathrm{J} = \boxed{1.25\times10^3\ \mathrm{J}}$$

Alternatively, we could start from

$$W = \int_{t_i}^{t_f} P\,dt = \int_0^{2\,\mathrm{s}}\left(48t + 288t^3\right)dt$$

.57 (a) To calculate the change in kinetic energy, we integrate the expression for a as a function of time to obtain the car's velocity:

$$v = \int_0^t a\,dt = \int_0^t\left(1.16t - 0.210t^2 + 0.240t^3\right)dt$$

$$= 1.16\frac{t^2}{2} - 0.210\frac{t^3}{3} + 0.240\frac{t^4}{4}\bigg|_0^t = 0.580t^2 - 0.070t^3 + 0.060t^4$$

At $t = 0$, $v_i = 0$. At $t = 2.5$ s,

$$v_f = \left(0.580\ \mathrm{m/s^3}\right)(2.50\ \mathrm{s})^2 - \left(0.070\ \mathrm{m/s^4}\right)(2.50\ \mathrm{s})^3 + \left(0.060\ \mathrm{m/s^5}\right)(2.50\ \mathrm{s})^4 = 4.88\ \mathrm{m/s}$$

The change in kinetic energy during this interval is then

$$K_i + W = K_f$$

$$0 + W = \frac{1}{2}mv_f^2 = \frac{1}{2}(1\,160\ \mathrm{kg})(4.88\ \mathrm{m/s})^2 = \boxed{1.38\times10^4\ \mathrm{J}}$$

(b) The road does work on the car when the engine turns the wheels and the car moves. The engine and the road together transform chemical potential energy in the gasoline into kinetic energy of the car.

$$P = \frac{W}{\Delta t} = \frac{1.38\times10^4\ \mathrm{J}}{2.50\ \mathrm{s}}$$

$$P = \boxed{5.52\times10^3\ \mathrm{W}}$$

(c) The value in (b) represents only energy that leaves the engine and is transformed to kinetic energy of the car. Additional energy leaves the engine by sound and heat. More energy leaves the engine to do work against friction forces and air resistance.