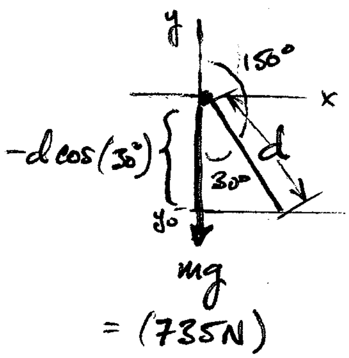
CH6 EXERCISES:

#1 (6.5) Given: $m = 75\,kg$, $d = 2.75\,m$, $\theta = 30°$



where $y_o = -d\cos\theta = -(2.75\,m)\cos(30°) = \underline{-2.38\,m}$

(a) $W = F\cdot y_o$ (work = Force × displacement) $= F\cdot(-d\cos\theta)$

$= mg\cdot(-d\cos\theta)$

$= (75\,kg)(9.8\,m/s^2)(-2.38\,m)$

$= \boxed{-1750\,J}$

(b) No, gravity does not depend on the motion of the painter. Since the displacement of painter is upward along the ladder and the gravity force is downward, the WORK gravity does on the painter is negative.

#2. (6.15) Given: $F = 30\,N$, $\theta = 37°$ $\Rightarrow \begin{cases} F_x = (30\,N)\cos(37°) = 24.0\,N \\ F_y = (30\,N)\sin(37°) = 18.1\,N \end{cases}$

$W = \vec{F}\cdot\vec{s} = F_x s_x + F_y s_y$ (recall: vector "dot" product)

(a) $\vec{s} = (5m)\hat{i}$

$\Rightarrow W = [(30N)\cos(37°)]\cdot(5m)\hat{i} = \boxed{120\,J}$

(b) $\vec{s} = -(6m)\hat{j}$

$\Rightarrow W = F_x\cdot(0)\hat{i} + [(30N)\sin(37°)](-6m)\hat{j} = \boxed{-108\,J}$

(c) $\vec{s} = -(2m)\hat{i} + (4m)\hat{j}$

$\Rightarrow W = [(30N)\cos(37°)](-2m) + [(30N)\sin(37°)](4m)$

$= -48\,J + 72.4\,J$

$= \boxed{24.4\,J}$

#3. (6.19) Given $m = 1.4 \cdot 10^8$ kg, $v = 12 \cdot 10^3$ m/s

(a) $K = \frac{1}{2} m v^2$

$= \frac{1}{2} (1.4 \cdot 10^8 \text{ kg})(12 \cdot 10^3 \text{ m/s})^2$

$= (0.7 \cdot 10^8 \text{ kg})(1.44 \cdot 10^8 \text{ m}^2/\text{s}^2)$

$= \boxed{1.0 \cdot 10^{16} \text{ J}}$

(b) As compared to a 1 megaton nuclear bomb, meteor crater

$\Rightarrow \dfrac{1.0 \cdot 10^{16} \text{ J}}{4.184 \cdot 10^{15} \text{ J}} = \boxed{2.4 \text{X}}$

#4. (6.21) $W_{tot} = K_2 - K_1$

(a) Given: $h = 95$ m, $K_2 = \frac{1}{2} m v^2$

$W_{tot} = (\frac{1}{2} m v^2) - mgh = 0$

$\Rightarrow v^2 = \dfrac{2 \cancel{m} g h}{\cancel{m}} = 2gh$

$\Rightarrow v = \sqrt{2gh} = \sqrt{2(9.8 \text{ m/s}^2)(95 \text{ m})} = \boxed{43.2 \text{ m/s}}$

(b) Given: $h = 525$ m, $m = ?$ kg

$W_{tot} = K_2 - K_1$ where $K_2 = \frac{1}{2} m v^2$
$K_1 = mgh$

$K_2 - K_1 = 0$

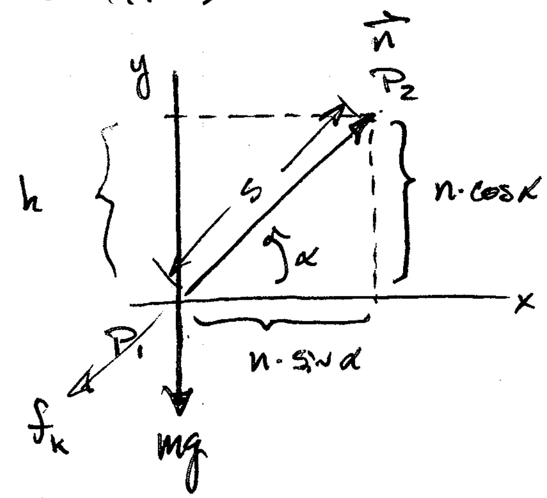
$\Rightarrow K_2 = K_1$

$\Rightarrow \frac{1}{2} \cancel{m} v^2 = \cancel{m} g h$

$\Rightarrow v^2 = 2gh$

$v = \sqrt{2gh} = \sqrt{2(9.8 \text{ m/s}^2)(525 \text{ m})} = \boxed{101 \text{ m/s}}$

#5 (6.23)



$s = h/\sin\alpha$

Q: what v_0 must you give a box at bottom of incline to reach P_2 ??

Work is done by gravity and friction...

$$W_{tot} = K_2 - K_1 = W_{mg} + W_f$$

where $K_2 = \frac{1}{2} m v_f^2 = 0$

$$K_1 = \frac{1}{2} m v_0^2$$

$$W_{mg} = -mgh = - \cancel{mg(s \cos\alpha)}$$

$$W_f = -fs = -\mu \cdot n \cdot s$$

$$= -\mu \cdot (mg \cos\alpha) \cdot \left(\frac{h}{\sin\alpha}\right)$$

$$= \frac{-\mu \cdot mgh}{\tan\alpha}$$

thus, ...

$$-\frac{1}{2} \cancel{m} v_0^2 = -\cancel{m}gh - \frac{\mu \cancel{m} gh}{\tan\alpha}$$

$$v_0^2 = 2gh\left(1 + \frac{\mu}{\tan\alpha}\right)$$

$$\therefore \quad v_0 = \sqrt{2gh\left(1 + \frac{\mu_k}{\tan\alpha}\right)}$$

#6 (6.39) Given: $m = 6$ kg, $v_0 = 3$ m/s, $k = 75$ N/cm $\cdot \left(\frac{100 \text{ cm}}{\text{m}}\right) = 7{,}500$ N/m

$$W_{tot} = \cancel{\tfrac{1}{2}} k x^2 = \cancel{\tfrac{1}{2}} m v_0^2$$

$$\Rightarrow \quad x^2 = \frac{m v_0^2}{k}$$

$$\Rightarrow \quad x = v_0 \cdot \sqrt{\frac{m}{k}}$$

$$= (3 \text{ m/s}) \sqrt{\frac{(6 \text{ kg})}{(7500 \text{ N/m})}}$$

$$= \boxed{0.085 \text{ m}}$$

#7 (6.45) Given: $k = 40\,\frac{N}{cm}\cdot\left(\frac{100\,cm}{m}\right) = 4{,}000\ N/m$, $m = 70\,kg$, $x_1 = 0.375\,m$

(a) $W_{tot} = K_2 - K_1 = 0$ where $K_1 = \frac{1}{2}kx^2 = W_{spring}$
$K_2 = \frac{1}{2}mv^2$

$$\Rightarrow \cancel{\tfrac{1}{2}}mv^2 = \cancel{\tfrac{1}{2}}kx^2$$

$$\Rightarrow v^2 = \frac{kx^2}{m}$$

$$\Rightarrow v = x\sqrt{\frac{k}{m}} = (0.375\,m)\sqrt{\frac{(4000\,N/m)}{(70\,kg)}} = \boxed{2.83\ m/s}$$

(b) Given: $x_2 = 0.2\,m$

$W_{tot} = K_2 - W_{spring} = 0$ where $W_{spring} = \frac{1}{2}kx_1^2 - \frac{1}{2}kx_2^2$

$$\Rightarrow \cancel{\tfrac{1}{2}}mv^2 = \cancel{\tfrac{1}{2}}k\,(x_1^2 - x_2^2)$$

$$\Rightarrow v^2 = \frac{k}{m}(x_1^2 - x_2^2)$$

$$\Rightarrow v = \sqrt{\frac{k}{m}(x_1^2 - x_2^2)}$$

$$= \sqrt{\frac{(4000\,N/m)}{(70\,kg)}\left[(0.375)^2 - (0.2)^2\right]}$$

$$= \sqrt{(57.1\ s^{-2})\left[(0.14) - (0.04)\right]}$$

$$= \boxed{2.40\ m/s}$$

#8 (6.49) $F(x) = 18\,N - (0.53\,N/m)\,x$, $m = 6\,kg$, $x_1 = 0$, $x_2 = 14\,m$

$$W_{tot} = K_2 - K_1 \quad \text{where} \quad K_2 = \tfrac{1}{2} m v^2$$

$$K_1 = \int_{x_1}^{x_2} F(x)\,dx$$

$$\Rightarrow \tfrac{1}{2} m v^2 = \int_{x_1}^{x_2} \left(18\,N - 0.53\,\tfrac{N}{m}\,x\right) dx$$

$$\Rightarrow \tfrac{1}{2} m v^2 = (18\,N)\,x - \left(\tfrac{0.53}{2}\,\tfrac{N}{m}\right) x^2 \Big|_0^{14}$$

$$\Rightarrow v^2 = \frac{2}{m}\left[(18\,N)(14\,m) - \left(0.265\,\tfrac{N}{m}\right)(14\,m)^2\right]$$

$$= \frac{2}{(6\,kg)}\left[252\,N\cdot m - 51.9\,N\cdot m\right]$$

$$\therefore\ v = \sqrt{\left(\frac{1}{3\,kg}\right)(200\,N\cdot m)} = \boxed{8.16\,m/s}$$

#9. (6.51) Given: $P = 100\,W$, $t = 60\,min = 3600\,s$, $m = 70\,kg$

$$E = W = P\cdot\Delta t = (100\,W)(3600\,s) = \boxed{3.6\cdot 10^5\,J}$$

$$W = \tfrac{1}{2} m v^2 = 3.6\cdot 10^5\,J$$

$$\Rightarrow v^2 = \frac{2}{m}\left(3.6\cdot 10^5\,J\right)$$

$$\therefore\ v = \sqrt{\frac{7.2\cdot 10^5\,J}{70\,kg}} = \sqrt{1.03\cdot 10^4\,m^2/s^2} = \boxed{101\,m/s}$$

#10. (6.57) Given: $m = 30\,kg$, $h = 0.9\,m$, $P = 0.5\,hp\cdot\left(\frac{736\,J/s}{hp}\right) = 368\,J/s$

(a) $$P = \frac{\Delta W}{\Delta t} \Rightarrow \Delta t = \frac{\Delta W}{P} = \frac{mgh}{P} = \frac{(30\,kg)(9.8\,m/s^2)(0.9\,m)}{(0.5\,\cancel{hp})(736\,J/s)}$$

$$= \frac{264.6\,J}{368\,J/s} = 0.719\,s$$

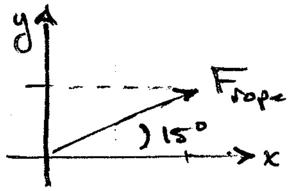
Noted: 1 hp = 746 J/s

$$\therefore\ \#\text{ of crates per minute} = \left(\frac{1}{0.719\,s}\right)\times\left(\frac{60\,s}{min}\right) = \boxed{83.4/min}$$

(b) Similarly, $$\frac{(100\,W)}{(30\,kg)(9.8\,m/s^2)(0.9\,m)} = \frac{0.378}{s}\times\left(\frac{60\,s}{min}\right) = \boxed{22.7/min}$$

#11 (6.59) Given: $\theta = 15°$, $s = 300\,m$, $v = 12\,km/h \times \left(\frac{1000\,m}{km}\right) \times \left(\frac{hr}{3600\,s}\right) = 3.33\,m/s$

$m = (70\,kg) \times 50 = 3500\,kg$

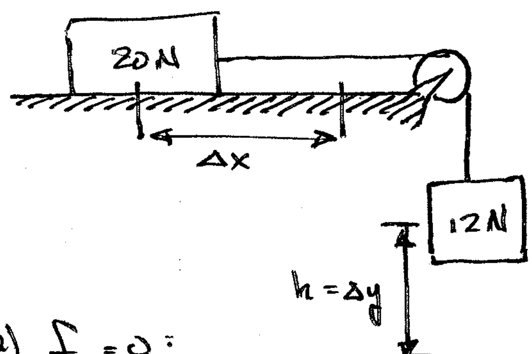


$F_{rope} = mg \cdot \sin\theta = (3500\,kg)(9.8\,m/s^2)\sin(15°)$

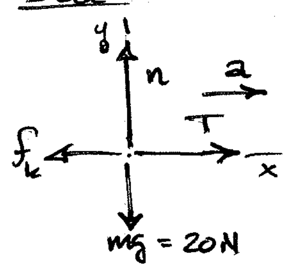
$= 8.88 \cdot 10^3\,N$

$P = F_{rope} \cdot v = (8.88 \cdot 10^3\,N)(3.33\,m/s) = \boxed{29.6\,kW}$

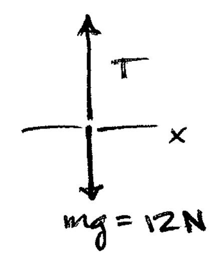
#12 (6.68) Given: block A = 20 N, block B = 12 N, $\Delta x = 75\,cm = 0.75\,m$



Block A:



Block B:



(a) $f_k = 0$:

(1): $T - f_k = m_A a$ (2): $w_B - T = m_B a$

Solve Eqn (2) in terms of acceleration...

$a \cdot m_B = w_B - T \Rightarrow a = \frac{w_B - T}{m_B}$

Substitute into Eqn (1): (where $f_k = 0$)

$T = m_A a = m_A \left(\frac{w_B - T}{m_B}\right)$

Noted: $m_A = \frac{20\,N}{(9.8\,m/s^2)} = \underline{2.04\,kg}$

$m_B = \frac{12\,N}{(9.8\,m/s^2)} = \underline{1.22\,kg}$

$\Rightarrow T \cdot m_B = m_A w_B - m_A \cdot T$

$\Rightarrow T \cdot m_B + T \cdot m_A = m_A \cdot w_B$

$\Rightarrow T(m_B + m_A) = m_A \cdot w_B$

$T = \frac{m_A \cdot w_B}{(m_B + m_A)} = w_B \left(\frac{m_A}{m_B + m_A}\right) = (12\,N)\left(\frac{2.04\,kg}{1.22\,kg + 2.04\,kg}\right)$

$= (12\,N)(0.626) = \underline{7.5\,N}$

$\therefore W_A = F \cdot \Delta x = (7.5\,N)(0.75\,m) = \boxed{5.63\,J}$

$W_B = (w_B - T)\Delta x = (12\,N - 7.5\,N)(0.75\,m) = \boxed{3.38\,J}$

#12 (6.65) cont... $\mu_k = 0.375$ between block A and table ...

(b) $f_k = \mu_k (m_A g) = (0.375)(20\,N) = 7.5\,N$

Eqn ①: $T - f_k = m_A \cdot a$

Eqn ②: $w_B - T = m_B \cdot a \Rightarrow a = \dfrac{w_B - T}{m_B}$

Substitute expression for acceleration into Eqn ①:

$$T - f_k = m_A \cdot \left(\frac{w_B - T}{m_B} \right)$$

$$\Rightarrow m_B (T - f_k) = m_A w_B - T m_A$$

$$T m_B - m_B \cdot (\mu_k w_A) = m_A w_B - T m_A$$

$$T \cdot m_B + T \cdot m_A = m_A \cdot w_B + m_B (\mu_k \cdot w_A)$$

$$T (m_B + m_A) = m_A \cdot w_B + m_B (\mu_k \cdot w_A)$$

$$T = \frac{m_A \cdot w_B + m_B (\mu_k \cdot w_A)}{(m_B + m_A)}$$

$$= \frac{(2.04\,kg)(12\,N) + (1.22\,kg)(0.375)(20\,N)}{(1.22\,kg + 2.04\,kg)}$$

$$= \frac{24.48\,kg \cdot N + 9.15\,kg \cdot N}{(3.26\,kg)}$$

$$= \underline{10.3\,N}$$

∴ Work done on block "A"

$$W_A = (T - f_k) \cdot \Delta x = (10.3\,N - 7.5\,N)(0.75\,m) = \boxed{2.10\,J}$$

$$W_B = (w_B - T) \cdot \Delta x = (12\,N - 10.3\,N)(0.75\,m) = \boxed{1.28\,J}$$

#13 (6.73) Given: $m = 1200\ kg$, $v = 0.65\ m/s$, $\Delta x = 0.09\ m$

$\frac{1}{2} m v^2 = \frac{1}{2} k (\Delta x)^2$ ... Solve for k

$$\Rightarrow \quad k = \frac{m v^2}{(\Delta x)^2} = \frac{(1200\ kg)(0.65\ m/s)^2}{(0.09\ m)^2} = \boxed{6.3 \cdot 10^4\ \frac{N}{m}}$$

#14 (6.85) Given: $m = 800\ kg$, $h = 14\ m$, $v = 18\ m/s$

(a) $W_{lift} = mgh$

$$= (800\ kg)(9.8\ m/s^2)(14\ m) = \boxed{1.10 \cdot 10^5\ J}$$ → work required to "lift" a mass to height $\underline{h}$

(b) $W_{eject} = \frac{1}{2} m v^2$

$$= \frac{1}{2}(800\ kg)(18\ m/s)^2 = \boxed{1.30 \cdot 10^5\ J}$$ ⇒ work required to eject H_2O at 18 m/s.

(c) Pump Output Power (per minute ⇒ $\Delta t = 60\ s$)

$$P_{tot} = \frac{W_{lift} + W_{eject}}{\Delta t}$$

$$= \frac{(1.10 \cdot 10^5\ J + 1.30 \cdot 10^5\ J)}{60\ s}$$

$$= \frac{2.40 \cdot 10^5\ J}{60\ s}$$

$$= 3.99 \cdot 10^3\ W = \boxed{3.99\ kW}$$