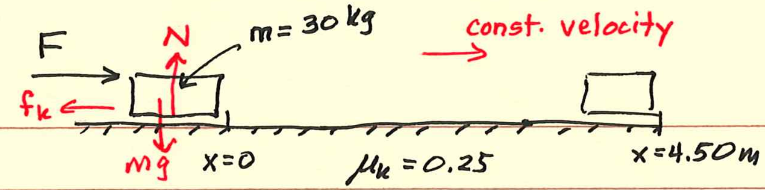
Chapter 6

Ex. 3



b.) $W_F = \mu_k mg(s) = 0.25(30\,kg)(9.8\,m/s^2)(4.50\,m) = \underline{331\ J}$

a.) $F = \mu_k mg = 0.25(30\,kg)(9.8\,m/s^2) = \underline{73.5\ N}$

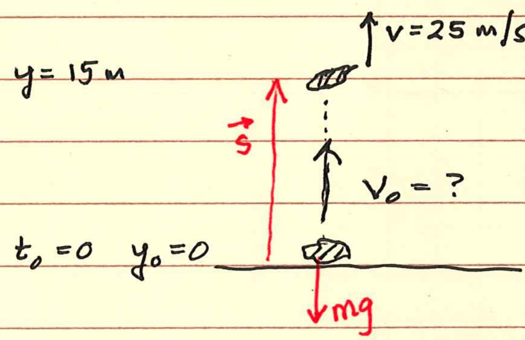
c.) $W_{f_k} = -\mu_k mgs = -331\ J$

d.) $W_N = N(s)\cos(90°) = 0\ J$

$W_{gr} = mg(s)\cos(90°) = 0\ J$

e.) $W_{TOTAL} = W_F + W_{fr} + W_N + W_{gr}$

Ex. 24 You throw a 3.00 N rock vertically . . .



a.) $v_0 = ?$

$W_{gr} = \Delta K$

$\cancel{m}g(15\,m)\cos(180°) = \frac{1}{2}\cancel{m}(v^2 - v_0^2)$

$2g(15\,m)(-1) = v^2 - v_0^2$

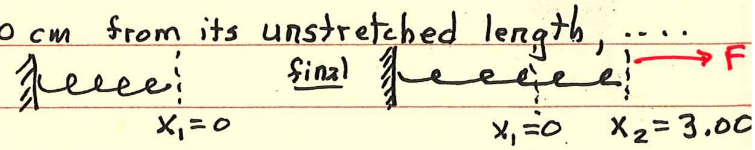
$v_0^2 = v^2 + (30\,m)(g) = 919\ m^2/s^2$ $\quad \underline{v_0 = 30.3\ m/s}$

b.) $-2g(h) = v^2 - v_0^2$ (with $v = 0$) $\quad v_0^2 = 2gh \quad h = \frac{v_0^2}{2g} = \frac{(30.3\,m/s)^2}{19.6\,m/s^2}$

$\underline{h = 46.9\ m}$

Ex. 32 To stretch a spring 3.00 cm from its unstretched length, ...

W = 12.0 J initial



Force & displacement are in the same direction

$$W = \int_0^{3cm} F(x)\,dx = k\int_0^{3cm} x\,dx = \frac{1}{2}kx^2 \Big|_{0\,cm}^{0.03\,m} = \frac{1}{2}k(0.03\,m)^2 = 12.0\,J$$

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Ex. 32 cont'd

$$k = \frac{(12.0\ J)2}{(0.03m)^2} = \boxed{2.67 \times 10^4\ N/m}$$

b.) $F = kx = 2.67 \times 10^4\ N/m\ (0.03\ m) = \boxed{800\ N}$

c.) $W = \int_0^{-4cm} kx\,\cos(0^\circ)\,dx = +\frac{1}{2}kx^2 \Big|_0^{-4cm} = \frac{1}{2}(2.67\times10^4\ N/m)((-0.04\ m)^2 - 0^2)$

$W = 21.36\ J$ $\boxed{W = 21.4\ J}$

$F = kx = 2.67\times10^{+4}\ N/m\ (0.04\ m) = \boxed{1068\ N}$

Ex. 34 A child applies a force $\vec{F}$ parallel to the x-axis to a 10-kg sled ....

a.) Work done on the sled by the force $\vec{F}$. (0 m → 8 m)

$W_{0\to8m}$ = area = $\frac{1}{2}(8\ m)(10\ N) = \underline{40.0\ J}$

b.) $W_{8m\to12m}$ = area = $\frac{1}{2}(4m)(10\ N) = \underline{20.0\ J}$

c.) $W_{0m\to12m}$ = total area $= 40.0\ J + 20.0\ J = \underline{60.0\ J}$

Question not asked: If the sled starts from rest, and the surface of the ice is frictionless, what is the speed of the sled after 12.0 meters?

$W_{TOT} = \frac{1}{2}m(v^2 - v_0^2)$ $W_{TOT} = \frac{1}{2}mv^2$

$v^2 = \frac{2\,W_{TOT}}{m}$ $v = \sqrt{\frac{2(60.0\ J)}{10\ kg}} = 3.46\ m/s$

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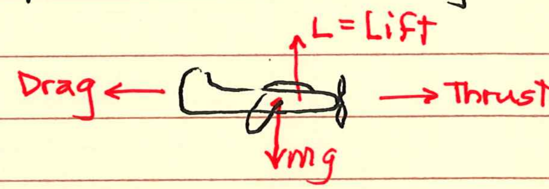
Ex. 52 When its 75-kW (100 hp) engine is generating full power, a small single-engine airplane with mass 700 kg

$$\frac{\Delta y}{\Delta t} = 2.5\ \frac{m}{s}$$



$\sum F_y = 0$ because $V_y = \text{constant}$

$L - mg = 0 \qquad L = mg \qquad W_L$ = work done by lift (the engine)

$$\text{Power})_L = \frac{W_L}{\Delta t} = \frac{F_L \cdot \Delta y}{\Delta t} = \text{Lift}\left(\frac{\Delta y}{\Delta t}\right) = mg\left(\frac{\Delta y}{\Delta t}\right) = 700\,kg\left(9.8\frac{m}{s^2}\right)\left(2.5\frac{m}{s}\right)$$

$$\text{Power})_{Lift} = 17.15\ kW$$

$$\text{Fraction} = \frac{\text{Power})_{Lift}}{\text{Power})_{engine}} = \frac{17.15\ kW}{75\ kW} = \underline{0.23} \quad \text{or } 23\%$$

Ex. 54 An elevator has mass 600 kg (= M), not including passengers.

$$\frac{\Delta y}{\Delta t} = \frac{20\ m}{16\ s} = 1.25\ \frac{m}{s} \qquad P_{motor} = 40\ hp\left(746\frac{W}{hp}\right) = 29{,}840\ W$$

m_p = mass of an average passenger = 65.0 kg

$$P_{motor} = (M + n m_p)\, g \frac{\Delta y}{\Delta t} \qquad (M + n m_p) = \frac{P_{motor}}{g(\Delta y/\Delta t)}$$

(n = # of passengers = ?)

$$n = \frac{\frac{P_{motor}}{g\,\Delta y/\Delta t} - M}{m_p} = \frac{\frac{29{,}840}{1.25(9.8)} - 600}{65.0} = 28.2 \text{ passengers}$$

n = 28 passengers (maximum)

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Prob. 71 A small block with a mass of 0.0600 kg is attached to a cord.

a.) Tension @ r_1 = ?

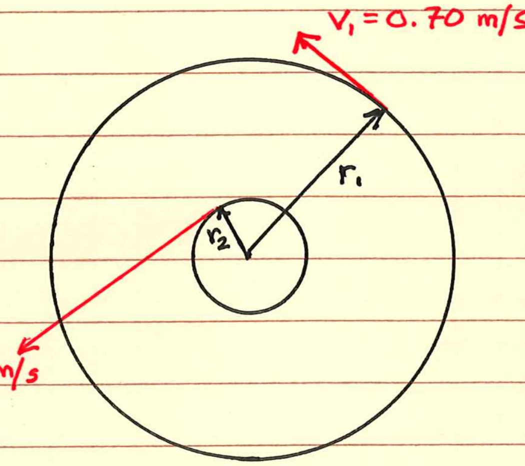
$r_1 = 0.40\ m$

$r_2 = 0.10\ m$

$$T_1 = \frac{m v_1^2}{r_1}$$

$$T_1 = 0.060\ kg \frac{(0.70\ m/s)^2}{0.40\ m}$$

$$\boxed{T_1 = 0.0735\ N}$$



b.) Tension @ r_2 = ?

$$T_2 = m \frac{V_2^2}{r_2} = 0.060\ kg \frac{(2.80\ m/s)^2}{0.10\ m}$$

$$\boxed{T_2 = 4.704\ N}$$

c.)

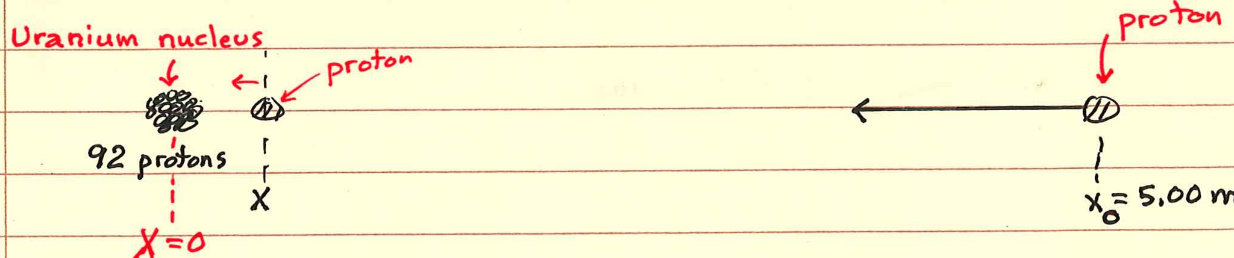
$$W_{Tension} = \int \vec{T} \cdot d\vec{r} = -\int_{0.40\ m}^{0.10\ m} T\, dr = \int_{0.10\ m}^{0.40\ m} T(r)\, dr = \Delta K$$

We don't know the functional form for T(r)

$$W_{Tension} = \frac{1}{2} m \left(V_f^2 - V_i^2\right) = \frac{1}{2} (0.0600\ kg)\left((2.80)^2 - (0.70)^2\right) m^2/s^2$$

$$\boxed{W_{Tension} = 0.2205\ J}$$

Prob. 72 A proton with mass 1.67×10^{-27} kg is propelled at an initial speed of 3.00×10^5 m/s . . . .



$F = \alpha / X^2$ $\qquad \alpha = 2.12 \times 10^{-26}\ N \cdot m^2$

$V = ?$ when $X = 8.00 \times 10^{-10}\ m$

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Prob. 71 cont'd.

$\overleftarrow{d\vec{r}}$ (P) $\overrightarrow{\vec{F}}$

$$W_{TOT} = W_F = \int \vec{F}\cdot d\vec{r} = \int_{x_0}^{x} F\,dx = \alpha \int_{x_0}^{x} \frac{dx}{x^2} = \frac{1}{2}m(v^2 - v_0^2)$$

Work-Energy Theorem

$$\alpha \int_{x_0}^{x} x^{-2}\,dx = -\alpha \frac{1}{x}\Big|_{x_0}^{x} = -\alpha\left[\frac{1}{x} - \frac{1}{x_0}\right] = \frac{1}{2}m(v^2 - v_0^2)$$

x: 8×10^{-10}; x_0: 5; find $v = ?$

$$-\frac{\alpha}{x} = \frac{1}{2}m(v^2 - v_0^2) \qquad v^2 - v_0^2 = \frac{-2\alpha}{mx} \qquad v = \sqrt{v_0^2 - \frac{2\alpha}{mx}}$$

$$v = \sqrt{(3.00\times10^5\,m/s)^2 - \frac{2(2.12\times10^{-26}\,N\cdot m^2)}{(1.67\times10^{-27})(8.00\times10^{-10})}} \Rightarrow \boxed{v = 2.414\times10^5\,m/s}$$

b.) At $x = ?$ does $v \to 0$

$$-\frac{\alpha}{x} = \frac{1}{2}m(v^2 - v_0^2) \qquad -\frac{\alpha}{x} = -\frac{1}{2}mv_0^2$$

($v = 0\,m/s$)

$$x = \frac{2\alpha}{mv_0^2} = \frac{2(2.12\times10^{-26}\,N\cdot m^2)}{1.67\times10^{-27}\,kg\,(3.00\times10^5\,m/s)^2}$$

distance of closest approach

$$\boxed{x = 2.82\times10^{-10}\,m}$$

"head on"

c.)

$$-\alpha\left[\frac{1}{x} - \frac{1}{x_0}\right] = \frac{1}{2}m\underbrace{(v^2 - v_0^2)}_{=0} \Rightarrow \boxed{v = v_0 = 3.00\times10^5\,m/s}$$

x: 5.00 m; x_0: 5.00 m