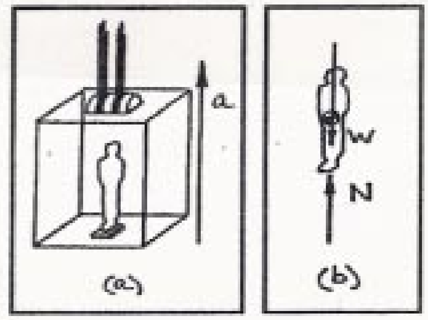
Homework Solution – #10 MTH1250



(3.5) **Solution:** The motion is in the y direction. Figure (b) is the free body diagram of the man. The equation of motion is $\sum F_y = N - W = ma_y$, where $W = mg$. Thus, $m = 150/32.2 = 4.66 slug$.

(a) If the scales read *155 lb*, evaluation of the equation of motion yields $a_y = 1.07\ ft/s^2$.

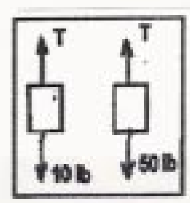
(b) If acceleration $a_y = -2\ ft/s^2$, then the equation of motion yields $N = 140.68\ lb$ for the scale reading.

(3.12) **Solution** The mass of the helicopter is $m = \frac{W}{g} = 466.27\ slugs$. The acceleration is $\vec{a} = \frac{\vec{F}}{m} - g\vec{j} = (42.89 - g)\vec{j} = 10.72\vec{j}\ (ft/s^2)$. The velocity is $\vec{v}(t) = 10.72t\vec{j}\ (ft/s)$, since $\vec{v}(0) = 0$. The distance is $\vec{r}(t) = \frac{10.72}{2}t^2\vec{j}\ (ft)$, since $\vec{r}(0) = 0$. At $t = 2\ s$, $\boxed{\vec{r}(2) = 21.45\vec{j}\ (ft)}$

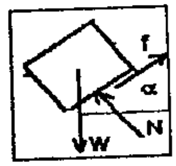
(3.28)

Solution Write the equations for the position of the 50 *lb.* weight, with y positive downward. From Newton's second law, $T - 10 = \left(\frac{10}{g}\right)a_{10}$, and $T - 50 = \left(\frac{50}{g}\right)a_{50}$, and since the pulley is one-to-one: $a_{10} = -a_{50}$, from which $a_{50} = \left(\frac{g}{60}\right)F = \left(\frac{2}{3}\right)g\ ft/s^2$.

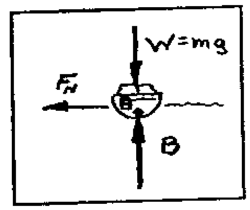
The velocity is $v(t) = \left(\frac{2}{3}\right)gt\ ft/s$ since $v(0) = 0$. The position is $y(t) = \frac{gt^2}{3}\ ft$, since $y(0) = 0$. The distance fallen in one-half second is $\boxed{y(t = 0.5) = \frac{g}{12} = 2.68\ ft}$



(3.39) **Solution** The force on the load required to induce slip forward on the bed is $F = \mu_s W\cos\alpha + W\sin\alpha$. From Newton's second law, $F = ma_L$, from which the acceleration of the load relative to the vehicle is $a_L = \frac{F}{m} = g(\mu_s \cos\alpha + \sin\alpha)$. The acceleration required of the vehicle is $a_v = -a_L = -g(\mu_s \cos\alpha + \sin\alpha) = -16.1\ ft/s^2$. The velocity is $v(t) = a_v t + 10\ ft/s$, since $v(0) = 10\ ft/s$. Substitute and solve: the vehicle will come to a stop at $t = \frac{10}{a_v} = 0.6217\ s$. The distance traveled in this time is $s(t) = -a_v t^2 + 10t\ ft$, since $s(0) = 0$, from which $\boxed{s(t = 0.6217) = 3.11\ ft}$ This is the shortest possible distance that the vehicle can be stopped without the load slipping.



(.66) **Solution:** First, we need to draw free body diagrams of the boat, showing forces in all three coordinate directions. A top view and a rear view are shown. The mass of the boat is determined from *W=mg*. The equations of motion in the three coordinate directions are $\sum F_t = ma_t = m\,dv/dt$, $\sum F_n = ma_n = mv^2/R$, and $\sum F_{vert} = B - mg = 0$. For this problem, we have $dv/dt = 0$, $R = 80 ft$, and $v = 15 mi/hr = 22 ft/s$. Substituting these values into the equations of motion, we get $a_t = 0$, $a_n = 6.05 ft/s^2$, and $a_{vert} = 0$. Hence, the associated forces are $\sum F_t = 0$, $\sum F_{vert} = 0$, and $\sum F_n = 488.5\ lb$ (inward toward the center of curvature of the path.)



(3.80) **Solution** The weight is $\vec{W} = -\vec{j}W = -\vec{j}(2\times10^5)\ lb$. The normal acceleration is $\vec{a}_n = \vec{i}\left(\frac{v^2}{\rho}\right)$. The lift is

$$\vec{L} = |\vec{L}|(\vec{i}\cos 105^o + \vec{j}\sin 105^o) = |\vec{L}|(-0.2588\vec{i} + 0.9659\vec{j}).$$

(a) From Newton's second law, $\sum \vec{F} = \vec{L} + \vec{W}_n = m\vec{a}_n$, from which, substituting values and separating the $\vec{j}$ components: $|\vec{L}|(0.9659) = 2\times10^5$, $\boxed{|\vec{L}| = \frac{2\times10^5}{0.9659} = 207055\ lb}$. (b) The radius of curvature is obtained from Newton's law: $|\vec{L}|(-0.2588) = -m\left(\frac{v^2}{\rho}\right)$, from which $\boxed{\rho = \left(\frac{W}{g}\right)\left(\frac{v^2}{|\vec{L}|(0.2588)}\right) = 417637\ ft}$.

Note: If the value $g = 32.2\ ft/s^2$ is adopted, $\rho = 417248\ ft$

(3.104) **Solution** From Newton's second law for the radial component $-mg\sin\theta \pm \mu_s N = -mR\omega^2$, and for the normal component: $N - mg\cos\theta = mR\alpha$. Solve, and note that $\alpha = \frac{d\omega}{dt} = \omega\frac{d\omega}{d\theta} = 1 = const$, $\omega^2 = 2\theta$, since $\omega(0) = 0$, to obtain $-g\sin\theta \pm \mu_s(g\cos\theta + R\alpha) = -2R\theta$. For $\alpha = 1$, $R = 1$, this reduces to $\pm\mu_s(1 + g\cos\theta) = -2\theta + g\sin\theta$. Define the quantity $F_R = 2\theta - g\sin\theta$. If $F_R > 0$, the block will tend to slide away from O, the friction force will oppose the motion, and the negative sign is to be chosen. If $F_R < 0$, the block will tend to slide toward O, the friction force will oppose the motion, and the positive sign is to be chosen. The equilibrium condition is derived from the equations of motion: $\text{sgn}(F_R)\mu_s(1 + g\cos\theta) = (2\theta - g\sin\theta)$. from which $\boxed{\mu_s = \text{sgn}(F_R)\frac{2\theta - g\sin\theta}{1 + g\cos\theta} = 0.406}$. Since $F_r = -3.86 < 0$, the block will slide toward O.