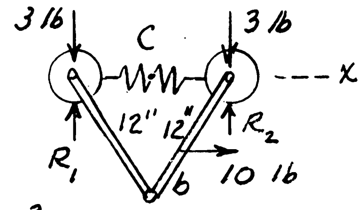
4/1 | C = mass center of system



$\Sigma F_x = m\bar{a}_x$: $\bar{a}_x = a_c = \dfrac{10}{6/32.2}$

$$\underline{a_c = 53.7 \text{ ft/sec}^2}$$

Dimension b has no influence on ΣF_x but it would influence R_1 & R_2.

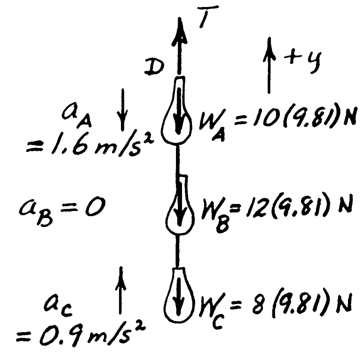
4/2

For system $\Sigma F_y = \Sigma m_i a_i$

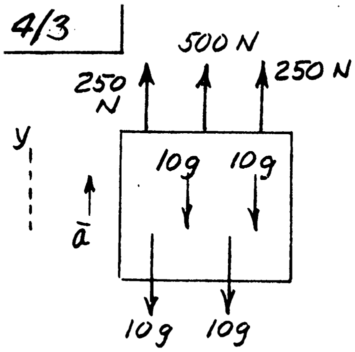
$T - 9.81(10+12+8)$

$= 10(-1.6) + 12(0) + 8(0.9)$

$T - 294 = -8.8$, $\underline{T = 286 \text{ N}}$



4/3



$$\Sigma F_y = m\bar{a}_y$$

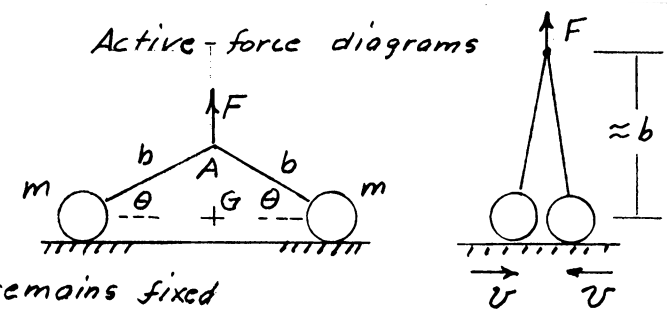
$$500 + 250 + 250 - 40(9.81) = 40\bar{a}$$

$$40\bar{a} = 1000 - 392$$

$$\underline{\bar{a} = 15.19 \text{ m/s}^2}$$

4/4

Active-force diagrams



Mass center remains fixed so long as $F < 2mg$

For system $U = \Delta T$: $F(b - b\sin\theta) = 2(\frac{1}{2}mv^2)$

$$v = \sqrt{\frac{Fb}{m}(1-\sin\theta)}$$

4/5

$$\underline{F}_{av} = \frac{\Delta \underline{G}}{\Delta t} = \left[(3.7-3.4)\underline{i} + (-2.2+2.6)\underline{j} + (4.9-4.6)\underline{k}\right]/0.2$$

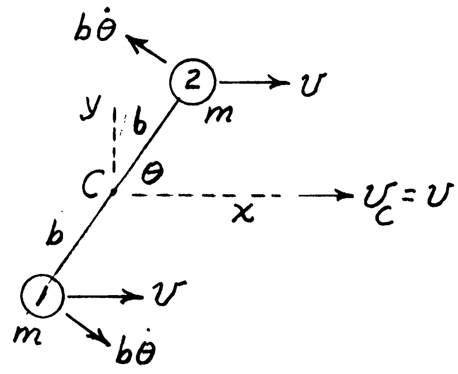
$$= 1.5\underline{i} + 2.0\underline{j} + 1.5\underline{k} \text{ N}$$

$$F = |\underline{F}_{av}| = \sqrt{1.5^2 + 2.0^2 + 1.5^2} = \underline{2.92 \text{ N}}$$

4/6

For sphere 1,

$$\underline{G}_1 = m\left[(v + b\dot{\theta}\sin\theta)\underline{i} - (b\dot{\theta}\cos\theta)\underline{j}\right]$$



For sphere 2

$$\underline{G}_2 = m\left[(v - b\dot{\theta}\sin\theta)\underline{i} + (b\dot{\theta}\cos\theta)\underline{j}\right]$$

$$\underline{G} = \underline{G}_1 + \underline{G}_2 = m\left[v + v\right]\underline{i} = \underline{2mv\,\underline{i}}$$

4/7

$$\underline{H}_O = \underline{H}_G + \bar{\underline{r}} \times \underline{G}\ , \quad \underline{G} = 3(3\underline{i} + 4\underline{j})\ \text{kg}\cdot\text{m/s}$$

$$= 1.20\underline{k} + (0.4\underline{i} + 0.3\underline{j}) \times 3(3\underline{i} + 4\underline{j})$$

$$= 1.20\underline{k} + 3(1.6\underline{k} - 0.9\underline{k})$$

$$= 1.20\underline{k} + 3(0.7\underline{k}) = \underline{3.3\underline{k}\ \text{kg}\cdot\text{m}^2/\text{s}}$$

4/8

$\Sigma M_O = \dot{H}_O$ where O-O is the axis of rotation

$$M = \frac{dH_O}{dt}, \quad \int_0^t M\,dt = \int_0^{H_O} dH_O = H_O$$

$$Mt = 4m(r\omega)r, \quad t = \frac{4mr^2\omega}{M}$$

4/9

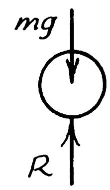
For the system of two spheres

$$U' = 0 = \Delta V_g + \Delta T$$

$$0 = -mgr - mgr\left(1 - \frac{1}{\sqrt{2}}\right) + \frac{1}{2} 2m v^2, \quad v^2 = gr\left(2 - \frac{1}{\sqrt{2}}\right)$$

$$\underline{v = 1.137\, gr}$$

Sphere 1 just prior to reaching A



$a_n = v^2/r$
$= 1.293g$

$\Sigma F_y = ma_y: \quad a_y = a_n = 1.293g$

$$R - mg = m(1.293g)$$

$$\underline{R = 2.29\, mg}$$

4/10 $\quad \Sigma \underline{M}_O = \dot{\underline{H}}_O \; , \quad \underline{M}_{O_{av.}} = \dfrac{\Delta \underline{H}_O}{\Delta t}$

$$(\underline{M}_O)_{av} = \frac{1}{0.1}\left[(3.67-3.65)\underline{i}+(4.30-4.27)\underline{j}+(-5.30+5.36)\underline{k}\right]$$

$$= \frac{1}{0.1}(0.02\underline{i}+0.03\underline{j}+0.06\underline{k}) =$$

$$= (2\underline{i}+3\underline{j}+6\underline{k})10^{-1} \; N\cdot m$$

$$|\underline{M}_O|_{av} = \underline{0.7 \; N\cdot m}$$

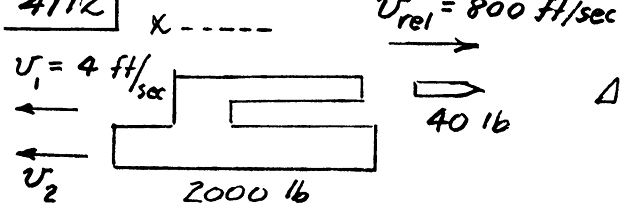
4/11 $\int_0^t M_z \, dt = H_{z_2} - H_{z_1}$, $H_z = \sum m_i r_i (r_i \dot{\theta})$

$H_z = 2(3)(0.3)^2\dot{\theta} + 2(3)(0.5)^2\dot{\theta} = 2.04\dot{\theta}$

so $30t = 2.04\,(20-[-20]) = 81.6$

$\underline{t = 2.72 \text{ s}}$

4/12



$\Delta G_x = 0, \quad G_1 = G_2$

$$\frac{1}{g}(2000 + 40)4 = \frac{1}{g}\left(2000 v_2 - 40[800 - v_2]\right)$$

$$8160 = 2040 v_2 - 32000$$

$$\underline{v_2 = 19.69 \text{ ft/sec}}$$

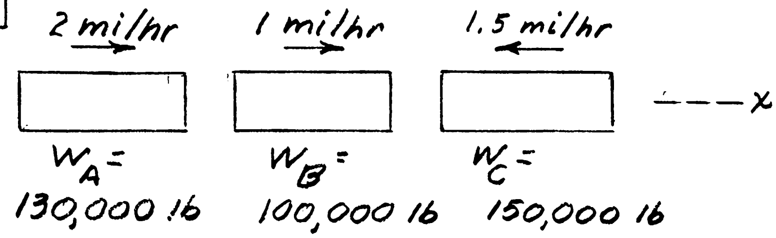
$\boxed{4/13}$ For entire system $\Delta G_x = 0$, x horiz.

$$(300 + 400 + 100)v - (300 \times 0.6 - 400 \times 0.3 + 100 \times 1.2 \cos 30°) = 0$$

$$800v = 163.9, \quad \underline{v = 0.205 \text{ m/s}}$$

Momentum is conserved regardless of sequence of events, so final velocity would be the same.

4/14



$\Sigma F_x = 0$ for system so $\Delta G_x = 0$

$$(130 \times 2 + 100 \times 1 - 150 \times 1.5)\frac{44}{30}\frac{10^3}{32.2} - (130 + 100 + 150)\, v \,\frac{44}{30}\frac{10^3}{32.2} = 0$$

$$v = \frac{260 + 100 - 225}{130 + 100 + 150} = \underline{0.355 \text{ mi/hr}}$$

% loss of energy $= \dfrac{T_i - T_f}{T_i} 100 = 100\left(1 - \dfrac{T_f}{T_i}\right) = n$

$$n = 100\left\{1 - \frac{\frac{1}{2g}(130 + 100 + 150)(0.355)^2}{\frac{1}{2g}(130 \times 2^2 + 100 \times 1^2 + 150 \times 1.5^2)}\right\} = 100\left(1 - \frac{47.96}{957.5}\right)$$

$$\underline{n = 95.0\ \%}$$

4/15 Let P_p = power to move 10 people

P_b = " " " 3 boys

Velocity of people vertically up is $\frac{20}{40} = 0.5$ ft/sec

" " boys " down is $1-0.5=0.5$ ft/sec

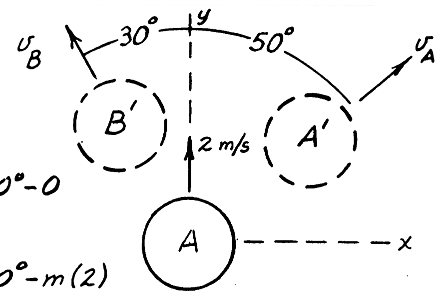
$P = dV_g/dt$, $P_p = \dfrac{10(150)(0.5)}{550} = 1.364$ hp

$P_b = \dfrac{3(120)(-0.5)}{550} = -0.327$ hp

$P_{fr} = 2.2$ hp

Thus $P = 1.364 - 0.327 + 2.2 = \underline{3.24 \text{ hp}}$

4/16



For the system as a whole

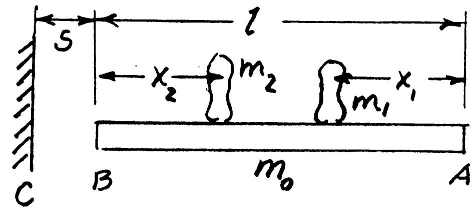
$\Sigma F_x = \Sigma F_y = 0$ so

$\Delta G_x = 0$: $-mv_B \sin 30° + mv_A \sin 50° - 0 = 0$

$\Delta G_y = 0$: $mv_B \cos 30° + mv_A \cos 50° - m(2) = 0$

Solve & get $\underline{v_A = 1.015 \text{ m/s}}$, $\underline{v_B = 1.556 \text{ m/s}}$

4/17 With respect to C, $\Sigma m_i x_i$ = constant



$$m_1 l + m_2(0) + m_0 \frac{l}{2} = m_1(s + l - x_1) + m_2(s + x_2) + m_0\left(s + \frac{l}{2}\right)$$

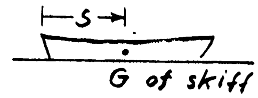
Simplify & get $s = \dfrac{m_1 x_1 - m_2 x_2}{m_0 + m_1 + m_2}$

But they meet when $x_2 + x_1 = l$ so

$$s = \frac{(m_1 + m_2)x_1 - m_2 l}{m_0 + m_1 + m_2}$$

4/18 With neglect of hydraulic forces linear momentum is conserved & velocity $v_2 = v_1 = 1$ knot. Center of mass does not change position with respect to reference axes moving with constant speed of 1 knot.

Thus $(\Sigma m_i x_i)_1 = (\Sigma m_i x_i)_2$



$$\frac{1}{32.2}\left[120(2) + 180(8) + 160(16) + 300(s)\right]$$

$$= \frac{1}{32.2}\left[120(14+x) + 180(4+x) + 160(10+x) + 300(s+x)\right]$$

$$4240 = 4000 + 760x, \quad x = \frac{240}{760} = \underline{0.316 \text{ ft}}$$

Timing & sequence of changed positions does not affect final result because all forces are internal.

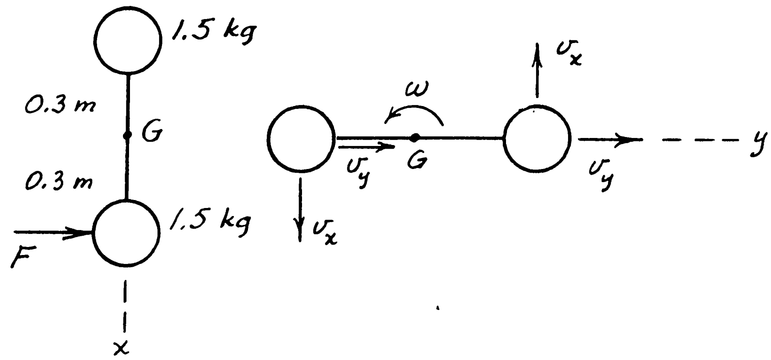
4/19 | $\underline{H}_O = \underline{H}_G + \bar{\rho} \times m\bar{v}$

$$\underline{H}_G = \Sigma \rho_i \times m_i \dot{\rho}_i = 2r \times m \times r\omega \underline{k} = 2mr^2\omega \underline{k}$$

$$\bar{\rho} \times 2m\bar{\underline{v}} = (x\underline{i} + y\underline{j}) \times 2mv\underline{i} = -2mvy\underline{k}$$

so $\underline{H}_O = 2mr^2\omega\underline{k} - 2mvy\underline{k}$, $\underline{H}_O = 2m(r^2\omega - vy)\underline{k}$

4/20



$$\int \Sigma F_x \, dt = 0 \quad \text{so} \quad \Delta G_x = 0$$

$$\int \Sigma F_y \, dt = \Delta G_y: \quad 10 = 2(1.5)v_y, \quad v_y = 3.33 \text{ m/s}$$

$$\int \Sigma M_G \, dt = \Delta H_G: \quad 10(0.3) = 2(1.5)v_x(0.3), \quad v_x = 3.33 \text{ m/s}$$

$$v = 3.33\sqrt{2} = \underline{4.71 \text{ m/s both spheres}}$$

4/21

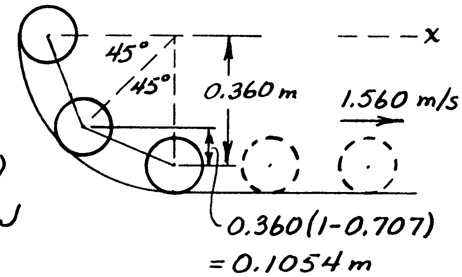
$U'_{1-2} = \Delta T + \Delta V_g$

$= 3\left(\frac{1}{2} \times 2.75 \times 1.560^2\right) - 0$

$- 2.75 \times 9.81(0.360 + 0.1054)$

$= 10.04 - 12.56 = -2.52$ J

so loss is $\underline{\Delta Q = 2.52 \text{ J}}$



$I_x = \int \Sigma F_x \, dt = \Delta G_x = G_2 - G_1, \; G_2 = 3mv = 3(2.75)(1.560)$

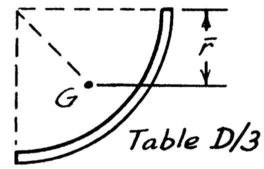
$= 12.87$ N·s, $G_1 = 0$

$\underline{I_x = 12.87 \text{ N·s}}$

4/22 $\Delta T = \Delta V_e = 0$ so $U' = \Delta V_g = -\Delta Q$

$\Delta V_g = -mg\bar{r}$, $|\Delta V_g| = \frac{\pi r \rho}{2} g \frac{2r}{\pi} = \underline{\rho g r^2}$

$= \Delta Q$



$\bar{r} = 2r/\pi$

Energy is lost in the generation of heat and sound upon impact of rope with fixed guide.

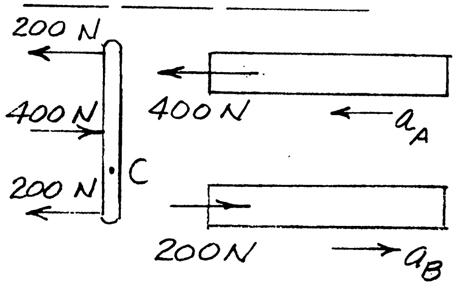
4/23 (a) $\Sigma F_x = m\bar{a}_x$; $F = 2m\bar{a}$, $\underline{\bar{a} = F/2m}$

(b) $H_G = 2m\left(\frac{L}{2}\right)^2\dot{\theta}$, $\dot{H}_G = mL^2\ddot{\theta}/2$

$\Sigma M_G = \dot{H}_G$; $Fb = mL^2\ddot{\theta}/2$, $\underline{\ddot{\theta} = \frac{2Fb}{mL^2}}$

4/24 For system of 2 bars & lever, mass center is in line with C & has the same acceleration as C.

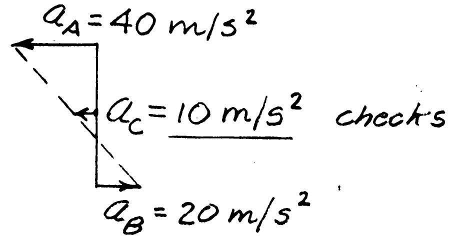
$\Sigma F = m a_C$; $200 = 2(10) a_C$, $a_C = 10 \; m/s^2$



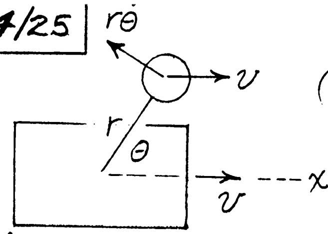
$\Sigma F = ma$

$400 = 10 a_A$, $a_A = 40 \; \frac{m}{s^2}$

$200 = 10 a_B$, $a_B = 20 \; \frac{m}{s^2}$



4/25



$\Sigma F_x = 0$ for system so $\Delta G_x = 0$

$(G_x)_{\theta=0} = (20+5)(0.6) = 15.0$ N·s

$(G_x)_{\theta=60^\circ} = (20+5)v - 5(1.6)\sin 60^\circ$

$= 25v - 6.93$ N·s

$r\dot\theta = 0.4(4) = 1.6$ m/s

Thus $15.0 = 25v - 6.93$, $v = 21.9/25 = \underline{0.877 \text{ m/s}}$