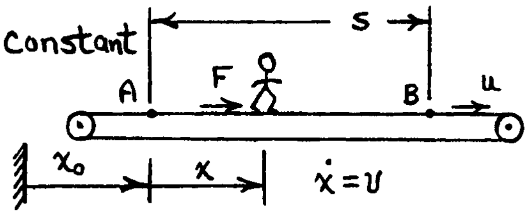
3/312 $F = \text{constant}$



Absolute: $U = \Delta T$: $F(s + \Delta x_0) = \frac{1}{2}m(u+v)^2 - \frac{1}{2}mu^2$

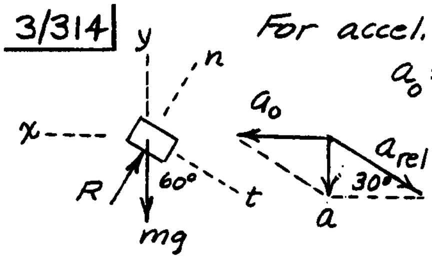
$$Fs + F\Delta x_0 = \frac{1}{2}mv^2 + muv \quad (1)$$

Relative to walkway : $U_{rel} = \Delta T_{rel}$: $Fs = \frac{1}{2}mv^2 - 0 \quad (2)$

Subtract (2) from (1) : $F\Delta x_0 = muv$

The term muv represents the work done by force F due only to the movement of the walkway.

3/314



For accel. a vertically down,

$$a_o = a_{rel}\cos 30°$$

$a_x = 0$ so $\Sigma F_x = 0$

$-R\sin 30° = 0$, $\underline{R = 0}$

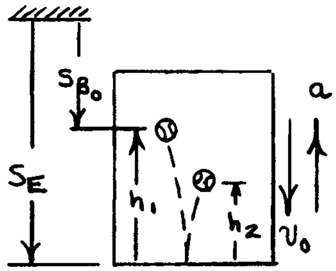
$\Sigma F_y = ma_y$, $mg = ma$

$a = g$ & $a_o = a\sqrt{3} = g\sqrt{3}$

$= 9.81\sqrt{3} = \underline{16.99 \frac{m}{s^2}}$

▸3/319 (a) $a = 0$, elevator is Newtonian frame

$$v' = ev = e\sqrt{2gh_1} = \sqrt{2gh_2}$$



$a = \frac{g}{4}$

$$\underline{h_2 = e^2 h_1}$$

(b) $a = \frac{g}{4}$ up

Let B = ball, E = elevator, $\downarrow +$

At impact, $s_B = s_E$: $s_{B_0} + v_{B_0}t + \frac{1}{2}gt^2 = s_{E_0} + v_{E_0}t - \frac{1}{2}\frac{g}{4}t^2$

$$s_{B_0} + v_0 t + \frac{1}{2}gt^2 = (s_{B_0} + h_1) + v_0 t - \frac{1}{8}gt^2, \quad t = 2\sqrt{\frac{2h_1}{5g}}$$

$$v_{B/E} = v_B - v_E = \left(v_0 + g\,2\sqrt{\frac{2h_1}{5g}}\right) - \left(v_0 - \frac{g}{4}2\sqrt{\frac{2h_1}{5g}}\right)$$

$$= \sqrt{\frac{5h_1 g}{2}}$$

After collision, $v'_{B/E_0} = -e\sqrt{\frac{5h_1 g}{2}}$ (up)

$$v'_{B/E} = v'_{B/E_0} + a_{B/E}t = -e\sqrt{\frac{5h_1 g}{2}} + \frac{5}{4}gt$$

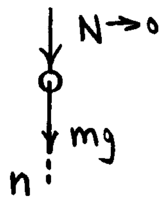
When $v'_{B/E} = 0$, $t = 2e\sqrt{\frac{2h_1}{5g}}$

$$s'_{B/E} = s'_{B/E_0} + v'_{B/E_0}t + \frac{1}{2}\frac{5}{4}gt^2$$

$$= 0 - e\sqrt{\frac{5h_1 g}{2}}\,2e\sqrt{\frac{2h_1}{5g}} + \frac{5}{8}g\,4e^2\frac{2h_1}{5g}$$

$$= -e^2 h_1 \quad \Rightarrow \quad \underline{h_2 = e^2 h_1}$$

3/326 Dynamics at B (top of loop)



$\Sigma F_n = ma_n: \quad mg = m\frac{v_B^2}{R}$

$v_B^2 = gR$

Work-kinetic energy from A to B:

$T_A + U_{A-B} = T_B: \quad 0 + \frac{1}{2}k\delta^2 - mg\mu_k R - mg(2R)$

$= \frac{1}{2}m(gR)$

$$\delta = \sqrt{\frac{mgR(5 + 2\mu_k)}{k}}$$

$\underline{3/235}$ $\sum M_o = \dot{H}_o = 0$, so angular momentum is conserved : $H_{o_1} = H_{o_2}$ (O: any point on axis)

$$0.2\,(0.3 \cos 30°)^2\,4 = 0.2(0.2 \cos 30°)^2\,\omega$$

$$\underline{\omega = 9 \text{ rad/s}}$$

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

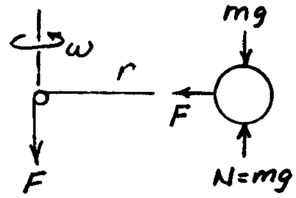
$$\Delta T = \frac{1}{2}(0.2)\left[(0.2 \cos 30° \cdot 9)^2 - (0.3 \cos 30° \times 4)^2\right]$$

$$= 0.1350 \text{ J}$$

$$\Delta V_g = 0.2\,(9.81)\,(0.1 \sin 30°) = 0.0981 \text{ J}$$

So $U'_{1-2} = 0.1350 + 0.0981 = \underline{0.233 \text{ J}}$

3/241



Angular momentum about central axis is conserved so

$\dot{H} = \frac{d}{dt}(mr^2\omega) = 0$

$m(2r\omega dr + r^2 d\omega) = 0$, $\underline{\frac{d\omega}{dr} = -\frac{2\omega}{r}}$

$\Sigma F_n = ma_n$; $F = mr\omega^2$

$dU = dT$; $-F\,dr = d(\frac{1}{2}mr^2\omega^2)$

so $-mr\omega^2 dr = m(r\omega^2 dr + r^2\omega\, d\omega)$

$= m(r\omega^2 dr + r^2\omega[-\frac{2\omega}{r}dr])$

$= -mr\omega^2 dr$ (check)

3/242 Path form: $\dfrac{x^2}{a^2} + \dfrac{y^2}{b^2} = 1$ $\left(\begin{array}{l} a = 5 \text{ ft} \\ b = 4 \text{ ft} \end{array}\right.$

Angular momentum about O is conserved:

$$m r_A v_A = m r_B v_B : \quad v_B = \frac{r_A}{r_B} v_A = \frac{a}{b} v_A$$

$$= \frac{5}{4}(8) = 10 \text{ ft/sec}$$

$$y = b\left[1 - \left(\frac{x}{a}\right)^2\right]^{1/2}$$

$$\frac{dy}{dx} = \frac{1}{2} b \left[1 - \left(\frac{x}{a}\right)^2\right]^{-\frac{1}{2}} \cdot \left(-\frac{2x}{a^2}\right) = -\frac{bx}{a^2}\left[1 - \left(\frac{x}{a}\right)^2\right]^{-\frac{1}{2}}$$

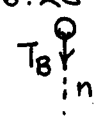
$$\frac{d^2y}{dx^2} = -\frac{b}{a^2}\left[1 - \left(\frac{x}{a}\right)^2\right]^{-\frac{1}{2}} - \frac{bx}{a^2}\left(-\frac{1}{2}\right)\left[1 - \left(\frac{x}{a}\right)^2\right]^{-\frac{3}{2}}\left(-\frac{2x}{a^2}\right)$$

$$= -\frac{b}{a^2}\left[1 - \left(\frac{x}{a}\right)^2\right]^{-\frac{1}{2}} - \frac{bx^2}{a^4}\left[1 - \left(\frac{x}{a}\right)^2\right]^{-\frac{3}{2}}$$

Now, $\left.\dfrac{dy}{dx}\right|_{x=0} = 0$ and $\left.\dfrac{d^2y}{dx^2}\right|_{x=0} = -\dfrac{b}{a^2} = -\dfrac{4}{5^2} = -\dfrac{4}{25}$

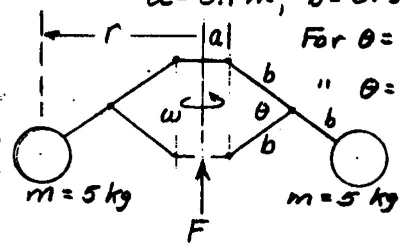
$$\rho_{xy} = \frac{\left[1 + \left(\frac{dy}{dx}\right)^2\right]^{3/2}}{d^2y/dx^2} = \frac{[1+0]^{3/2}}{-4/25} = -6.25'$$

So $\rho = 6.25'$; $\Sigma F_n = m\dfrac{v^2}{\rho}$: $T_B = \dfrac{1.5}{32.2}\,\dfrac{10^2}{6.25} = \underline{0.745 \text{ lb}}$



▶ **3/243** $\omega_0 = 40(2\pi)/60 = 4.19$ rad/s

$a = 0.1$ m, $b = 0.3$ m



For $\theta = 90°$, $r_0 = 0.1 + 2(0.3)\cos 45° = 0.524$ m

" $\theta = 60°$, $r = 0.1 + 2(0.3)\cos 30° = 0.620$ m

$\Delta H = 0$; $2mr_0^2\omega_0 - 2mr^2\omega = 0$

$\omega = \frac{r_0^2}{r^2}\omega_0 = \left(\frac{0.524}{0.620}\right)^2(4.19)$

$= \underline{3.00 \text{ rad/s}}$

(or $\frac{3.00}{2\pi}60 = 28.6$ rev/min)

$U = \Delta T + \Delta V_g = 2(\frac{1}{2}m)(r^2\omega^2 - r_0^2\omega_0^2) + 2mg\,\Delta h$

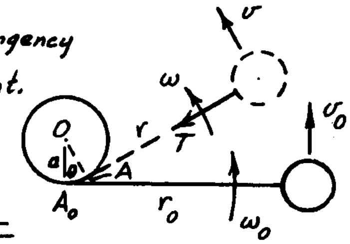
where $\Delta h = 2b(\sin 45° - \sin 30°)$

$= 2(0.3)(0.7071 - 0.5) = 0.1243$ m

$U = 5([0.620 \times 3.00]^2 - [0.524 \times 4.19]^2) + 2(5)(9.81)(0.1243)$

$= -6.850 + 12.190 = \underline{5.34 \text{ J}}$

▶3/244 Moment of tension T about tangency point A is zero, but A is not a fixed point. And moment about fixed point O is not zero. Thus <u>angular momentum is not conserved.</u> Also $\Sigma F \neq 0$ so <u>linear momentum is not conserved.</u>



Energy is conserved so $\frac{1}{2}m(r_0\omega_0)^2 = \frac{1}{2}m(r\omega)^2$.
Thus

$$\omega = \frac{r_0}{r}\omega_0 = \frac{r_0}{r_0 - a\theta}\omega_0 \quad \text{or} \quad \underline{\omega = \frac{\omega_0}{1 - a\theta/r_0}}$$

$\Sigma M_O = \dot{H}_O$: $-Ta = \frac{d}{dt}(mvr) = mv\dot{r}$ since $v = \text{const.}$

But $\dot{r} = \frac{d}{dt}(r_0 - a\theta) = -a\dot{\theta} = -a\omega$

so $T = -\frac{m}{a}v(-a\omega) = mv\omega$

or $\underline{T = mr_0\omega_0\omega}$ since $v = v_0 = r_0\omega_0$