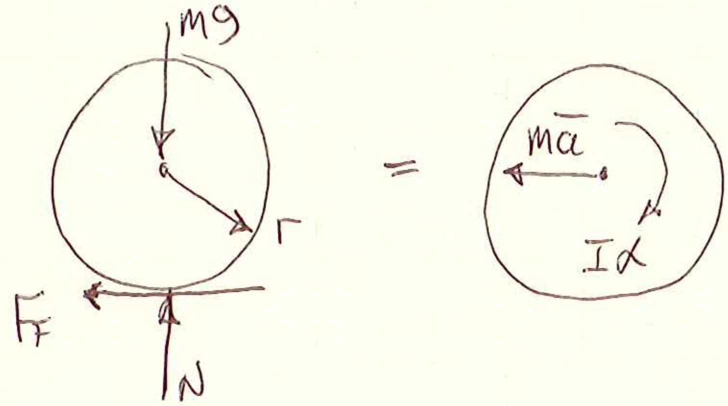
PROB. 16-69

$r = \frac{4}{12} = \frac{1}{3}$ ft, $W = 12$ LB, $\vec{v}_0 = (15)\hat{i}\ \frac{ft}{s}$, $\vec{\omega}_0 = (9)\hat{k}\ \frac{RAD}{s}$,

$\mu_K = 0.1$

FIND TIME t_1 AT WHICH BALL ROLLS WITHOUT SLIDING, SPEED OF BALL AT t_1, DISTANCE TRAVELED AT t_1

KINETICS:



$\Sigma F_x = ma_x$: $-F_F = -m\bar{a}$, $\bar{a} = \frac{F_F}{m} = \frac{\mu m g}{m}$ $\boxed{= \mu g \leftarrow}$

$\Sigma \vec{M}_G = \Sigma (\vec{M}_G)_{EFF}$ $+\circlearrowleft$: $-rF_F = -I\alpha$, $\alpha = \frac{rF_F}{I}$

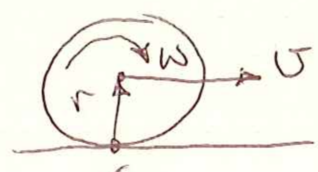
FOR A SPHERE, $I = \frac{2}{5}mr^2$

$$\alpha = \frac{r \cdot \mu m g}{\left(\frac{2}{5} m r^2\right)} \boxed{= \frac{5}{2}\left(\frac{\mu g}{r}\right) \circlearrowright}$$

KINEMATICS:

ASSUMING CONSTANT ACCELERATION, VELOCITY OF G IS

$v = v_0 + at = v_0 - \mu g t$



PROB. 16-69 CONT.

ASSUMING CONSTANT ANGULAR ACCELERATION, THE ANGULAR VELOCITY OF THE BALL IS

$$\omega = \omega_0 + \alpha t = -\omega_0 + \frac{5}{2}\left(\frac{\mu g}{r}\right)t.$$

THE BALL ROLLS WITHOUT SLIDING WHEN $v = r\omega$ OR

$$\omega = \frac{v}{r} = -\omega_0 + \frac{5}{2}\left(\frac{\mu g}{r}\right)t$$

$$\frac{1}{r}\left(v_0 - \mu g t\right) = -\omega_0 + \frac{5}{2}\left(\frac{\mu g}{r}\right)t$$

$$\frac{v_0}{r} - \left(\frac{\mu g}{r}\right)t = -\omega_0 + \frac{5}{2}\left(\frac{\mu g}{r}\right)t$$

$$t\left[\frac{5}{2}\left(\frac{\mu g}{r}\right) + \left(\frac{\mu g}{r}\right)\right] = \frac{v_0}{r} + \omega_0$$

$$t\left[\frac{7}{2}\left(\frac{\mu g}{r}\right)\right] = \left(\frac{v_0 + r\omega_0}{r}\right)$$

$$t = \left(\frac{2}{7}\right)\left(\frac{r}{\mu g}\right)\left(\frac{v_0 + r\omega_0}{r}\right)$$

$$t = \frac{2}{7} \cdot \frac{(v_0 + r\omega_0)}{\mu g}$$

$$t = \frac{2}{7} \cdot \frac{\left[\left(15\ \frac{ft}{s}\right) + \left(\frac{1}{3}\ ft\right)\left(9\ \frac{RAD}{s}\right)\right]}{(0.1)\left(32.2\ \frac{ft}{s^2}\right)} \boxed{= 1.597\ s}$$

$$v = r\omega = r\left[-\omega_0 + \frac{5}{2}\left(\frac{\mu g}{r}\right)t\right]$$

PROB. 16-69 CONT.

$$v = \left(\frac{1}{3}ft\right)\left\{-\left(9\frac{RAD}{s}\right) + \frac{5}{2}\cdot\left[\frac{(0.1)\left(32.2\frac{ft}{s^2}\right)}{\left(\frac{1}{3}ft\right)}\right]\cdot\left(1.597^s\right)\right\}$$

$$\boxed{v = 9.857\frac{ft}{s}}$$

$$X - X_0 = v_0 t + \frac{1}{2}at^2 = v_0 t - \frac{1}{2}\mu g t^2$$

$$\Delta X = \left(15\frac{ft}{s}\right)\left(1.597^s\right) - \frac{1}{2}(0.1)\left(32.2\frac{ft}{s^2}\right)\left(1.597^s\right)^2$$

$$\boxed{\Delta X = 19.85^{ft}}$$

TOPS. 35500