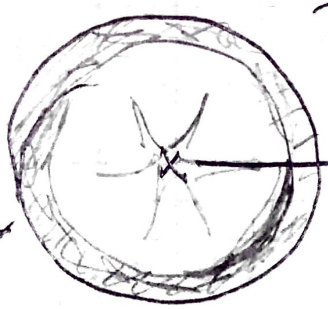
11.19

Tire (rolling)



Supposed to be a tire. ↗

$V_{cm} = 90.0\,\frac{km}{hr} \times \frac{1\,hr}{3600\,s} \times \frac{10^3\,m}{1\,km}$

$V_{cm} = 25.0\ m/s$

The $v_{cm} = v_{tangential}$ of wheel (if not slipping)

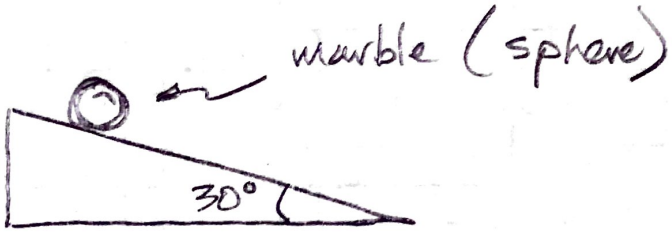
So....

$v = r\omega \rightarrow \omega = \frac{v}{r} = \frac{25.0\ m/s}{0.75\ m} = \frac{0.75/2}{}$

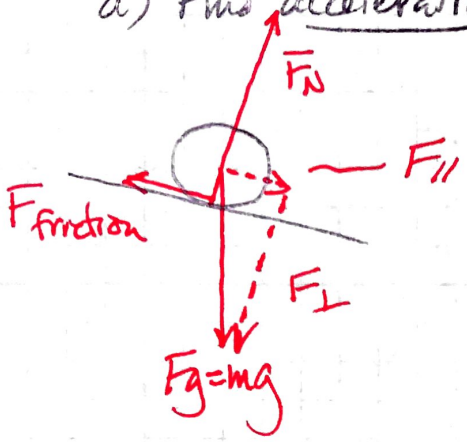
$= 33.3\ rad/s$ ~~oops. This diameter. Not radius!~~ $66.7\ rad/s$

This is critical feature of rolling motion!

11.23



a) Find acceleration, so I'll try a force analysis.



$$\Sigma F_x = ma_x$$
$$F_{||} - F_f = ma$$
$$mg\sin\theta - F_f = ma$$

F_f here $\neq \mu F_N$! Why? When we calculate $F_f = \mu F_N$ for static (non-sliding) friction, it's a theoretical maximum value. It's not how much static friction is actually acting!

Need to use a Torque analysis instead.

$$\Sigma\tau = I\alpha$$
$$R \times F_f = \left(\tfrac{2}{5}MR^2\right)\frac{a}{R}$$
$$F_f = \tfrac{2}{5}Ma$$

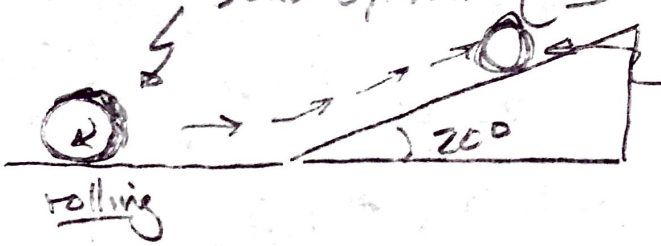
Now, sub & solve!

$$mg\sin\theta - \tfrac{2}{5}ma = ma$$
$$g\sin\theta = \tfrac{7}{5}a$$
$$a = \boxed{\tfrac{5}{7}g\sin\theta} = 3.50\ m/s^2$$

b) How far does it go in 3.0s?

$$\Delta x = v_i t + \tfrac{1}{2}at^2$$
$$\Delta x = 0 + \tfrac{1}{2}\left(\tfrac{5}{7}g\sin\theta\right)t^2$$
$$= \tfrac{5}{14}(9.8)(\sin 30)(3.0)^2$$
$$= \boxed{15.8\ m}$$

11.31 Solid cylinder ($I = \frac{1}{2}MR^2$)



How far up the incline does it travel?

I'm going to do an Energy analysis here.

$$U_{gi} + K_i = U_{gf} + K_f$$

$$0 + \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = mgh + 0 + 0$$

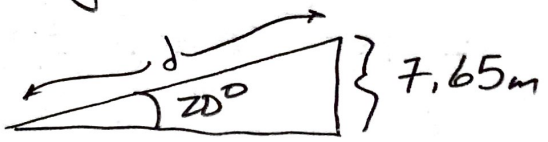
$$\frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{1}{2}mR^2\right)\left(\frac{v}{r}\right)^2 = mgh$$

$$\frac{1}{2}mv^2 + \frac{1}{4}mv^2 = mgh$$

$$h = \frac{\frac{3}{4}v^2}{g} = \frac{\frac{3}{4}(10)^2}{9.8} = 7.65\text{ m high}$$

Wow. Seems kind of high.

But they actually want to know how far up the ramp it goes.



$d = ?$

$\sin\theta = \frac{opp}{hyp}$, so $d = \frac{7.65}{\sin 20} = \boxed{22.4\text{ m}}$?!