Q.1

a) number of radians a spinning object traverses in 1 second

b) how much the angular velocity changes in 1 second

c) curved distance (in meters) covered in 1 second

d) The amount the tangential velocity changes in direction.

Points towards the center

e) how much the tangential velocity changes in 1 second

f) The thing that makes something rotate

g) a measure of how hard it is to stop something rotating

Q.2

a) Yes. It tells us that ω changes by 4000 rev/min every second. Just like we could say 5 km/h /second.

b) max ω is 20000 revs /min. We want rad/s

$$20000 \frac{\cancel{revs}}{\cancel{min}} \times \frac{1\cancel{min}}{60\,sec} \times \frac{2\pi\,rad}{\cancel{rev}}$$

c) $$\frac{4000\ revs/min}{sec} = \frac{\frac{4000\,rev}{min} \times \frac{1min}{60sec} \times \frac{2\pi\,rad}{rev}}{1\ sec}$$

d) Number of revolutions = $\frac{\Delta\theta}{2\pi}$

$\Delta\theta = \theta_0 + \omega_i t + \frac{1}{2}\alpha t^2 = \frac{1}{2}\alpha t^2$ $\quad$ α from part c

$t=5$

e) $v = r\omega$

what is ω?

$\omega = \omega_0 + \alpha t = 0 + \alpha(t)$ α from (c)
$t = 4$

$v = r\omega$

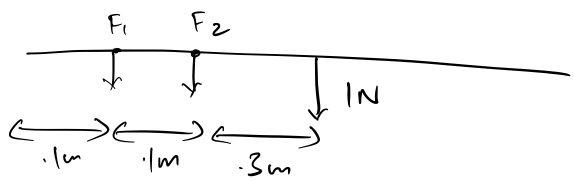
g) is like (d)

Q.3

If you thought one force goes up and one goes down, great.

It doesn't matter if you didn't.

* Static equilibrium, so $\Sigma\tau = 0$



→ Take pivot at F_1 to eliminate F_1

$\tau_{F_2} = -0.1 F_2$ $\tau_g = -0.4(1)$ negative because clockwise

$\Sigma\tau = -0.1F_2 - 0.4 = 0$

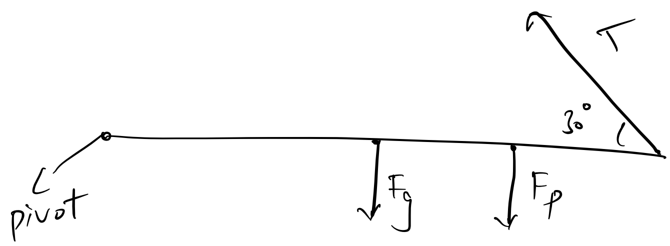
$F_2 = -4$ → negative so it points upwards.

we initially took it pointing downward and got a negative answer. So it points up.

→ Take pivot at F_2 and you get $F_2 = 3N$ downward.

→ For F_2 you can also use $\Sigma F = ma$ because you can deal with rotation and translation separately.

Q.4



→ lets see what T we need to keep it still.

$\Sigma \tau = 0$

$\tau_{F_g} = -1450\, g \cdot 3m$ (clockwise)

$\tau_{F_p} = -80\, g \cdot 3.2m$

$\tau_T = T \sin 30 \cdot 6m$

$\Sigma \tau = T\sin 30 \cdot 6 - 1450 \cdot g \cdot 3 - 80 \cdot g \cdot 3.2 = 0$

→ T turns out to be > 15000, so they better be scared.

Q.5

★ NO external torque/work. Think angular momentum

a) $L_i = L_f$

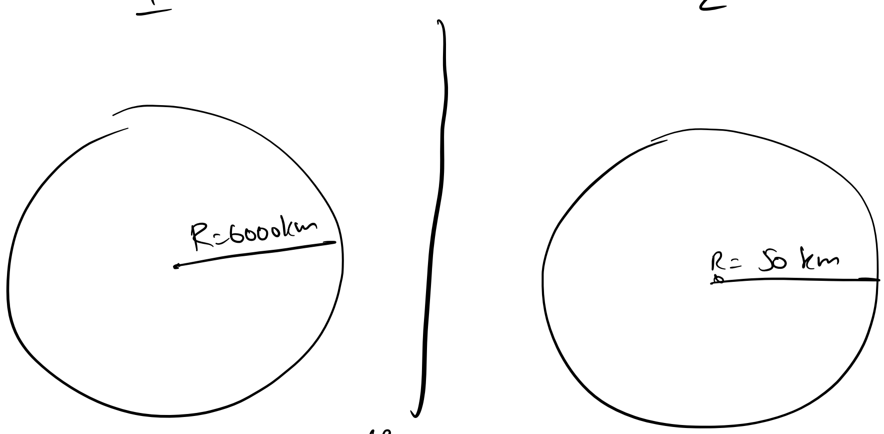
$I_i \omega_i = I_f \omega_f$ $\qquad I = \frac{2}{5} mR^2$

If R decreases, I decreases.

If I decreases, ω has to increase to keep L the same

b)

1 $\qquad\qquad$ 2



L_1 $\qquad$ Always use meters ↗ $\qquad\qquad$ L_2

$I_1 = \frac{2}{5} m(6000{,}000)^2$ $\qquad\qquad$ $I_2 = \frac{2}{5} m(50{,}000)^2$

$\omega_1 = ?$ $\qquad\qquad$ $\omega_2 = \frac{2\pi \text{ rad}}{s}$ (Once every second)

$\rightarrow L_1$ has to be equal to L_2.

$$L_1 = L_2$$

$$I_1 \omega_1 = I_2 \omega_2$$

$$\frac{2}{5} m (6000{,}000)^2 \omega_1 = \frac{2}{5} m (50{,}000)^2 (2\pi)$$

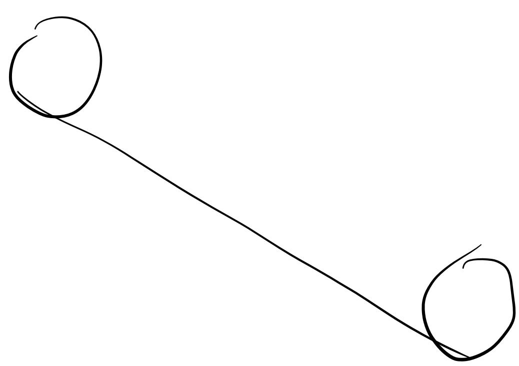
we can find ω_1

Q.6

Step 1 $\rightarrow$ hard question. lets see whats going on. two things are going down a slope. one is rolling without slipping. one is just sliding. what does the coefficient of friction have to be for their translational velocities to be the same at the bottom. does the coefficient of friction affect the velocity of the rolling ball? no it doesnt. we can easily find what its velocity should be.

Step 2 $\rightarrow$ then, using the work energy theorem, we can see what the coefficient of friction between the ice and the surface is in terms of its final velocity. plug in the ball's velocity for v and solve for mu.

Step 1



$$W = \Delta KE$$

$$mgh = \Delta KE = KE_f - \cancel{KE_i}^{\,0}$$

$$mgh = KE_{rotational} + KE_{translational}.$$

$$mgh = \frac{1}{2} I \omega^2 + \frac{1}{2} m v^2$$

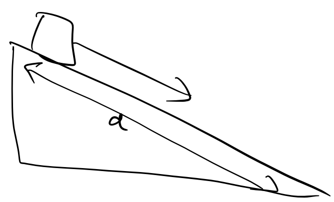
$v = r\omega$ because rolling without slipping

$\omega = \frac{v}{r}$

$$\cancel{m}gh = \frac{1}{\cancel{2}}\left(\frac{\cancel{2}}{3}\cancel{m}\cancel{r^2}\right)\left(\frac{v^2}{\cancel{r^2}}\right) + \frac{1}{2}\cancel{m}v^2$$

$$V_{ice} = \sqrt{\frac{6gh}{5}}$$ } This is V_{trans} for the basketball.

Lets see what v is for the ice



$W = \Delta KE$

$W_g + W_f = KE_f$

$\cancel{m}gh - \mu \cancel{m}g\cos\theta \cdot d = \frac{1}{2}\cancel{m}v^2$

W_f is negative because friction is slowing it down.

$$V_{ice} = \sqrt{2gh - 2\mu g\cos\theta \cdot d}$$

We want $V_{ice} = V_{ball}$

$$\cancel{\sqrt{\ }}\ 2gh - 2\mu g\cos\theta \cdot d = \cancel{\sqrt{\ }}\ \frac{6}{5}gh$$

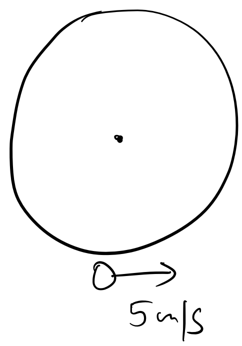
$$2\cancel{g}h = 5\mu\cancel{g}\cos\theta \cdot d$$

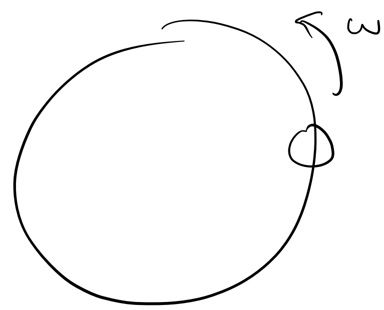
$$\mu = \frac{2}{5}\,\frac{h}{d}\,\frac{1}{\cos\theta} \xrightarrow{\frac{h}{d} = \sin\theta} \boxed{\frac{2}{5}\tan\theta}$$

Q.7

★ NO external torque/work. Think angular momentum

a) 1 | 2





$L_1 = L_{1_c} + L_{1_m}$

child / merry go round

$= I_c \omega_{c_1} + I_M \omega_{m_1}$

$\omega_{m_1} = 0$

$= I_c \omega_{c_1}$

$\omega = \frac{v}{r}$

$= m_c r^2 \left(\frac{v}{r}\right)$

$= m_c r v$

$= 40(3)(5)$

$L_2 = L_{2c} + L_{2m}$

$= I_c \omega_{c_2} + I_m \omega_{m_2}$

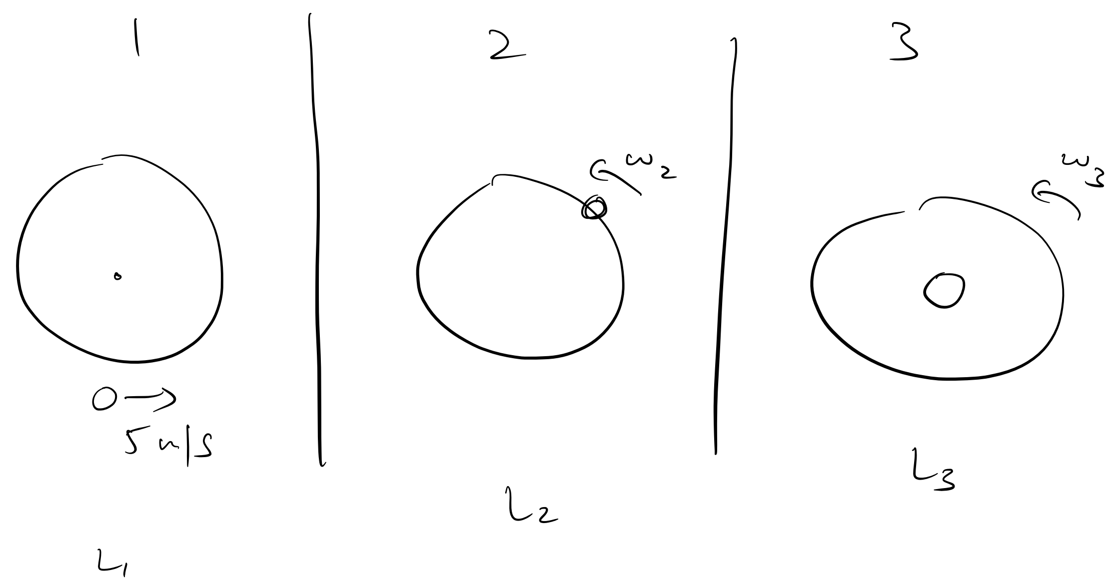
$\omega_{c_2} = \omega_{m_2}$

$= m_c r^2 \omega_2 + \frac{1}{2} m_m r^2 \omega_2$ (They are spinning together)

$= \omega_2 (3)^2 \left(40 + \frac{1}{2}(200)\right)$

Set $L_1 = L_2$ and find ω_2

b)



$L_1 = L_2 = L_3$ because L is always conserved.

$$L_3 = I_c\,\omega_3 + I_m\,\omega_3$$

$$= 0 + \frac{1}{2} MR^2 \omega_3$$

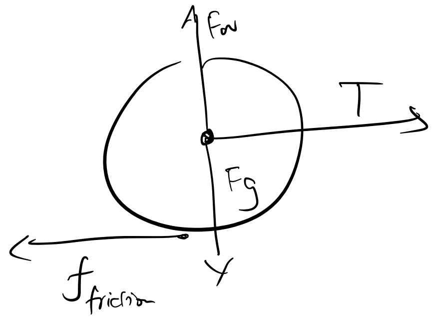
I_c is now 0 because the kid is standing at the center.

Set L_3 equal to either L_1 or L_2 and find ω_3.

Q.8

→ Combination of rotational and translational dynamics.

→ Use $\Sigma F = ma$ AND $\Sigma \tau = I\alpha$.



→ Center of wheel is our pivot.

→ Only f creates a torque about the center.

$$\Sigma F_x = ma_x$$

$$T - f = ma_x$$

$$T - \frac{ma}{2} = ma$$

$$a = \frac{2T}{3m}$$

$$\Sigma \tau = I\alpha$$

$$f \cdot R = \frac{1}{2} MR^2 \alpha$$

$$\alpha = \frac{a}{r} \quad \text{(rolling constraint)}$$

$$f\cancel{R} = \frac{1}{2} MR^{\cancel{2}} \left(\frac{a}{\cancel{R}}\right)$$

$$f = \frac{Ma}{2}$$

$$f = \frac{T}{3}$$

$$\boxed{\text{Note that } f \neq \mu F_N \text{ because that only tells you the max value of static friction}}$$