Problem Set #5 due beginning of class, Monday, Oct. 16. *Solutions*

1) Please redo your midterm showing work, but not providing way too much information. Hopefully, the solutions were helpful
2) Section 4.0 Exercise 1, collision of rotating bodies. NOTE!!!: The grader made a mistake here… as did most of the students. Angular momentum is a VECTOR. You must treat it as one. Because the two discs are spinning in *opposite* directions, the total angular momentum is less than that of disk A… just like you would subtract the momentum of two bodies having a linear collision. Omega_f = Omega_B, and you lose 80% of the original kinetic energy to thermal energy.

A 2) (4.0, #1) Two identical disks ("A" and "B") are spinning in opp. directions in space, $\omega_A = 3\omega_B$.

I would use an angular momentum lens since I'm comparing their angular momentums. $\vec{l}_A = I\vec{\omega}$. For disk A, it would be $l_A = I_A \omega_A$, and for B it's, $\vec{l}_B = I_B \vec{\omega}_B = I_B(\frac{1}{3}\omega_A)$. Since this disks are identical, $I_A = I_B$. So, $\vec{l}_B = \frac{1}{3}\vec{l}_A$ … $\boxed{\vec{l}_A = 3\vec{l}_B}$

For their kinetic energies, I would use a rotational kinetic energy lens since I'm dealing with their transfers of energy. $E_K = \frac{1}{2}I\vec{\omega}^2$. $I_A = I_B = I$

$E_{K(A)} = \frac{1}{2}I_A\vec{\omega}_A^2 = \frac{1}{2}I(3\vec{\omega}_B)^2$ $\quad E_{K(B)} = \frac{1}{2}I_B\vec{\omega}_B^2 = \frac{1}{2}I\vec{\omega}_B^2$

$E_{K(A)} = 9(\frac{1}{2}I\vec{\omega}_B)$ $\quad E_{K(B)} = \frac{1}{2}I\vec{\omega}_B^2$

$\boxed{E_{K(A)} = 9E_{K(B)}}$

– The two bodies collide and stick together.
- The linear analogue to these disks colliding would be two carts or blocks colliding.
- I would use an angular momentum lens here since this collision is in an isolated system and therefore momentum is conserved. (No outside forces)

$\vec{l}$ is a vector

$\vec{\omega}_A = -3\vec{\omega}_B$

$\vec{l}_i = \vec{l}_f \rightarrow I_A\vec{\omega}_A + I_B\vec{\omega}_B = (I_A + I_B)\vec{\omega}_f$, $\rightarrow I_A = I_B = I$

$\omega_f = \dfrac{I_A\vec{\omega}_A + I_B\vec{\omega}_B}{I_A + I_B} = \dfrac{I(3\omega_B) + I\omega_B}{2I} = \dfrac{\cancel{4}I\omega_B}{\cancel{2I}} = \cancel{2}\omega_B = \vec{\omega}_B$

$\omega_B = \frac{1}{3}\omega_A \Rightarrow \omega_f = \cancel{2}\omega_B = \cancel{2}(\frac{1}{3}\omega_A) = \boxed{\frac{1}{3}\omega_A = \omega_f}$

- I would use an energy lens here since I see that there's a transformation of energy in this collision.

$\sum E_{Ki} = \sum E_{K(A)} + \sum E_{K(B)}$ $\quad \sum E_{Kf} = \frac{1}{2}I_{A+B}\,\omega_f^2$

$= 9E_{K(B)} + E_{K(B)}$ $\quad = \frac{1}{2}(I_A + I_B)(\frac{1}{3}\omega_A)^2$

$= 10E_{KB}$ $\quad = \frac{1}{2}(2I)(\frac{1}{9}\omega_A^2)$

$= 10(\frac{1}{2}I\vec{\omega}_B^2)$ $\quad = \frac{1}{9}I(3\omega_B)^2$

$= 5I\vec{\omega}_B^2 = 10(\frac{1}{2}I\vec{\omega}_B^2)$ $\quad = \cancel{4}\,I\omega_B^2 = \cancel{2}2(\frac{1}{2}I\omega_B^2)$

$= 10E_{K(B)} = \sum E_{Ki}$ $\longrightarrow$ $= \cancel{2}2E_{K(B)} = \sum E_{Kf}$

80% of the original $E_K \Rightarrow E_{th}$

Is this the same as in an inelastic collision?

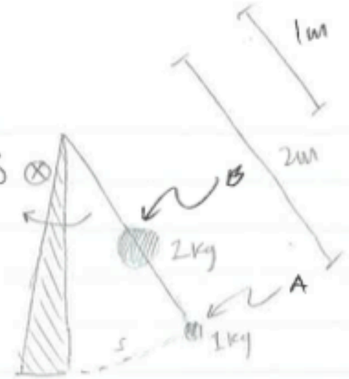
$\boxed{m} \rightarrow v_0 \quad 3v_0 \leftarrow \boxed{m}$

Using E_{KB}, and that $E_{KA} = 9E_{KB}$ I found the initial and final energies of the system. $\sum E_{Ki} = 10E_{KB}$ while $\sum E_{Kf} = 2E_{KB}$. Therefore, we see that an energy equal to $8E_{KB}$ was "lost" to heat due to the collision.

3) Section 4.1 Example 1, Rotation Direction

Well done in notes

4) Section 4.2 Exercise 1, Rotation and kinetic energy. While most students solved this by finding rotational energy of each mass, you could also have just used ½ mv^2 for each mass.



)(4.2, # 1) Rigid rod, driven by motor, rotates about pivot at top of triangular support at $\vec{\omega} = 10\ \text{rad/s}$. The 2m long rod is very light, w/ 1 kg mass @ end and 2 kg mass in the middle of the rod.

a) I would use a rotational kinematics lens for this since I'm analyzing the rod's rotational motion as an explicit function of time.

$$\vec{\omega} : 10\ \frac{\cancel{\text{rad}}}{\cancel{s}} \times \frac{1\ \text{revolution}}{2\pi\ \cancel{\text{rad}}} \times \frac{60\cancel{s}}{1\ \text{min.}} = \boxed{95.493\ \text{rpm}}$$

~~*~~without a calculator

b) I would use a rotational kinematics lens for the same reason. I know that the rod rotates at $\vec{\omega} = 10\ \text{rad/s}$, therefore each mass must also rotate at $\vec{\omega} = 10\ \text{rad/s}$, like any point on the rod, since they all cover the same $\Delta\theta$ in the same Δt. However, mass A must move faster translationally than mass B since mass A covers a larger arc length "s" in the same Δt that mass B covers a smaller s, since $s = r\Delta\theta$,

$$\vec{V} = \frac{ds}{dt} = \frac{r\,d\theta}{dt} = r\vec{\omega} \Rightarrow \begin{aligned} \vec{V}_A &= (2m)(10\ \text{rad/s}) = \boxed{20\ \text{m/s} = \vec{V}_A} \\ \vec{V}_B &= (1m)(10\ \text{rad/s}) = \boxed{10\ \text{m/s} = \vec{V}_B} \end{aligned}$$

c) I would use a rotational kinetic energy lens for this since I'm find the E_K of each mass ⇒ there's energy transformation

We know $E_{RK} = \frac{1}{2} I \omega^2$ and $I = mr^2$, But you could also just use $E_K = \frac{1}{2}mv^2$

$$\begin{aligned} E_{RK(A)} &: \tfrac{1}{2} I_A (\omega_A)^2 \\ &= \tfrac{1}{2} m_a (r_A)^2 (\omega_A)^2 \\ &= \tfrac{1}{2}(1\,kg)(2m)^2(10\ \text{rad/s})^2 \\ &= 200\ kg\ \text{m}^2/\text{s}^2 = \boxed{200\,J} \end{aligned} \qquad \begin{aligned} E_{RK(B)} &= \tfrac{1}{2} I_B (\omega_B)^2 \\ &= \tfrac{1}{2} m_B (r_B)^2 (\omega_B)^2 \\ &= \tfrac{1}{2}(2kg)(1\,m)^2(10\ \text{rad/s})^2 \\ &= 100\ kg \cdot \text{m}^2/\text{s}^2 = \boxed{100\ J} \end{aligned}$$

d) I use a rotational kinetic energy lens here for the same reason.

$$\begin{aligned} \Sigma E_K = \Sigma E_{KR} &= E_{RK(A)} + E_{RK(B)} \\ &= 200\ J + 100\ J \\ &= \boxed{300\ J} \end{aligned}$$

5) Section 4.2 Exercise 2 Rotation and linear speed

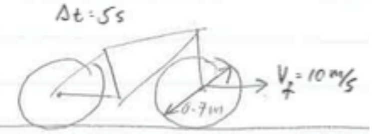
$\odot$ $\otimes$

$(\cdot) \longleftarrow \quad \longrightarrow (+)$

(diameter = 0.700 m) $V_0 = 0\ m/s$

$\Delta t = 5s$

) (4.2, #2) Riding on bike with 700 mm wheels. Starting @ rest, you smoothly accelerate in $\Delta t = 5s$, to a speed $V = +10\ m/s$ (right).



a) I use a kinematics lens since I'm analyzing translational motion over time. I would need a translational acceleration of $\vec{a} = \frac{\Delta \vec{v}}{\Delta t} = \frac{10\ m/s}{5s} = 2\ m/s^2$, which is possible on level ground.

b) I use a rotational kinematics lens since I'm analyzing rotational motion as an explicit f(t). I know that arc length $s = r\Delta\theta$. So therefore, $\vec{\omega}$ would be $\vec{V} = \frac{\Delta S}{\Delta t} = \frac{r\,\Delta\vec{\theta}}{\Delta t} \rightarrow \vec{\omega} = r\vec{\omega} \Rightarrow \vec{\omega} = \frac{\vec{V}}{r} = \frac{10\ m/s}{\frac{1}{2}(0.7m)} = \boxed{28.57\ rad/s}$

According to the right-hand rule, the direction is $\otimes$. (+)

c) I use a rotational kinematics lens here for the same reason as (b) and (a). We know $\vec{\omega} = \frac{\Delta\vec{\theta}}{\Delta t}$, so

$\vec{\alpha} = \frac{\Delta\vec{\omega}}{\Delta t} = \frac{28.57\ rad/s}{5\ s} = \boxed{5.71\ rad/s^2}$ (constant)

d) I use a kinematics lens here for the same reason as (a), (b), and (c). We know $\vec{\omega} = \frac{\Delta\vec{\theta}}{\Delta t}$, so

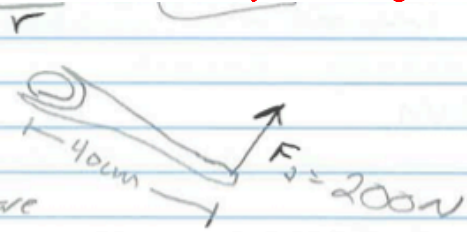
$\Delta\vec{\theta} = \omega_{avg}\Delta t = \left(\frac{28.57\ rad/s}{2}\right)(5s) = \boxed{71.43\ rad}$

average! ~~this is the ω_f oh nevermind...~~ great

I use the average $\vec{\omega}$ since the bike starts at rest

6) Section 4.3 Exercise 2, The student below used lovely estimating in my opinion.

(6) 4.3 Ex) 2



a) First, dynamics lens b/c there are τ's and α's

$\tau = F \cdot r = 200N \cdot .4m = \boxed{80\,Nm}$

Now, energy lens, b/c work is done on the nut as it turns

$W = \tau \cdot \Delta\theta = 80Nm \cdot 2\pi \approx \boxed{500\,J}$

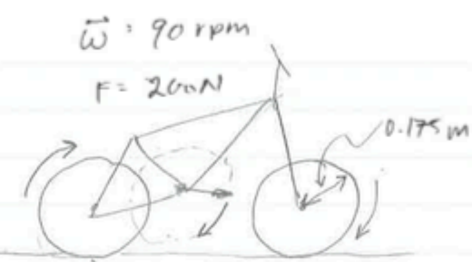
b) This energy was converted to heat through friction.

c) $P = \frac{W}{\Delta t} = \frac{500J}{2s} = \boxed{250\,W}$

great!

7) Section 4.3 Exercise 4

arc length = S



7) (4.3, #4) You're bicycle. You're able to push the pedal w F = 200 N and radius of crank shaft (arm) is r = 175 mm = 0.175 m. Can spin legs @ 90 rpm.

- I use a rotational dynamics lens since I see torque causing angular acceleration, then an energy lens since I want to find power, the rate of change of energy.

$\tau = r F_\perp$

$= (0.175\,m)(200\,N) =$

$= \boxed{35\,Nm}$

$90 \frac{\cancel{rev}}{min} \cdot \frac{2\pi\ rad}{1\ \cancel{rev}} \cdot \frac{1\ \cancel{min}}{60\ sec} = 9.42\ rad/s = \vec{\omega}$

$P = \frac{\Delta E}{\Delta t} = \frac{W}{\Delta t} = \frac{\tau\,\Delta\theta}{\Delta t} \rightarrow \vec{\omega} = \tau\,\Delta\vec{\omega} = (35\,N\cdot m)(9.42\ rad/s)$

$= \boxed{329.87\,W}$ $\approx 330\,W$

- I use rotational kinematics since I'm analyzing rotational motion as an explicit f(t). We know $S = r\Delta\theta$, so

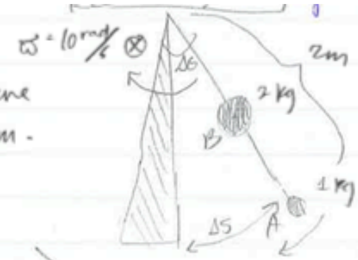
$\vec{V} = \frac{\Delta S}{\Delta t} = \frac{r\Delta\theta}{\Delta t} = r\vec{\omega} = (0.175m)(9.42\ rad/s) = \boxed{1.649\ m/s}$

$P = \frac{\Delta E}{\Delta t} = \frac{F \cdot \Delta x}{\Delta t} \rightarrow \vec{v} = F \cdot \vec{v} = (200\,N)(1.649\ m/s) = \boxed{329.87\ W}$ $\approx 330\,W$

great!

8) Section 4.4 Exercise 2

8)(4A, #2)



a) We know moment of inertia $I = mr^2$, where "r" is the length of the moment arm.

$I_A = m_A r^2 = (1\ kg)(2m)^2 = \boxed{4\ kg \cdot m^2}$

$I_B = m_B r^2 = (2\ kg)(1\ m)^2 = \boxed{2\ kg \cdot m^2}$

(not sure what lens to use here)

b) I use a rotational E_K lens here since I'm finding the total energy of the structure. We know $E_{RK} = \frac{1}{2} I\omega^2$

$\Sigma E = E_{RK(A)} + E_{RK(B)}$ $\quad \vec{V} = \frac{\Delta s}{\Delta t} = \frac{r\Delta\theta}{\Delta t} = r\vec{\omega}$

$= \frac{1}{2} I_A (\omega_A)^2 + \frac{1}{2} I_B (\omega_B)^2$ $\quad \vec{\omega}_A = \vec{\omega}_B = 10\ rad/s$

$= \frac{1}{2}\left[(4\ kg \cdot m^2)(10\ rad/s)^2 + (2\ kg \cdot m^2)(10\ rad/s)^2\right]$

$= \frac{1}{2}\left(400\ kg \cdot m^2 \cdot rad^2/s^2 + 200\ kg\,m^2 \cdot rad^2/s^2\right)$

$= \frac{1}{2}\left(600\ kg\ m^2/s^2\right) = \boxed{300\ J}$

c) Yes, this answer agrees w sec. 4.2 #1

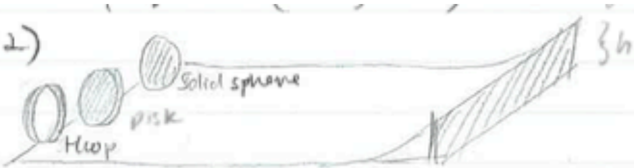
d) I prefer this method of finding E_R; it's more organized and you go thru every step to get to ΣE_{RK}.

9) Section 4.5 Exercise 1

You can look up the exact coefficients in the text. The key is that for the same radius, shapes that have the mass further from the center will have a higher coefficient… the highest will be the hoop, and the lowest will be the solid sphere… but the discus I had you do for 11 below, is likely lower still because the mass is localized much more near smaller radii.

10) Section 4.5 Exercise 2

10) (4.5, #2)



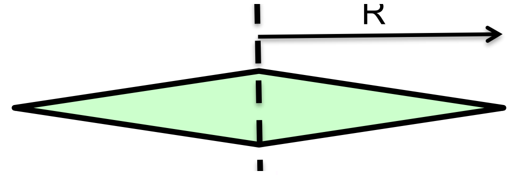
$I_{solid\ sphere} = \frac{2}{5} mr^2$

$I_{disk} = \frac{1}{2} mr^2$

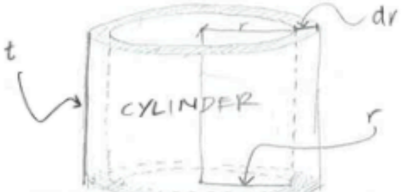
$I_{Hoop} = mr^2$

I use a rotational dynamics lens since I see that torques are causing rotational acceleration. We know that moment of inertia is a measure of how hard it is to rotationally accelerate a body; the more I a body has, the harder it is to apply an angular acceleration on it. Because the hoop has the highest I, it will go further up the hill than the others because it's harder for the force of gravity, and therefore friction to apply an angular acceleration (negative) to slow the disk down. great! I would use Energy lens to get the same answer! Can you try that too?

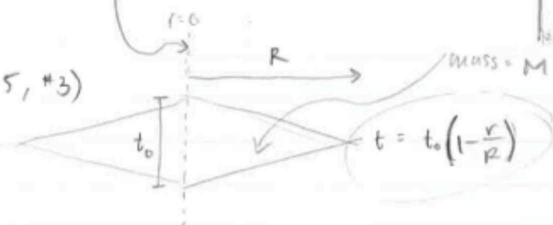
11) Read Section 4.5, exercise 3 and do the following:



"AoS" = Axis of Rotation



11) (4.5, #3)



mass = M

$t = t_0\left(1-\frac{r}{R}\right)$

$V = 2\pi r t$

$dV = 2\pi r\,dr\,(t)$

$dV = 2\pi r\,dr\,(t_0)\left(1-\frac{r}{R}\right)$

(a) To estimate the moment of inertia I of the discus, I must first analyze how the mass is distributed. Compared to a disk, it definitely has less I since a lot of the discus mass seems to be concentrated near the AoS. It's also less than a solid/hollow sphere since mass is more spread out in spheres. I would estimate $I_{discus} < I_{\text{solid sphere}} = \frac{2}{5}mr^2$.

(b) Exact moment of inertia. $I = mr^2$

To find volume, integrate using cylinders

$dV = 2\pi r\,dr\,(t)$

$$\text{Volume} = \int_{r=0}^{r=R} dV = \int_0^R 2\pi r\,dr\,(t_0)\left(1-\frac{r}{R}\right) = 2\pi t_0 \int_0^R r\left(1-\frac{r}{R}\right)dr$$

$$= 2\pi t_0 \int_0^R \left(r\,dr - \frac{r^2}{R}dr\right) = 2\pi t_0\left(\frac{r^2}{2} - \frac{r^3}{3R}\Big]_0^R\right)$$

$$= 2\pi t_0\left[\left(\frac{R^2}{2} - \frac{R^{\cancel{3}2}}{3\cancel{R}}\right) - \left(\frac{0^2}{2} - \frac{0^3}{3R}\right)\right] = 2\pi t_0\left(\frac{R^2}{2} - \frac{R^2}{3}\right)$$

$$= \cancel{2}\pi t_0\left(\frac{R^2}{\cancel{6}3}\right) = \frac{1}{3}\pi t_0 R^2 = V_{discus}$$

$$\rho = \frac{M}{V} = \frac{M}{\frac{1}{3}\pi t_0 R^2} = \frac{3M}{\pi t_0 R^2}$$

constant

$M = \rho V$

$dM = \rho\,dV$

$(t_0)\left(1-\frac{r}{R}\right)$

integrate over mass

$$I = mR^2,\quad dI = dm\,R^2 = \rho\,dV\,r^2 = \rho(2\pi r\,dr(t))\,r^2 = \rho 2\pi r^3 dr(t)$$

$$I = \int_0^R dI = \int_0^R \rho 2\pi r^3 dr\,(t_0)\left(1-\frac{r}{R}\right) = 2\pi\rho t_0 \int_0^R \left(1-\frac{r}{R}\right) r^3 dr$$

$$= 2\pi\rho t_0 \int_0^R \left(r^3 dr - \frac{r^4}{R}dr\right) = 2\pi\rho t_0\left[\left(\frac{r^4}{4} - \frac{r^5}{5R}\right)\Big]_0^R\right]$$

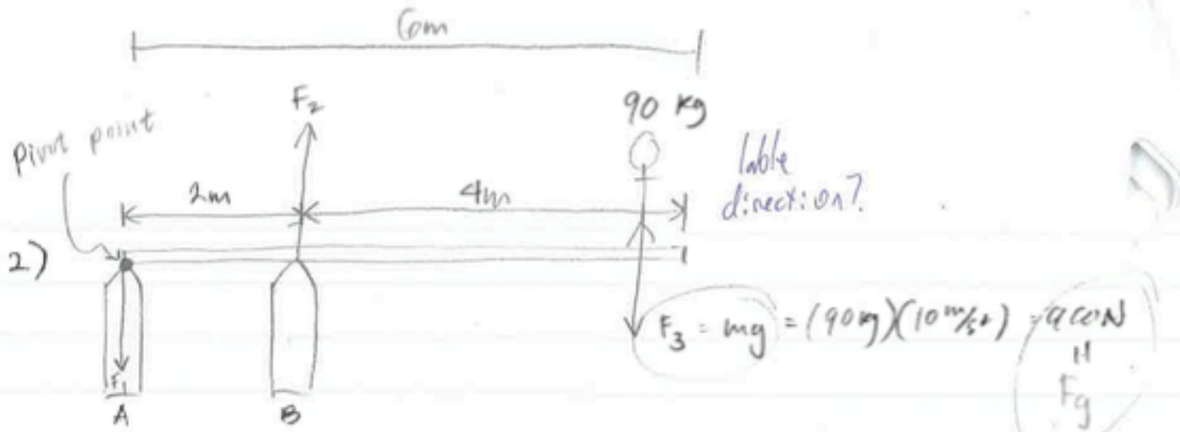
$$= 2\pi\rho t_0\left(\frac{R^4}{4} - \frac{R^{\cancel{5}4}}{5\cancel{R}} - \frac{0^4}{4} + \frac{0^5}{5R}\right) = 2\pi\rho t_0\left(\frac{R^4}{20}\right) = \frac{1}{10}\pi\rho t_0 R^4$$

$$= \frac{1}{10}\pi\left(\frac{3M}{\pi \cancel{t_0} R^2}\right)\cancel{t_0} R^{\cancel{4}2} = \boxed{\frac{3}{10}MR^2 = I_{discus}}$$

You can also see my solution at
http://sharedcurriculum.wikispaces.com/file/view/PS7_SUS_W15_Q5%20solution.jpg/542965166/PS7_SUS_W15_Q5%20solution.jpg

12) Section 4.6 Exercise 2

2) (4.6, #2)



I use a (and rotational) dynamics lens for this since I see that there are forces (and torque) here that cause (and angular) acceleration, or lack thereof, making this a statics problem. $\sum \vec{F} = m\vec{a} = 0$, $\sum \vec{\tau} = r\vec{F}_{\perp} = 0$

$$\sum \vec{F} = \vec{F}_2 - (\vec{F}_1 + \vec{F}_3) = 0 \qquad \sum \vec{\tau} = \sum r\vec{F}_{\perp} = 0$$

$$\vec{F}_2 - \vec{F}_1 - m\vec{g} = 0 \qquad = \tau_2 - \tau_1 - \tau_3 = 0$$

$$\vec{F}_2 - m\vec{g} = \vec{F}_1 \qquad = (2m)F_2 - (0m)F_1 - (6m)mg = 0$$

$$2700N - 900N = \vec{F}_1 \qquad (2m)F_2 = (6m)(900\,N)$$

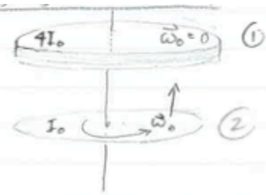
$$F_1 = 1800N \qquad F_2 = (900N)(3) = 2700\,N$$

$$\sum \vec{F} = F_2 - F_1 - F_3 = 2700\,N - 1800N - 900N = 0N \quad \sum\tau = 0?$$

$$\boxed{F_1 = -1800N,\ F_2 = 2700N,\ F_3 = -900N}$$

13) Section 4.7 Exercise 1

13) (4.7 # 1) The base of turntable rotates freely at ω_0 on very good bearing when 4 disks are dropped on it.



a) I use an angular momentum (ℓ) lens for this since I see ℓ transferred in this collision and there's no outside forces. We know $\vec{\ell} = I\vec{\omega}$ and

$$\vec{\ell}_i = \vec{\ell}_f \Rightarrow I_1\vec{\omega}_1 + I_2\vec{\omega}_2 = (I_1 + I_2)\vec{\omega}_f$$

$$(4I_0)(0\ \text{m/s}) + (I_0)\vec{\omega}_0 = (4I_0 + I_0)\vec{\omega}_f$$

$$\vec{\omega}_f = \frac{\cancel{I_0}\vec{\omega}_0}{5\cancel{I_0}} = \boxed{\frac{1}{5}\omega_0 = \omega_f}$$

b) I use a rotational kinetic energy lens for this since I want to see if / how much E_{RK} was "lost". $\Rightarrow E_{Ri} = E_{Rf} = E_{RKf} + E_{th}$

$E_{Ri} = \frac{1}{2}I_1\omega_1^2 + \frac{1}{2}I_2\omega_2^2$
$= \frac{1}{2}(4I_0(0\ \text{m/s})^2 + I_0\omega_0^2)$
$= \frac{1}{2}I_0\omega_0^2 = E_{Ri}$

$E_{Rf} = \frac{1}{2}I_{1+2}\,\omega_f^2$
$= \frac{1}{2}(4I_0 + I_0)(\frac{1}{5}\omega_0)^2$
$= \frac{5}{2}I_0 \cdot \frac{1}{25}\omega_0^2 = \frac{1}{5}(\frac{1}{2}I_0\omega_0^2) = \boxed{\frac{1}{5}E_{Ri} = E_{Rf}}$

We see that $E_{Rf} = \frac{1}{5}E_{Ri}$, meaning that $\frac{4}{5}E_i$ was converted to E_{th}, or heat, into the surroundings.

lost 80% of E_K

$$\omega_f = \frac{1}{5}\omega_0$$

c) I use an angular momentum lens since I'm analyzing the angular impulse on each body ($\Delta\vec{\ell}$). We know $\Delta\vec{\ell} = I\Delta\vec{\omega}$.

$$\Delta\vec{\ell}_1 = \vec{\ell}_f - \vec{\ell}_i = (4I_0)(\tfrac{1}{5}\omega_0) = \boxed{\tfrac{4}{5}I_0\,\omega_0 = \Delta\ell_1}$$

$$\Delta\vec{\ell}_2 = \vec{\ell}_f - \vec{\ell}_i = (I_0)(\tfrac{1}{5}\omega_0) - (I_0)(\omega_0) = \boxed{-\tfrac{4}{5}I_0\,\omega_0 = \Delta\ell_2}$$

d) —

The surfaces rub against each other.

14) Section 4.7 Exercise 2 In this situation, we are conserving momentum, true, but its *angular* momentum that this problem is about. It seems that we should also conserve energy because there is no work done from the outside… but can work be done from the *inside?...* the answer is certainly "yes!"… think about an explosion that blows two particles apart. There's no outside force, but there can be lots of work done on each particle.

14) 4.7 Ex) 2

a) - Momentum is conserved b/c there are no outside forces.

- Energy is always conserved, but KE would also be conserved here b/c there is no loss to heat. maybe!

- Kinematics, $\vec{v}$ stays the same, so $\vec{\omega}$ would increase since the radius decreases.

- There are no outside force. The only force is that of the motor pulling the mass's inward.

b) $I = mr^2$, $r = \frac{1}{3}r_0$, so $\boxed{I_F = \frac{1}{9} I_0}$

c) $L_0 = L_F$; Momentum cons

$I_0 \vec{\omega}_0 = I_F \vec{\omega}_F$; $I_F = \frac{1}{9} I_0$

$\cancel{I_0} \vec{\omega}_0 = \frac{1}{9} \cancel{I_0} \vec{\omega}_F$

$\vec{\omega}_0 = \frac{1}{9} \vec{\omega}_F$, $\boxed{\vec{\omega}_F = 9\vec{\omega}_0}$

d) Energy cons, there is KE_{rot}

$KE_0 = \frac{1}{2} I_0 \vec{\omega}_0^2$ $\quad \frac{1}{2} I_0 \vec{\omega}_0^2$; $\frac{1}{2}(\frac{1}{9} I_0)(9\vec{\omega}_0)^2$

$KE_F = \frac{1}{2} I_F \vec{\omega}_F^2$ $\quad \frac{1}{2} I_0 \vec{\omega}_0^2$; $\frac{1}{2}(9) I_0 \omega_0^2$

$\boxed{KE_F = 9 KE_0}$ I guess KE is not conserved

yes!

e) Energy cons

$\frac{1}{2} I_0 \vec{\omega}_0^2 = \frac{1}{2}(\frac{1}{9} I_0)(\vec{\omega}_F)^2$

$\frac{1}{2} I_0 \vec{\omega}_0^2 = \frac{1}{18}(I_0)(\vec{\omega}_F)^2$ so $\boxed{\vec{\omega}_F = \sqrt{2}\,\vec{\omega}_0}$

f) Yes, momentum cons

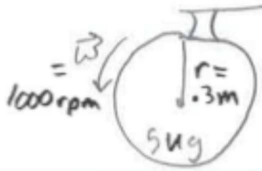
$\boxed{L_F = \frac{\sqrt{2}}{9} L_0}$

g) I think that L is conserved and KE_{rot} is not, because work must be done in order to move the masses inward. yes!

15) You have an ax to grind, and you decide to grind it on the outer rim of a round 5 kg stone grinding wheel of uniform thickness and radius 30 cm. The coefficient of friction between steel and stone is 0.3. You spin the wheel up to 1000 rpm with a 100 W motor.

a) How long does it take to spin the wheel up to 1000 rpm? What lens do you use?

b) Then I push the ax against the wheel with a force of 100 N and the sparks fly! But as soon as you start, the electricity goes out and the wheel is spinning freely without power. What is the angular acceleration of the wheel as you push against it with the ax?



$\mu = .3$

a) Energy lens, b/c the work done by the motor is converted to the rotational kinetic energy of the wheel

$KE_{rot} = \frac{1}{2} I \omega^2$; $I = \frac{1}{2} m r^2$ (disk)

$\vec{\omega} = \frac{1000 \text{ rot}}{\text{min}} = \frac{2000\pi}{60 s} \approx 100/s$

$KE_{rot} = \frac{1}{2}\left(\frac{1}{2} 5kg (.3m)^2\right)(100/s)^2$

$KE_{rot} = 1{,}125 J$

$P_{motor} = 100W = \frac{100J}{s}$; $1125J \cdot \frac{s}{100J} \approx \boxed{11.25 s}$

b) Dynamics lens, b/c there are forces and accelerations.

$\Sigma \vec{\tau} = I \vec{\alpha}$ (For Fixed I)

$\tau = F \cdot r = F_F \cdot r = \mu F_N \cdot r$

$\tau = (.3)(100N) \cdot (.3m) = 9Nm$

$\vec{\alpha} = \frac{9Nm}{\frac{1}{2}(5kg)(.3m^2)} \approx \boxed{40/s^2}$