PS #5 121 Due Monday in class Schwartz

1) Section 4.1 Example 1, Rotation Direction *Answer in text/workbook.*
2) Section 4.2 Exercise 1, Rotation and kinetic energy of two masses

4.2 Exercise 1

a) Rotational kinematics lense because we are studying the rotational motion of the rod as an explicit function of time

$$\vec{w} = \frac{10\,rad}{s} \times \frac{1\,rev}{2\pi} \times \frac{60\,s}{min} = \boxed{95.5\ rpm}$$

b) Rotational kinematics lense because again we are studying the rotational motion of the rod as an explicit function of time

$$\vec{w} = 10\,rad/s$$

$$\rightarrow v = \frac{\Delta s}{\Delta t} = \frac{r\Delta\theta}{\Delta t} = r\vec{w}$$

$$\vec{v}_A = 2m(10\,rev/s) = \boxed{20\,m/s}$$

$$\vec{v}_B = 1m(10\,rev/s) = \boxed{10\,m/s}$$

c) Rotational KE lense because we are trying to calculate the KE of the structures masses

$$E_{RK} = \tfrac{1}{2} I w^2$$

$$E_{RK(A)} = \tfrac{1}{2} I_A (w_A)^2$$

$$\tfrac{1}{2} m_A (r_A)^2 (w_A)^2 = \tfrac{1}{2}(1)(2m)^2(10)^2$$

$$= \boxed{200\,J}$$

$$E_{RK(B)} = \tfrac{1}{2} I_B (w_B)^2$$

$$= \tfrac{1}{2} M_B (R_B)^2 (w_B)^2 = \tfrac{1}{2}(2)(1)^2(10)^2$$

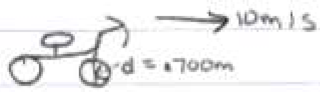
$$= \boxed{100\,J}$$

D) Rotational kinetic energy lense because we are calculating the KE for the total structure

$$\Sigma E_R = 200\,J + 100\,J = \boxed{300\,J}$$

3) Section 4.2 Exercise 2, Rotation and linear speed, bicycle problem

4.2 Exercise 2



$\Delta t = 5s$

$v = 10m/s$

a) Kinematics lense

$\vec{a} = \frac{\Delta v}{\Delta t} = \frac{10m/s}{5s} = \boxed{2m/s^2}$ yes it is possible

b) Rotational kinematics lens

$\vec{\omega} = \vec{v}/r = 10/\tfrac{1}{2}(.7m) = \boxed{28.6 \text{ rad/s}}$

c) $\vec{a} = \frac{\Delta \omega}{\Delta t} = \frac{28.57}{5} = \boxed{5.71 \text{ rad/s}^2}$

d) $\vec{\omega} = \frac{\Delta \theta}{\Delta t} = \frac{28.57 \text{rad}}{2}(5) = \boxed{71.45 \text{rad}}$

4) Section 4.3 Exercise 2, Turning a wrench

4.3 Exercise 2

a) Dynamics lense because we are looking at αs and τs

$\tau = F(r) = 200 \times .4 = \boxed{80Nm}$

Energy lense because work is being done on the nut while its being turned

$W = \tau(\Delta\theta)$

$= 80(2\pi) = \boxed{500J}$

b) Energy is lost to heat because of friction

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

5) Section 4.3 Exercise 4, Pedaling a bicycle

Exercise 4 4.3

a) Rotational dynamics lens

$\tau = r\vec{F}_{\perp}$

$= .175(200)$

$= \boxed{35 N\,m}$

$\frac{90\ r}{1 min} \cdot \frac{2\pi\ rad}{r} \cdot \frac{1 min}{60 s} = \boxed{\frac{9.42\ rad}{s}}$

$P = \frac{\Delta E}{\Delta t} = \frac{W}{\Delta t} = \tau \Delta \vec{\omega} = 35(9.42) = \boxed{330 W}$

b) Rotational kinematics lens

$\vec{v} = \frac{\Delta s}{\Delta t} = r(\vec{\omega}) = .175(9.42) = \boxed{1.64 m/s}$

$P = \frac{\Delta E}{\Delta t} = F(\vec{v}) = 200(1.64) = \boxed{300W}$

6) Section 4.4 Exercise 2, Kinetic energy of two masses

4.4 Exercise 2

- $I = m_1 r_1^2 + m_2 r_2^2$

  $= 2kg(1m)^2 + 1kg(2m)^2$

  $I = \boxed{6 kg m^2}$
- $E_R = 1/2 I \omega^2$

  $= 1/2(6)(10)^2$

  $= \boxed{300 J}$
- Yes
- Finding KE w/ rotational equations because there isnt as many steps

7) Your friend has a round-bottom swimming pool that they are cleaning, so it is empty! The pool is 4 m deep, so you and your friend (who has the same mass as you) drop in on your skateboards simultaneously from opposite sides, but your friend only drops from 2 m. You meet in the middle and hang onto each other.

   a) After you hit each other at the bottom, are the two of you at rest? If so, explain how you know.
   b) If not, please *estimate* the height you two roll up to before you come to a stop and start oscillating back and forth in the pool.

   Please see the solutions to Assessment #5 posted on main class website. These solutions should show you how your colleagues used an energy and then a momentum lens to find a final speed of our bodies of 1.3 m/s… Then how high did we ultimately go? You should be able to use an energy lens again to show we gain only about 8 cm of elevation… do you suppose some energy was converted to thermal energy in the collision?

8) Two identical disks ("A" and "B") are spinning in opposite directions in space, and $\omega_A = \underline{3}\omega_B$. They get slammed together and stick together. I am wondering if they are moving or not in the end. You have to help me find out.

   a) Which lens would you use and why?
   b) *Briefly* describe in 1 sentence the linear physics problem that is analogous to this
   c) Is there any thermal energy given off? How do you know? *Please see solutions to assessment #5 posted on main class website for the above two answers. To find this answer, we can provide two answers…. There is a friction interaction between the disks that generates a large amount of thermal energy (at the expense of lost rotational kinetic energy). Additionally, we could recognize this as an inelastic collision because the disks are rotating as a single body in the end, so they lost the "internal" energy corresponding to their "internal velocity" with respect to each other.*
   d) Calculate the thermal energy given off in terms of ω_B, and I, their moment of inertia. *Please see solutions to assessment #5 posted on main class website for the above two answers. To find this answer, we will need to follow the angular momentum lens to find the final omega and then calculate the total remaining kinetic energy. First, we recognize that angular momentum (like momentum) is a vector and these two are rotating in opposite directions! Thus the total angular momentum of the system is $2I\omega_B$ NOT $4I\omega_B$. Then because this angular momentum is of the <u>two bodies together</u>, the total moment of inertia of the two is $2I$. Thus, conserving angular momentum, we find that the final omega to be ω_B in the same direction as A was originally spinning. Now we can calculate the total rotational kinetic energy and compare it to the initial kinetic energy of the two spinning wheels. I find that the lost kinetic energy is $4I{\omega_B}^2$, (out of the original $5I{\omega_B}^2$,so most of it) which must be equal to the thermal energy generated in the inelastic skidding of the wheels that brought them together.*