Problem Set #5, Klay/Schwartz due beginning of class, Monday, Oct. 21

1) Redo your assessment in fine fashion, correction any mistakes. You don't need to do it if you got right. Feel free to submit it with your original assessment.
2) Section 4.0 Exercise 1, collision of rotating bodies – what is the linear analogue for this problem?

1) lens: angular momentum, momentum is conserved

$\omega_A = 3\omega_B$ $\quad \boxed{\ell_A = 3\ \ell_B}$

Disk A $\quad$ Disk B

$\ell_A = I\omega_A \quad \ell_B = I_B\omega_B$

$\ell_B = I_B(\frac{1}{3}\omega_A)$

$I_A = I_B$

$\ell_B = \frac{1}{3}\ell_A$

lens: Rotational Energy, transfer of kinetic energies

$\boxed{E_{RA} = 9\ E_{RB}}$

$E_{RA} = \frac{1}{2}I\omega_2 \quad E_{RB} = \frac{1}{2}I(3\omega_B)^2$

$= 9(\frac{1}{2}I\omega_B^2)$

eat!

The linear analogue for this situation would be an inelastic collision between two carts or blocks moving toward each other.

The most important lens to use here would be the angular momentum lens here, because momentum is conserved since there are no outside forces.

$\ell_i = \ell_f$

$I_A\omega_A + I_B\omega_B = (I_A + I_B)\omega_f \qquad I_A = I_B = I$

$\omega_f = \frac{I_A\omega_A + I_B\omega_B}{(I_A + I_B)} = \frac{I_A(3\omega_B) + I_B\omega_B}{2I} \Rightarrow \omega_B = \frac{1}{3}\omega_A \quad \boxed{\omega_f = \frac{2}{3}\omega_A}$

I would use rotational energy lens because there is a transformation of KE

$\Sigma KE = KE_A + KE_B \qquad \Sigma KE_f = \frac{1}{2}I_{A+B}\omega_f^2$

$= 9KE_B + KE_B \qquad = \frac{1}{2}(I_A + I_B)(\frac{2}{3}\omega_{iA})^2$

$= 10KE_B \qquad = \frac{1}{2}(2I)(\frac{4}{9}\omega_{iA}^2)$

$= 10(\frac{1}{2}I\omega^2) \qquad = \frac{4}{9}I(3\omega_B)^2$

$= 5I\omega^2 = \underline{2KE_{Ri}} \qquad = I\omega_B^2 = 2(\frac{1}{2}I\omega_B)^2$

$\boxed{2KE_{Ri} = \Sigma E_{Rf}}$

80% of the original E_k will be lost to heat, $\Sigma E_{Ri} = 10\Sigma E_{RB}$ while $\Sigma E_{Rf} = 2E_{RB}$.

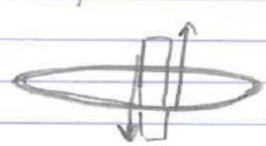
Therefore we see that an energy equal to $8\Sigma E_{RB}$ was lost to heat due to collision.

3) Section 4.1 Example 1, Rotation Direction

4.1 Ex 1

(rotational acceleration)

$\boxed{C.}$ Shows torque in the leftward $-\hat{x}$ direction.



4) Section 4.2 Exercise 1, Rotation and kinetic energy of two masses

a) lens: rotational kinematics, rod's rotational motion as an explicit function of time

$\vec{\omega} = \frac{10\,rad}{1s} \times \frac{1\,rev}{2\pi\,rad} \times \frac{60s}{1\,min} = \frac{600\,rev}{2\pi\,min} = \boxed{\frac{300}{\pi}\,rev/min} \approx 100\,rev/min$ ✓

b) lens: rotational kinematics, rod's rotational motion as an explicit function of time

$v = r\omega$

$v_A = 2m(10^r/s) = \boxed{20\,m/s}$ ✓

$v_B = 1m(10^r/s) = \boxed{10\,m/s}$ ✓

c) lens: Rotational energy, because we are finding rotational kE

$kE_{rot} = \frac{1}{2} I \omega^2 \qquad I = mr^2$

$kE_A = \frac{1}{2}(mr_A^2)\omega_A^2 \qquad kE_B = \frac{1}{2}(mr_B^2)\omega_B^2$

$= \frac{1}{2}(1kg(2m)^2)(10^r/s)^2 \qquad = \frac{1}{2}(2kg(1m)^2)(10^r/s)^2$

$= \boxed{200J}$ ✓ $\qquad = \boxed{100J}$ ✓

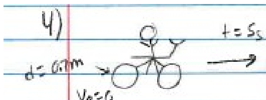
d) lens: energy, find the sum of the rotational kE

$\Sigma E_{rt} = kE_{RA} + kE_{RB}$

$= 200J + 100J = \boxed{300J}$ ✓

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

4)



a) lens: kinematics, motion as an explicit function of time

$\vec{a} = \frac{\Delta v}{\Delta t} = \frac{10m/s}{5s} = \boxed{2m/s^2}$ yes, possible on level ground ✓

b) lens: kinematics, rotational kinematics, motion as an explicit function of time

$v = r\omega$

$\frac{10m/s}{.35m} = \frac{.35m(\omega)}{.35m} \quad \boxed{\omega_f \approx 29\,rad/s}$ ✓

c) lens: rotational kinematic lens, rotational motion as an explicit function of time

$a_T = r\alpha$

$\frac{2m/s^2}{.35m} = \frac{.35m\,\alpha}{.35m} \quad \boxed{\alpha \approx 6\,rad/s^2}$ ✓

d) lens: rotational kinematic lens, rotational as an explicit function of time

$\omega = \frac{\Delta\theta}{\Delta t} \qquad \Delta\theta = \omega_{ave} \cdot \Delta t$

$= \frac{29\,rad/s}{2}(5s) = \boxed{72.5\,rad}$ ✓

6) Section 4.3 Exercise 2, Turning a wrench

5)

a) lens: rotational dynamics, because τ causes α

$\tau = I\alpha$

$= F_1 \cdot r = 200N \cdot .04m = \boxed{8.0\,Nm}$ ✓

lens: energy, because of rotational energy

$W = \tau \cdot \Delta\theta$

$= 80N\,m \cdot 2\pi = \boxed{500J}$ ✓

b) This energy was converted to heat due to friction.

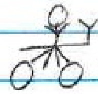
c) lens: energy, because of rotational energy

$P_{rot} = \tau\omega = \frac{W}{\Delta t}$

$= \frac{500J}{2s} = \cancel{\boxed{225w}}$ 250 W

7) Section 4.3 Exercise 4, Pedaling a bicycle

6)



$r = .175m$ $\vec{\omega} = 90 rpm$

$F = 200N$

a) lens: rotational dynamic, because τ causes α, then an energy lens because of power

$\tau = F_\perp r$ $\qquad \frac{90 rev}{1 min} \cdot \frac{2\pi rad}{1 rev} \cdot \frac{1 min}{60 sec} = 9.42 \, rad/s$

$= 200N(.175m)$

$= \boxed{35 Nm}$

$P = \tau \Delta \vec{\omega} = (35Nm)(9.42 \, rad/sec) \approx \boxed{330W}$ ✓

b) lens: rotational kinematics, because rotational motion as an explicit function of time

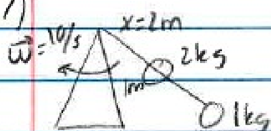
$V = r\omega = (.175m)(9.42 \, rad/s)$

$= \boxed{1.64 \, m/s}$

$P = \frac{W}{t} = \frac{F\Delta x}{\Delta t} = F \cdot v = (200N)(1.64 \, m/s) \approx \boxed{330W}$ ✓

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

7)



lens: energy, finding inertia as a motion of rotation

a) $\Sigma I = m_1 r_1^2 + m_2 r_2^2$

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

$\boxed{I = 6 kgm^2}$

b) $E_R = \frac{1}{2} I \omega^2$

$= \frac{1}{2}(6kg \cdot m^2)(10/s)^2$

$= 30 \, kg \cdot m^2/s^2$

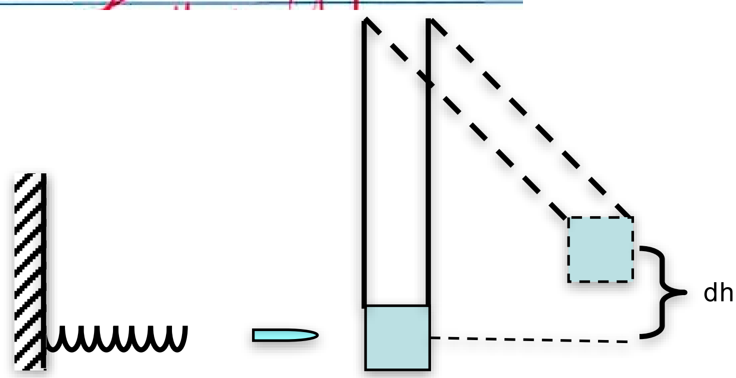
$= \boxed{300J}$

c) My answer agrees!

d) Finding kinetic energy with rotational kinetic energy is much easier because it only took one step, rather than having to find velocity first.

9) From Assessment #4: A spring of spring constant 2500 N/m is compressed 10 cm behind a 250 g projectile. When released, the projectile is fired into and sticks inside of a 2.0 kg block. The block and projectile lift up to a maximum height *dh*. I want to find *dh*. I have a plan to use $U_{sp} = U_g$ to solve for the final height. Does this method work?

- If this the correct way to find dh, please explain why this is correct, and find dh.
- If this method doesn't work, please explain why it will not work and what has to be done differently to find dh. You don't have to calculate it.



Use as much paper as you like. Your work is important for us to read!

See assessment #4 Solutions