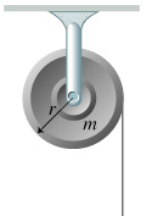
Physics 131.01 Monday October 25, 2010 Quiz number 6

Cooperative Learning: work together, and submit one solution to each problem. A "solution" is not just a number. The reasoning needs to be indicated. The units of the number need to be specified. If the answer is a vector, the vector needs to be specified. Magnitude alone is not usually enough. **Write all 3 names on each page you submit.**

1. **Acceleration of a Pulley – I** A string is wrapped around a uniform solid cylinder of mass m = 0.32 kg and radius r = 0.24 m, as shown in the figure. The cylinder can rotate freely about its axis. The loose end of the string is pulled with force $\mathbf{F}_P$ = 40 N.



a. What is the moment of inertia of the pulley? $I = 0.922 \times 10^{-2}$ kg m^2

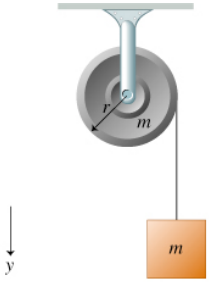
b. Indicate which direction of rotation you wish to be positive. What torque does the force $\mathbf{F}_P$ exert? τ = 9.6 Nm (positive = clockwise)

c. What is the angular acceleration α of the pulley (rad/s^2)? $\alpha = \tau/I$ = 1040 rad/s^2

d. What is the angular velocity ω after Δt = 12 s? 12,500 rad/s

e. What is the kinetic energy after Δt = 12 s? 7.20×10^5 J

2. **Acceleration of a Pulley – II** The pulley is the same as before, but now there is a mass M = 0.20 kg on the string.



a. Draw the free body diagrams for the mass M and the pulley. The diagram for the pulley should show only those forces that cause torques.

b. How is the acceleration a of the mass related to the angular acceleration α of the pulley? $a = r\alpha$

c. Write separate Newton's 2nd law equations for the mass and the pulley. $Mg - T = Ma$; $Tr = I\alpha$

d. What is the acceleration of the mass M? $a = Mg/(M+m/2)$ = 5.44 m/s^2

e. How much gravitational potential energy change has happened during a 1.00 meter fall of the mass M? ΔMgh = -1.96 J

e. When the mass M has fallen a distance of 1.00 m, what is the total kinetic energy of the mass and pulley? +1.96 J

f. At the same moment, what is the velocity of the pulley? The fraction of the KE belonging to the pulley is $(m/2)/(M+m/2)$ = 0.444, or $I\omega^2/2$ = 0.871 J. Therefore ω = 13.7 rad/s.

3. **Collision with rotation (angular momentum conservation).** A wheel in the form of a solid cylinder of radius R = 0.33 m and mass M = 0.20 kg is fixed on an immobile horizontal axis, allowing it to spin without friction. Its rest is disturbed by a m = 0.15 kg bird which flies horizontally at v =6.0 m/s until landing on the top of the wheel.

a. What is the moment of inertia of the wheel? I_1 = 0.0109 kg m^2

b. What is the initial angular momentum (the angular momentum of the bird relative to the wheel)? $L = mvR$ = 0.297 kg m^2/s

c. What is the final moment of inertia (of the wheel with the bird perched on it?) $I_2 = I_1 + mR^2$ = 0.0272 kg m^2.

d. What is the final angular velocity (of the wheel with the bird perched on it?) $\omega_f = L/I_2$ = 10.9 rad/s