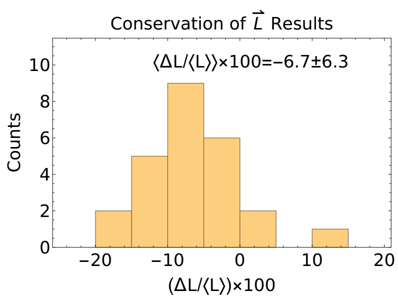
Physics 131-01 Test 3

I pledge that I have neither given nor received unauthorized assistance during the completion of this work.

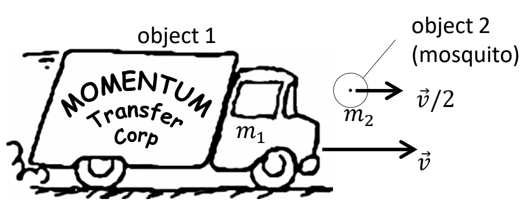
Name ______________________ Signature ______________________

Questions (5 for 8 pts. apiece) Answer in complete, well-written sentences WITHIN the spaces provided.

1. Consider the plot below which shows the results for the Conservation of Angular Momentum laboratory where you dropped a cylindrical weight on a rotating disk. You measured the initial and final angular momenta $L_{initial}$ and L_{final}, ($\Delta L = L_{final} - L_{initial}$, and $\langle L \rangle$ is the average of $L_{initial}$ and L_{final}. Is angular momentum conserved? Be quantitative in your answer.



2. Suppose the mass of object 1 is greater than that of object 2 and that object 2 is moving in the same direction as object 1 but not quite as fast, so that $m_1 > m_2$ and $\vec{v}_1 > \vec{v}_2$. Predict the relative magnitudes of the forces between the objects. Place a check next to your prediction. Explain your reasoning.



___ Object 1 exerts more force on object 2.

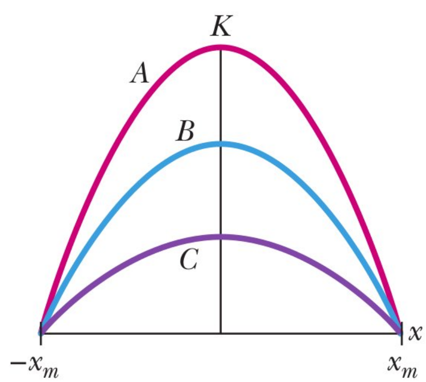
___ They exert the same force on each other.

___ Object 2 exerts more force on object 1.

3. Assume that an object is moving in a circle of constant radius, r. Using the definition of the radian, what is the general relationship between a length of arc, s, on a circle and the variables r and θ in radians? Using this relationship take the derivative of s with respect to time to find the velocity of the object. What is the relationship between the magnitude of the linear velocity, v, and the magnitude of the angular velocity, ω? Show all your steps for full credit.

4. You have a set of x and y position data as a function of time t from *Tracker* where each point on a frame marks the edge of a marker of the rim of a rotating disk. The origin is at the center of the disk. The data go on for several complete rotations of the disk. How would you obtain the angular position θ for all the data. Explain your reasoning.

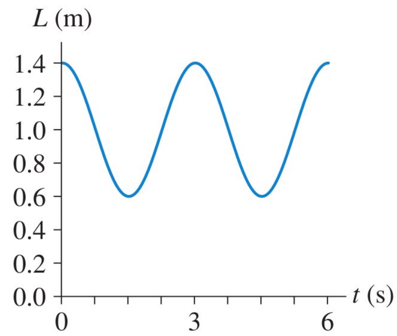
5. The figure shows plots of the kinetic energy K versus position x for three harmonic oscillators that have the same mass m. Rank the plots according to (a) the corresponding spring constant and (b) the corresponding period of the oscillator, greatest first. Explain your reasoning.



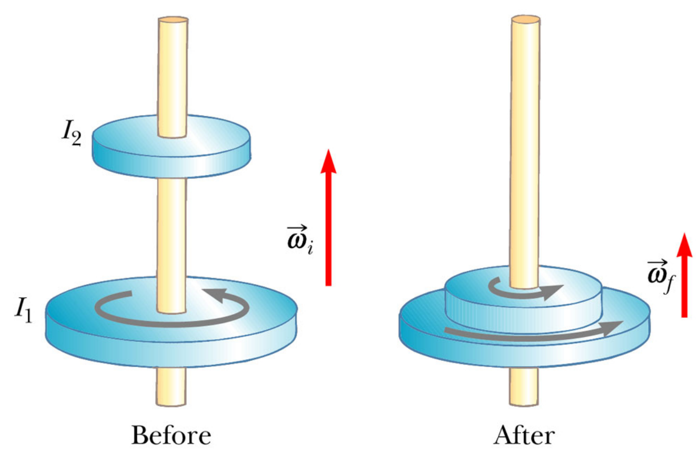
Problems (3). Clearly show all reasoning for full credit. Use a separate sheet to show your work.

1. 10 pts. A baseball pitcher can throw a ball with a speed of $v_p = 40\ m/s$. He is in the back of a pickup truck that is driving away from you. He throws the ball in your direction, and it floats toward you at a lazy $v_t = 10\ m/s$. What is the speed v_T of the truck?

2. 15 pts. Astronauts in space cannot weigh themselves by standing on a bathroom scale. Instead, they use a large spring. Suppose an astronaut attaches one end of a large spring to her belt and the other end to a hook on the wall of the space craft. A fellow astronaut then pulls her away from the wall and releases her. The spring's length as a function of time is shown in the figure. Ignore the mass of the belt and the spring. What is her mass m_1 if the spring constant is $k = 200\ N/m$? To test the device another astronaut hangs a known mass $m_2 = 50\ kg$ on the spring to calibrate the system. What will be the period of its oscillation?



3. 15 pts. A cylinder with moment of inertia I_1 rotates about a vertical, frictionless axle with angular speed ω_i. A second cylinder, this one having moment of inertia I_2 and initially not rotating, drops onto the first cylinder (see figure). Because of friction between the surfaces, the two eventually reach the same angular speed ω_f. (a) Calculate ω_f in terms of ω_i and the moments of inertia. (b) Show that the kinetic energy of the system decreases in this interaction and calculate the ratio of the final to the initial rotational energy. (c) How is the ratio of the final to initial angular velocity related to your answer in part (b) and to the moments of inertia?



4. 20 pts. A uniform solid sphere has a mass $m = 1.65\ kg$ and a radius $r = 0.226\ m$. What is the torque required bring the sphere from rest to an angular velocity $\omega = 317\ rad/s$ in a time $t = 15.5\ s$? The sphere rotates about an axis through its center. What force applied tangentially at the equator would provide the needed torque? How would the force change if the object was a thin, spherical shell with the same mass and radius (no calculations needed here)? Explain your reasoning.

Physics 131-1 Equations and Constants, Test 3

$$\Delta\vec{r} = \vec{r}_{finish} - \vec{r}_{start} \quad \Delta\vec{v} = \vec{v}_{finish} - \vec{v}_{start}$$

$$\langle\vec{v}\rangle = \frac{\Delta\vec{r}}{\Delta t} \qquad \vec{v} = \frac{d\vec{r}}{dt} = \lim_{\Delta t\to 0}\frac{\Delta\vec{r}}{\Delta t} = \lim_{\Delta t\to 0}\frac{\vec{r}(t+\Delta t)-\vec{r}(t)}{\Delta t}$$

$$\langle\vec{a}\rangle = \frac{\Delta\vec{v}}{\Delta t} \qquad \vec{a} = \frac{d\vec{v}}{dt} = \lim_{\Delta t\to 0}\frac{\Delta\vec{v}}{\Delta t} = \lim_{\Delta t\to 0}\frac{\vec{v}(t+\Delta t)-\vec{v}(t)}{\Delta t}$$

$$x(t) = \frac{1}{2}at^2 + v_0t + y_0 \quad v = at + v_0 \quad a = g \quad a_c = \frac{v^2}{r} \quad (\vec{v}\perp\vec{r} \quad \vec{v}\perp\vec{a}_c)$$

$$\vec{F}_{net} = \sum_i \vec{F}_i = m\vec{a} = \frac{d\vec{p}}{dt} \qquad \vec{F}_{AB} = -\vec{F}_{BA} \quad \vec{p} = \sum m_i\vec{v}_i \quad \vec{p}_i = \vec{p}_f$$

$$|\vec{F}_f| = \mu N \quad |\vec{F}_c| = m\frac{v^2}{r} \quad |\vec{F}_G| = \frac{Gm_1m_2}{r^2} \quad \vec{F}_s(x) = -kx\hat{i} \quad \vec{F}_g(y) = -mg\hat{j}$$

$$W = \int \vec{F}\cdot d\vec{s} = \int |\vec{F}|\;|d\vec{s}|\;\cos\theta = \Delta KE = -\Delta U \quad KE = \frac{1}{2}mv^2 \quad KE_i = KE_f \;\; elastic$$

$$KE_i + U_i = KE_f + U_f \quad KE = KE_{cm} + KE_{rot} \quad KE_{rot} = \frac{1}{2}I\omega^2 \quad U_s(x) = \frac{1}{2}kx^2 \quad U_g(y) = mgy$$

$$\theta = \frac{s}{r} \quad \omega = \frac{v_\perp}{r} = \frac{d\theta}{dt} \quad \alpha = \frac{a_\perp}{r} = \frac{d\omega}{dt} \quad I = \sum m_i r_i^2 = I_{cm} + Mh^2 \quad \vec{r}_{cm} = \frac{\sum m_i\vec{r}_i}{\sum m_i}$$

$$\vec{\tau} = rF\sin\phi\;\hat{\theta} = I\vec{\alpha} \quad \vec{L} = \sum_j I_j\vec{\omega}_j \quad \vec{L}_i = \vec{L}_f \quad v_{cm} = r\omega \quad \theta = \frac{\alpha}{2}t^2 + \omega_i t + \theta_i \quad \omega = \alpha t + \omega_i$$

$$x(t) = A\cos(\omega t + \phi) \quad \omega^2 = \frac{k}{m} \quad T = \frac{2\pi}{\omega} = \frac{1}{f} \quad PE = \frac{1}{2}kx^2 \quad ME = \frac{1}{2}kA^2 \quad \sin\theta \approx \theta \quad \omega^2 = \frac{mg\ell}{I}$$

$$v_i' = v_i - v \quad x' = x - vt \quad y' = y$$

$$\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k} \;\; \frac{dA}{dt} = 0 \;\; \frac{dt}{dt} = 1 \;\; \frac{dt^2}{dt} = 2t \;\; \frac{d}{dt}\cos\theta = -\sin\theta \;\; \frac{d}{dt}\sin\theta = \cos\theta$$

$$\int f(x)dx = \lim_{\Delta x\to 0}\sum f(x_i)\Delta x \qquad \int dx = x + c \qquad \int x dx = \frac{x^2}{2} + c$$

$$\sin\theta = \frac{opp}{hyp} \quad \cos\theta = \frac{adj}{hyp} \quad \tan\theta = \frac{opp}{adj} \quad x^2 + y^2 + z^2 = R^2 \quad \rho = \frac{m}{V}$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \quad C = 2\pi r \quad Area = \pi r^2 \quad Area = \frac{1}{2}bh \quad Area = 4\pi r^2$$

Speed of Light (c)	$2.9979 \times 10^8\ m/s$	proton/neutron mass	$1.67 \times 10^{-27}\ kg$
R	$8.31 J/K - mole$	g	$9.8\ m/s^2$
Gravitation constant	$6.67 \times 10^{-11}\ N - m^2/kg^2$	Earth's radius	$6.37 \times 10^6\ m$
Earth-Moon distance	$3.84 \times 10^8\ m$	Electron mass	$9.11 \times 10^{-31}\ kg$