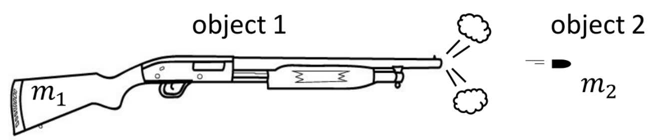
Physics 131-01 Test 3

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. You will be penalized for not following directions.

1. Suppose the mass of object 1 in the figure is greater than that of object 2 and that both objects are at rest until an explosion occurs, so that $m_1 > m_2$ and $|\vec{v}_1| < |\vec{v}_2|$. What are the relative magnitudes of the forces between object 1 and object 2? Explain.



2. Recall the lab where we tested the conservation of angular momentum by dropping a mass on a moving rotator and measuring the effect on the rate of rotation. How would the procedure you followed change if the weight was moving horizontally at a constant velocity when you dropped it (and it still stayed on the rotator)? If it changed, what would be different?

3. How does the period of a harmonic oscillator depend on the mass? How would one 'prove' that property. Describe a procedure.

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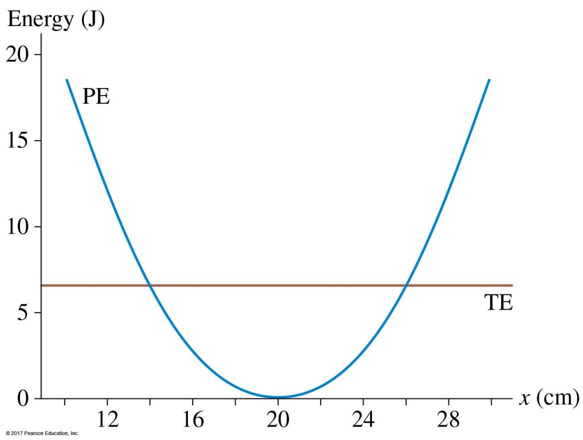
4. How do airbags in cars reduce injuries? Explain.

5. The figure below shows the potential energy (PE) curve for a mass on a spring and the total energy (TE) line. (a) Where are the turning points? Mark their location on the graph. (b) If the total energy doubles where will the turning points be located. Explain your reasoning.



Problems (3). Clearly show all reasoning for full credit. Use a separate sheet to show your work. YOU WILL BE PENALIZED FOR NOT FOLLOWING DIRECTIONS.

1. 12 pts. A block of mass $m = 2.0\ kg$ is attached to a spring with spring constant $k = 15\ N/m$. While the block is sitting at rest, a student hits it with a hammer and almost instantaneously gives it a speed of $v_i = 50\ cm/s$. What is the amplitude of the subsequent oscillations?

2. 20 pts. Most of us know intuitively that in a head-on collision between a dump truck and a subcompact car, you are better off being in the truck than in the car. Consider what happens to the two drivers. Suppose each vehicle is initially moving with a speed $v_0 = 10\ m/s$ and they undergo a perfectly inelastic, head-on collision. Each driver has a mass $m = 60\ kg$. Including the drivers the total vehicle masses are $m_c = 1000\ kg$ for the car and $m_t = 3000\ kg$ for the truck. What is the change in momentum $\Delta\vec{p}$ for each driver? Which one gets hurt the most?

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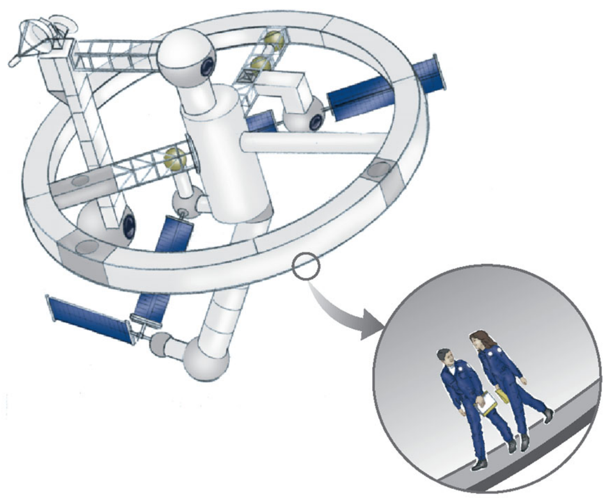
3. 28 pts. A von Braun wheel is a space station constructed in the shape of a hollow ring or thin cylindrical shell as shown in the figure. Crew members walk on a deck formed by the inner surface of the outer cylindrical wall. The mass is $m = 5 \times 10^4\ kg$, the radius is $R = 100\ m$, and the moment of inertia is $I = 5 \times 10^8\ kg - m^2$. At rest when constructed, the ring is set rotating about its axis so that the people inside experience an effective free-fall acceleration. The rotation is achieved by firing two small rockets attached tangentially to opposite points on the outside of the ring. If the space station starts from rest and the rockets fire for $\Delta t = 60\ min$ with a force of $F_t = 175\ N$, what is the final angular momentum of the station? What is the effective free-fall acceleration on the rim?



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Physics 131-1 Equations and Constants, Test 3

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

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

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

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

$$\vec{F}_{net} = \sum_i \vec{F}_i = m\vec{a} = \frac{d\vec{p}}{dt} \qquad \vec{F}_{AB} = -\vec{F}_{BA} \quad \vec{p} = \sum m_i\vec{v}_i \quad \vec{p}_i = \vec{p}_f \quad \Delta\vec{p} = \vec{J} = \int_{t_1}^{t_2}\vec{F}dt \quad \rho = \frac{m}{V}$$

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

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

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

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

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

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

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

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

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

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

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	$3.84 \times 10^8\ m$	Earth mass	$5.9742 \times 10^{24}\ kg$
Electron mass	$9.11 \times 10^{-31}\ kg$	Moon mass	$7.3477 \times 10^{22}\ kg$
1 newton	$0.2248\ lbs - force$	Moon radius	$1.74 \times 10^6\ m$
Solar radius	$6.96 \times 10^8\ m$	Solar mass	$1.99 \times 10^{30}\ kg$
Earth-Sun distance	$1.50 \times 10^{11}\ m$	1 u	$1.661 \times 10^{-27}\ kg$

Moments of Inertia