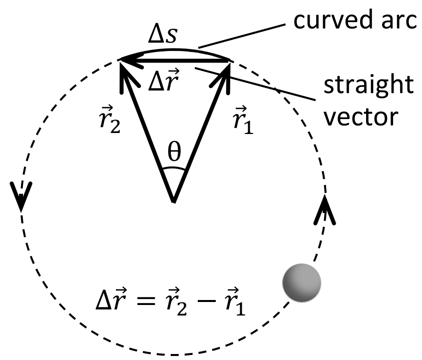
Physics 131-01 Test 1

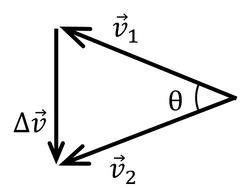
I pledge that I have neither given nor received unauthorized assistance during the completion of this work.

Signature ______________________________

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

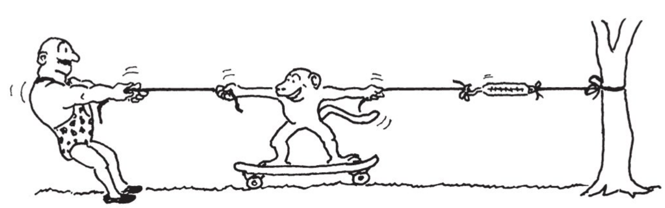
1. Explain why, at the two points shown on the circle, the angle between the position vectors at times t_1 and t_2 is the same as the angle between the velocity vectors at times t_1 and t_2. Hint: In circular motion, velocity vectors are always perpendicular to their position vectors.





2. Why does Saturn have rings?

3. The muscle man in the diagram below is pulling to the left on a rope with a force of $\vec{F} = -150N\ \hat{i}$. What force is the spring scale experiencing on its left end? What force is the spring scale experiencing on its right end? Explain your reasoning.



4. You are sleeping in your sister's room while she is away at college. Your house is on fire and smoke is pouring into the partially open bedroom door. The room is so messy that you cannot get to the door. The only way to close the door is to throw either a blob of clay or a super ball at the door - there's not enough time to throw both. Assuming that the clay blob and the super ball have the same mass, which would you throw to close the door: the clay blob (which will stick to the door) or the super ball (which will bounce back with almost the same velocity it had before it collided with the door)? Explain.

5. A ball falls toward the Earth from a tall building. Its momentum increases as it falls. Does this situation violate momentum conservation? Explain.

Problems. Clearly show all reasoning for full credit. Use a separate sheet to show your work. Note: Derivatives should be calculated using the the definition in terms of a limit.

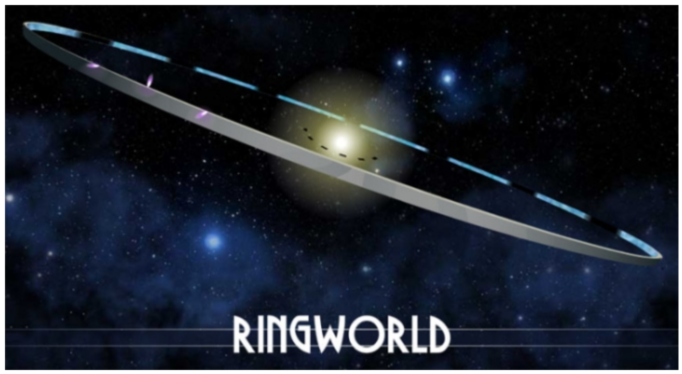
1. 8 pts. A friend claims that as long as he has his seat belt on, he can hold on to a child of mass $m = 10.0\ kg$ in a $v = 50.0\ mi/h$ head-on collision (which is about 27 m/s) with a brick wall in which the car passenger compartment comes to a stop in $\Delta t = 0.06\ s$. Clearly show that the violent force during the collision will tear the child from his arms. You may want to use some of the conversions on the equation sheet. (A child should always be in a toddler seat secured with a seat belt in the back seat of a car.)

2. 16 pts. The free-fall acceleration on the surface of the Moon is about one-sixth that on the surface of the Earth. The radius of the Earth is four times the Moon radius $R_E = 4R_M$. How is the density related to the acceleration and other constants? What is the ratio of the Earth's density to the Moon's, ρ_{Earth}/ρ_{Moon}?

3. 16 pts. A mass $m = 2.0\ kg$ is dropped onto a vertical spring with spring constant $k = 200.0\ N/m$. The block becomes attached to the spring and the spring compresses a distance $\Delta x = 0.15\ m$ before momentarily stopping. What is the mechanical energy at the start? What is the speed of the block just before impact?

Continue to the next page.

4. 20 pts. In author Larry Niven's epic sci-fi novel *Ringworld*, a huge ring rotates about a star and is home to a branch of humanity. The inhabitants of this ring world live on the starlit inner surface of the ring. Each person experiences a normal contact force $\vec{N}$. By itself, this normal force produces a centripetal acceleration $a_N = 9.90\ m/s^2$. The tangential speed of the ring is $v = 1.25 \times 10^6\ m/s$, and its radius is $R = 1.53 \times 10^{11}\ m$. What is the mass of the star? Compare it with the Sun's mass (see the equation sheet).



Physics 131-01 Equations and Constants

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

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

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

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

$$\vec{F}_{net} = \sum_i \vec{F}_i = m\vec{a} \qquad \vec{F}_{AB} = -\vec{F}_{BA} \quad |\vec{F}_e| = \frac{k_e q_1 q_2}{r^2} \quad |\vec{F}_G| = \frac{G m_1 m_2}{r^2} \quad d_{Roche} = \left(\frac{12M}{\pi\rho}\right)^{1/3}$$

$$|\vec{F}_k| = \mu_k N \quad |\vec{F}_s| \leq \mu_s N \quad |\vec{F}_c| = m\frac{v^2}{r} \quad \vec{F}_s(x) = -k\Delta s\ \hat{i} \quad \vec{F}_g(y) = -mg\hat{j}$$

$$W = \int \vec{F}\cdot d\vec{s} = \int |\vec{F}||d\vec{s}|\cos\theta = \Delta KE = -\Delta PE \quad KE = \frac{1}{2}mv^2 \quad PE_g = mgh \quad PE_s = \frac{1}{2}k\Delta s^2$$

$$PE_G = -\frac{Gm_1m_2}{r} \quad ME = KE + PE \rightarrow ME_f = ME_i \quad \vec{J} = \int_{t_1}^{t_2} \vec{F}dt = \Delta\vec{p} \quad \vec{p} = m\vec{v} \rightarrow \vec{p}_i = \vec{p}_f$$

$$\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k} \quad \vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta = A_xB_x + A_yB_y$$

$$\frac{dA}{dt} = 0 \quad \frac{dt}{dt} = 1 \quad \frac{dt^2}{dt} = 2t \quad \int f(x)dx = \lim_{\Delta x\rightarrow 0}\sum_{i=1}^{k} f(x_i)\Delta x$$

$$\sin\theta = \frac{opp}{hyp} \quad \cos\theta = \frac{adj}{hyp} \quad \tan\theta = \frac{opp}{adj} = \frac{\sin\theta}{\cos\theta} \qquad \cos^2\theta + \sin^2\theta = 1 \quad x^2 + y^2 + z^2 = R^2$$

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

$$V = \frac{4}{3}\pi r^3 \quad V = \pi r^2\ l \quad \theta = \frac{s}{r} \quad \rho = \frac{m}{V}$$

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 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	$1.99 \times 10^{30}\ kg$