# Physics 131-01 Test 2

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

Name _____   Signature _____

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

1. Suppose you have a cart with very little friction, and that you pull this cart with a constant force as shown below on the force versus time graph. Sketch on the axes below the velocity versus time and acceleration versus time graphs of the cart's motion. Explain your reasoning.
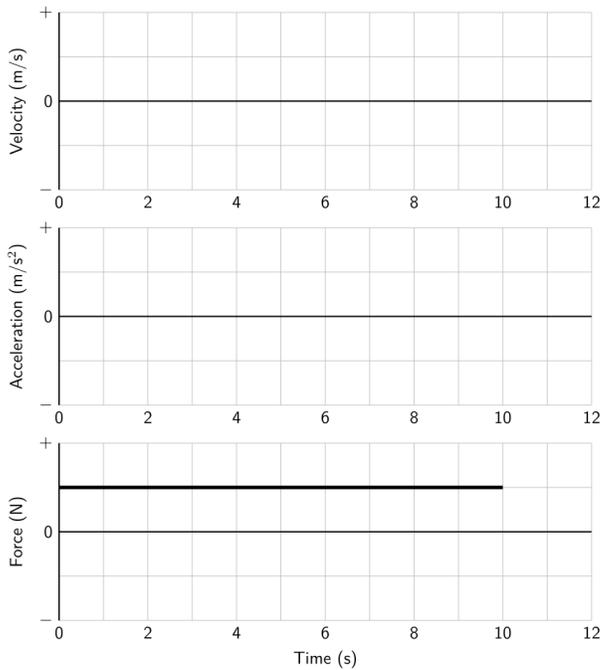
2. Consider the forces exerted by the strings in the figure below. What would happen to the direction of the forces as θ goes to zero? Is it possible for the string to support the mass when $\theta = 0$? Why?
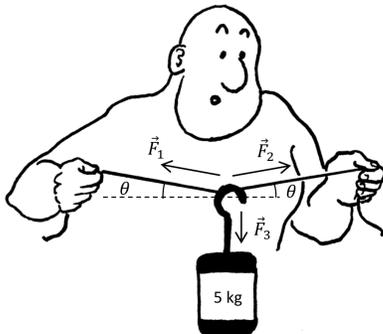
3. Recall our study of the centripetal force with flying pigs. You measured the horizontal component of the force F_c using m, the pig's mass, r, the radius of the flying pig's circular path, and v, the speed of the pig. Now, use r again with L, the length of the string that was rotating, to obtain the angle θ of the string to the horizontal. Next, use this information (θ and F_c) to get F_{plane}, the net force exerted on the pig you measured with a spring scale. A drawing might help. Explain your reasoning.

4. In our calculation of Roche's limit we used $\Delta \vec{F} = \vec{F}_2 - \vec{F}_1$ where $\vec{F}_{1,2}$ is the gravitational force between Saturn and the dust particles. How does $\Delta \vec{F}$ prevent the formation of moons close to Saturn? Explain your reasoning.

5. In the figure a block slides from A to C along a frictionless ramp, and then it passes through horizontal region $C-D$, where a frictional force acts on it. Is the block's kinetic energy increasing, decreasing, or constant in (a) region $A - B$, (b) region $B - C$, and (c) region $C - D$? Explain your answers.
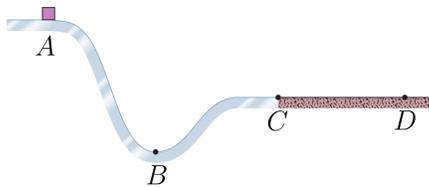

Problems. Clearly show all reasoning for full credit. Use a separate sheet to show your work. Note: Derivatives should be calculated using the the definition in terms of a limit.

1. 15 pts.   A block with $m = 25.0$ kg is initially at rest on a horizontal surface. A horizontal force of $|\vec{F}_1| = 78.0$ N is required to set the block in motion. It is in motion and a constant, horizontal force of $|\vec{F}_2| = 55.0$ N is required to keep the block moving with constant speed. What are the coefficients of static and kinetic friction?

DO NOT WRITE BELOW THIS LINE

2. 20 pts. A freight car of mass $m = 5000\ kg$ rolls along rails with negligible friction. The car is brought to rest by a combination of two coiled springs as illustrated in the figure below. Both springs obey Hooke's law with $k_1 = 1500\ N/m$ and $k_2 = 3500\ N/m$. After the first spring compresses a distance of $\Delta x_1 = 0.30\ m$, the second spring acts with the first to increase the force as additional compression occurs as shown in the graph. The car comes to rest $\Delta x_2 = 0.40\ m$ after first contacting the two-spring system. What is the freight car's initial speed?
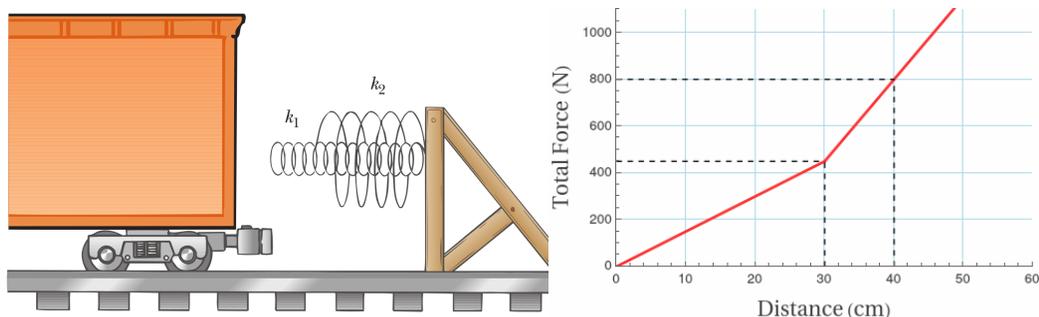
3. 25 pts. Certain neutron stars (old, very dense stars like the one in the figure below) are measured to be rotating at a rate $f = 1.5\ rev/s$. If such a star has a radius $r = 2 \times 10^4\ m$, then what is the minimum mass so any material on its surface remains in place during the neutron star's rotation?
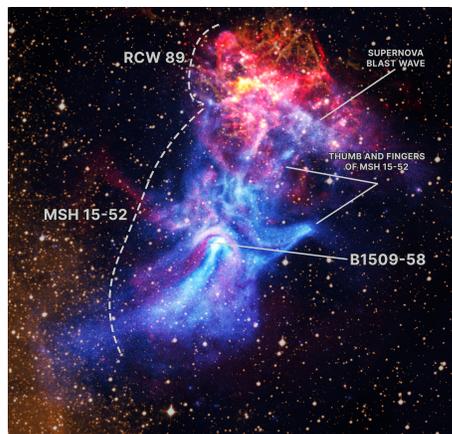
The neutron star B1509-58 is shown along with clouds of gas illuminated by radiation from the neutron star.

Physics 131-01 Constants and Conversion Factors

Speed of Light (c)	$2.9979 \times 10^8\ m/s$	proton/neutron mass	$1.67 \times 10^{-27}\ kg$
Electron mass	$9.11 \times 10^{-31}\ kg$	g	$9.8\ m/s^2$
Gravitation constant (G)	$6.67 \times 10^{-11}\ N-m^2/kg^2$	Earth radius	$6.37 \times 10^6\ m$
Earth-Moon distance	$3.84 \times 10^8\ m$	Earth mass	$5.9742 \times 10^{24}\ kg$
Moon radius	$1.74 \times 10^6\ m$	Moon mass	$7.3477 \times 10^{22}\ kg$
Jupiter radius	$7.15 \times 10^7\ m$	Jupiter mass	$1.90 \times 10^{27}\ kg$
Saturn radius	$6.02 \times 10^7\ m$	Saturn mass	$5.68 \times 10^{26}\ kg$

Physics 131-01 Equations

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

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

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

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

$$\vec{F}_{net} = \sum_i \vec{F}_i = m\vec{a} \qquad \vec{F}_{AB} = -\vec{F}_{BA} \quad |\vec{F}_e| = \frac{k_e q_1 q_2}{r^2} \quad |\vec{F}_G| = \frac{Gm_1 m_2}{r^2} \quad d_{Roche} = \left(\frac{12M}{\pi \rho}\right)^{1/3}$$

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

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

$$\cos(90-\theta) = \sin(\theta) \quad PE_G = -\frac{Gm_1 m_2}{r} \quad ME = KE + PE \to ME_f = ME_i \quad \sin(90-\theta) = \cos(\theta)$$

$$\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k} \quad \vec{A} \cdot \vec{B} = |\vec{A}||\vec{B}| \cos \theta = A_x B_x + A_y B_y \quad (1+x)^n \approx 1 + nx \ (x \ll 1)$$

$$\frac{dA}{dt} = 0 \quad \frac{dt}{dt} = 1 \quad \frac{dt^2}{dt} = 2t \quad \int_{x_1}^{x_2} f(x)dx = \lim_{\Delta x \to 0} \sum_{i=1}^{k} f(x_i)\Delta x = \begin{array}{c} \text{area under} \\ \text{curve} \end{array} \quad \int \frac{1}{x^2}dx = -\frac{1}{x}$$

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

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

$$V = \frac{4}{3}\pi r^3 \quad V = \pi r^2 \, l \quad \theta = \frac{s}{r} \quad \rho = \frac{m}{V} \quad \sin(\theta_1 + \theta_2) = \sin \theta_1 \cos \theta_2 + \cos \theta_1 \sin \theta_2$$

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