Physics 131-01 Test 2

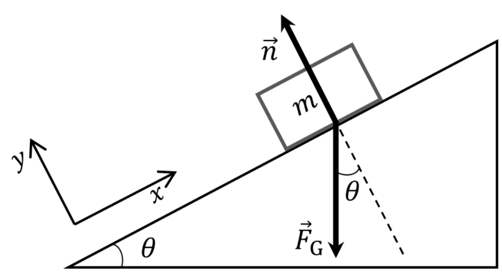
I pledge that I have neither given nor received unauthorized assistance during the completion of this work.

Name ______________________ Signature ______________________

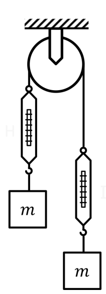
Questions (8 pts. apiece) Answer in complete, well-written sentences WITHIN the spaces provided.

1. Is the gravitational acceleration 'constant' g really a constant? Explain.

2. Consider the case of the block sliding down a "smooth" plane with a negligible amount of friction. The free-body diagram and coordinate system chosen for analysis are shown in the figure below. What is the sum of the x-components of the forces in terms of m, θ, g, and any other necessary constants? What is the sum of the y-components of the forces?



3. Suppose you hang equal masses of $m = 0.5\ kg$ in the configuration shown below. What do you predict for the reading on the spring scale? Explain your reasoning.



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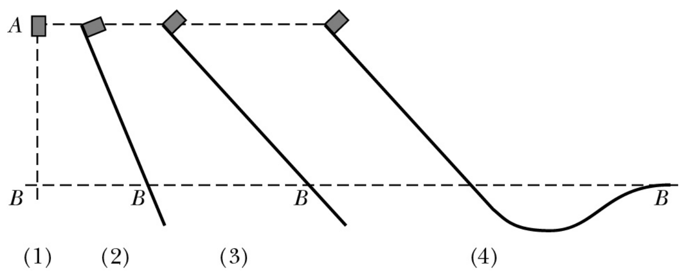
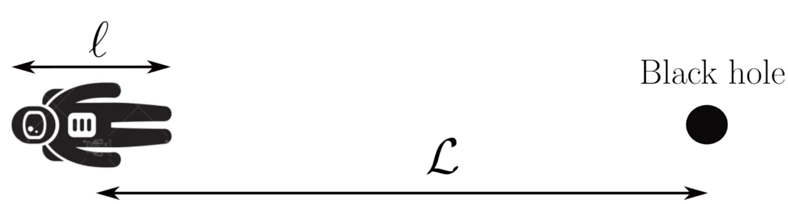
4. Recall the bungee-cord problem we solved in class. We put the origin at ground level ($y = 0$) and the jumper stepped off the bridge at an initial height $y_i = 267\ m$. We solved a quadratic equation and obtained two roots $y_{f1} = 258\ m$ and $y_{f2} = -8\ m$. What does each root tell us about the safety of the bungee system? Explain.

5. The figure below shows four situations - one in which an initially stationary block is dropped from rest (part (1) on the left-hand side of the figure below) and three in which the block is allowed to slide down frictionless ramps (parts (2)-(4) in the figure). Rank the situations according to the speed of the block at point B with the greatest first. Explain your reasoning.



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. An astronaut in a spacesuit has a length $\ell = 1.5\ m$ and a mass $m = 100\ kg$. She has strayed too close to a black hole having a mass 100 times that of the Sun. Her feet point towards the black hole, and the distance between her center and the center of the black hole is $\mathcal{L} = 1000.0\ km$. See the figure. What is the difference in the gravitational forces acting on the bottom of her feet and the top of her head? Assume half her mass is concentrated at each of these points. How many tons is this result ($1\ N = 1.124 \times 10^{-4}$ tons)? Is she in trouble?



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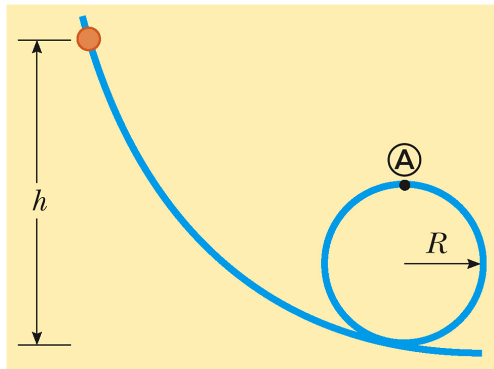
2. 20 pts. A bead slides without friction around a loop-the-loop (see the figure). The bead is released from a height $h = 4R$. (a) What is its speed at point **A** in terms of R, and any other constants? (b) What is Newton's Second Law for the bead at **A**? (c) How large is the normal force if its mass is m? Get your answer in terms of m, R, and any other constants.



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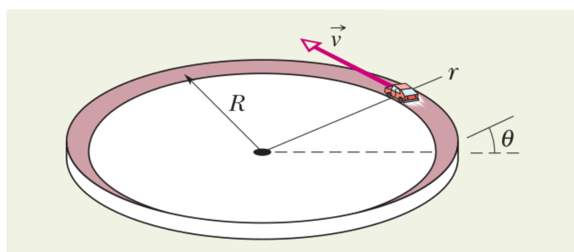
3. 25 pts. You cannot always count on friction to hold your car on the road on a turn if the road is wet or icy. This is why highway curves are banked. Suppose a car of mass m moves at a constant speed v around a banked, circular curve with a radius R. What bank angle θ is necessary so friction is unnecessary? Get your answer in terms of m, v, R, and any other constants.



Physics 131-01 Constants and Conversion Factors

Speed of Light (c)	$2.9979 \times 10^8\ m/s$	proton/neutron mass	$1.67 \times 10^{-27}\ kg$
R	$8.31 J/K - mole$	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	$5.9742 \times 10^{24}\ kg$
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	$1.99 \times 10^{30}\ kg$
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

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

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

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

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

$$\vec{F}_{net} = \sum_i \vec{F}_i = m\vec{a} \qquad \vec{F}_{AB} = -\vec{F}_{BA} \quad |\vec{F}_e| = \frac{k_e q_1 q_2}{r^2} \quad |\vec{F}_G| = \frac{Gm_1m_2}{r^2} \quad d_{Roche} = \left(\frac{12M}{\pi\rho}\right)^{1/3}$$

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

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

$$PE_G = -\frac{Gm_1m_2}{r} \quad ME = KE + PE \to ME_f = ME_i$$

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

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

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

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

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