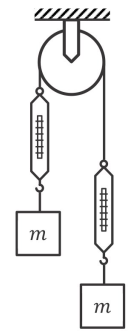
Physics 131-01 Test 1

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.

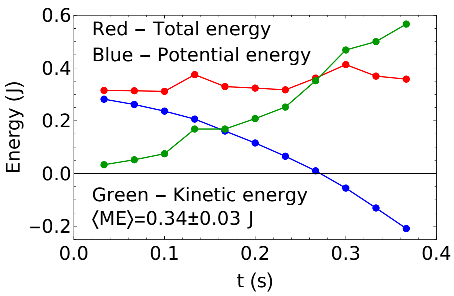
1. Suppose you were to hang equal masses of $m = 0.5\ kg$ in the configuration shown here. What is the tension in the string? Explain.

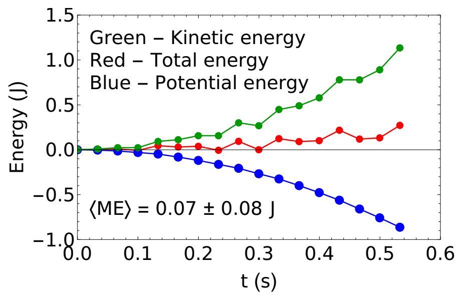


2. Consider the following equation. Is it correct? Why?

$$\int_{t_i}^{t_f} \frac{d\vec{p}}{dt} dt = \Delta\vec{p}$$

3. The plots show two tests of mechanical energy conservation done by measuring a falling ball as a function of time. Is mechanical energy conserved in each case here? Explain. Be quantitative in your answer.





DO NOT WRITE ON THIS PAGE BELOW THE LINE.

4. Which kinds of surfaces do you think will have the most friction - rough ones or smooth ones? Why?

5. In the movie *Elysium* the rich live off-planet on the rim of a large, circular habitat like the one in the figure (also known as a von Braun wheel). The habitat has a 20 km radius and is spun so that people standing on the rim feel a normal, Earth-like gravity. High-speed trains carry people around the rim. If you were riding on such a train in the same direction as the rotation of the rim, would your measured weight (*i.e.* the reading of a scale you are standing on) increase, decrease, or stay the same? Explain.

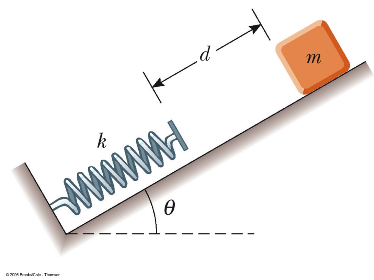
Problems (3). Clearly show all reasoning for full credit. Use a separate sheet to show your work.

1. 15 pts. Three forces, given by $\vec{F}_1 = (2.0\hat{i} + 2.0\hat{j})N$, $\vec{F}_2 = (5.0\hat{i} - 21.0\hat{j})N$, and $\vec{F}_3 = (-40.0\hat{i})N$ act on an object to give it an acceleration of magnitude 3.0 m/s^2.

    1. What is the direction of the acceleration?

    2. What is the mass of the object?

2. 20 pts. An object of mass m starts from rest and slides a distance d down a frictionless incline of angle θ. See the figure. While sliding, it contacts an unstressed spring of negligible mass as shown in the figure. The object slides an additional distance x as it is brought momentarily to rest by compression of the spring (of force constant k). Find the initial separation d between the object and the spring in terms of k, x, m, θ, and any other constants.



3. 25 pts. Much of our knowledge of the subatomic world is extracted with the help of the conservation laws. A radioactive nucleus at rest decays into an electron with momentum $\vec{p}_e = (1.22 \times 10^{-22}\ kg - m/s)\hat{i}$ and another particle with a momentum $\vec{p}_\nu = (6.4 \times 10^{-23}\ kg - m/s)\hat{j}$ leaving a residual, recoiling nucleus behind.

   1. What is $\vec{p}_n$ of the recoiling nucleus? Use the unit-vector notation to express your answer.
   2. The recoiling nucleus has a kinetic energy $KE_n = 1.59 \times 10^{-19}\ J$. What is the mass of the nucleus?
   3. What is the direction (or angle θ_n) of the recoiling nucleus?

Physics 131-01 Equations and Constants

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

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

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

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

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

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

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

$$ME = KE + PE \to ME_f = ME_i \quad \vec{J} = \int_{t_1}^{t_2}\vec{F}dt = \Delta\vec{p} \quad \vec{p} = m\vec{v} \to \vec{p}_i = \vec{p}_f$$

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

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

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

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

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

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'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	$7.3477 \times 10^{22}\ kg$