Physics 131-01 Final Exam

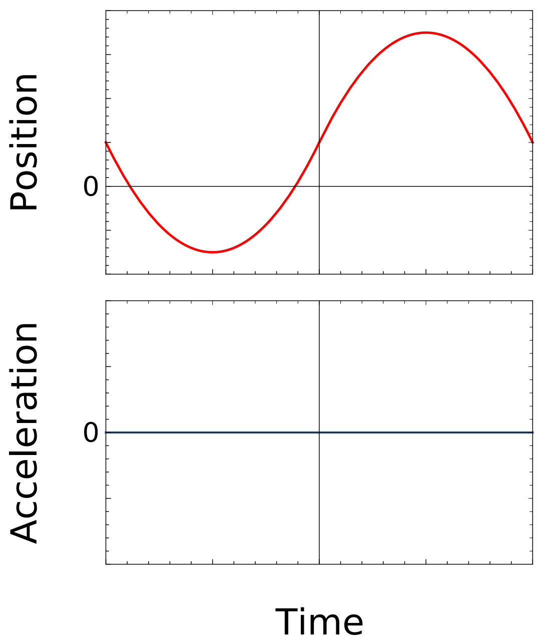
I pledge that I have neither given nor received unauthorized assistance during the completion of this work.

Signature ________________________________

Questions (5 pts. apiece) Answer in complete, well-written sentences WITHIN the spaces provided.

1. In the laboratory entitled *Galilean Relativity*, you measured the horizontal position of a projectile as a function of time from a stationary inertial frame and a moving one fixed to the projectile launcher. How did the two plots differ in appearance? Explain the difference.

2. In the bottom panel of the figure below sketch the acceleration versus time graph that would match the position versus time plot that is shown in the top panel of the figure. State the reasoning behind your sketch.

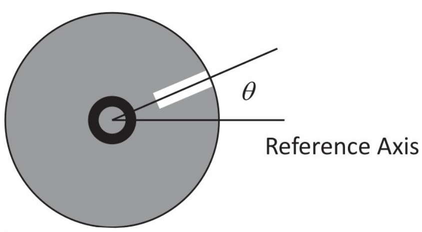


3. How is the work done on an object related to its kinetic energy? How is the work done on an object related to its potential energy? What is your evidence?

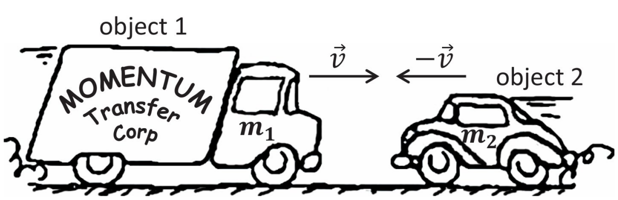
4. Suppose President Crutcher drops a 2.0-kg water balloon from the top of Maryland Hall (10.0 meters above the ground). The president takes the origin of his vertical axis to be even with the level of the top of the building. A student standing on the ground below considers the origin of his or her coordinate system to be at ground level. If the president and the student each calculate the total mechanical energy of the water balloon after it is released will their values agree? Explain.

5. There is a significant gravitational attraction halfway between the earth and the moon. Why, then, do astronauts experience 'weightlessness' when they are orbiting a mere 120 km above the earth?

6. Recall the rotating disk we studied in lab. The figure shows the rotator with a white marker on the disk and the definition of angular displacement. Consider when the disk is rotating at a constant speed. At any given time during the rotation, is the rate of change of the angle between the reference axis and the inner edge of the white marker the same as the rate of change of the angle between the axis and the outer edge, or do the rates differ? Explain.



7. Consider the collision shown below. The mass of object 1 is greater than that of object 2 and the objects are moving toward each other at the same speed 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 your reasoning.



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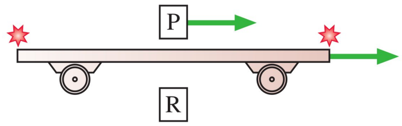
8. The figure shows Pat (P) standing at the center of her railroad car as it passes Rick (R) on the ground. Firecrackers attached to the ends of the car explode. A short time later, the flashes of light from the two explosions arrive at Pat at the same time. Were the explosions simultaneous in Pat's reference frame? If not, which exploded first? Explain your answer.



9. Consider the previous question. Were the explosions simultaneous in Rick's reference frame? If not, which exploded first? Explain your answer.

10. A mass m is hung from a spring with spring constant k_0. The spring is then cut into equal halves and the same mass is hung from one of the remaining half-springs. What is the spring constant k_1 of each half-spring in terms of k_0? Hint: Consider the forces exerted on the full- and half-springs when the mass m is hung on each.

Problems. Clearly show all reasoning for full credit. Use a separate sheet for your work.

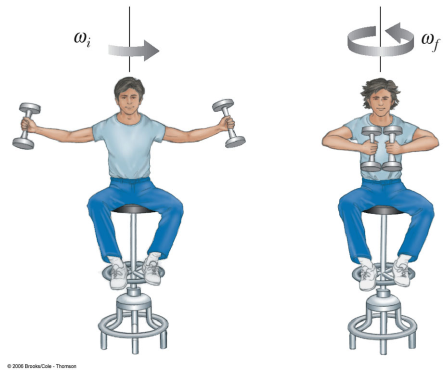
1. 8 pts. A friend passes by you in a spacecraft traveling at a high speed. She tells you that her craft is $\ell_1 = 25.0\ m$ long and that the identically constructed craft you are sitting in is $\ell_2 = 23.0\ m$ long. According to your observations, (a) how long is your spacecraft, (b) how long is your friend's craft, and (c) what is the speed of your friends craft?

2. 8 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 $m = 50\ kg$. Including the drivers the total vehicle masses are $m_c = 1000\ kg$ for the car and $m_t = 4000\ kg$ for the truck. What is the impulse $\vec{J}$ for each driver?

Do not write below this line.

Problems (continued). Clearly show all work for full credit.

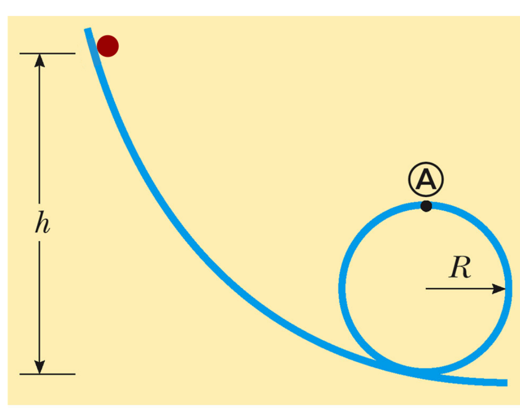
3. 8 pts. A student sits on a freely rotating stool holding two weights, each of mass $m = 4.0\ kg$ as shown in the figure. When his arms are extended horizontally, the weights are $\ell_1 = 1.0\ m$ from the axis of rotation and he rotates with an angular speed of $\omega_1 = 0.8\ rad/s$. The moment of inertia of the student plus stool is $I_s = 3.0\ kg - m^2$ and is assumed to be constant. The contribution of the student's arms to the moment of inertia is negligible. Treat the weights as points. The student pulls the weights inward horizontally to a position $\ell_2 = 0.45\ m$ from the rotation axis. What is the new angular speed of the student?



4. 8 pts. You've graduated from college and fulfilled a childhood dream to become a homicide detective in a large city. On your first day at work, you're investigating the death of a man who was found a distance $x_1 = 1.5$ m from the base of his apartment building and a height $y_i = 20$ m below his balcony. Do you think the death is accidental? Explain. The typical horizontal speed of a person who has been shoved is up to $v_s \approx 1.5\ m/s$.

5. 9 pts. You are riding in a car that is going around a flat curve that has a radius of $r = 40\ m$ from the middle of the car to the center of curvature. A good-luck charm that is hanging on the rear-view mirror from a string of length $\ell = 0.3\ m$ has a mass $m = 0.1\ kg$. The string makes an angle $\theta = 35.0\ deg$ to the vertical. What is the speed v of the car?

6. 9 pts. A pool ball (a uniform, solid sphere) rolls around a loop-the-loop (see the figure). The ball is released from a height $h = 3.0R$. (a) What is its speed at point **A** in terms of R and any other necessary constants? (b) How large is the normal force on it if its mass is $m = 0.17\ kg$?



Physics 131-1 Final Exam Sheet

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

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

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

$$\vec{A} = A_x\hat{i} + A_y\hat{j} \quad \vec{A}+\vec{B} = (A_x+B_x)\hat{i} + (A_y+B_y)\hat{j} \quad \vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta = A_xB_x + A_yB_y$$

$$\vec{F}_{net} = \sum_i \vec{F}_i = m\vec{a} = \frac{d\vec{p}}{dt} \quad \vec{F}_{AB} = -\vec{F}_{BA} \quad \vec{p} = \sum m_i\vec{v}_i \quad \vec{p}_i = \vec{p}_f$$

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

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

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

$$d_{Roche} = \left(\frac{12M}{\pi\rho}\right)^{1/3} \quad \rho = \frac{m}{V} \quad \vec{J} = \int_{t_1}^{t_2}\vec{F}dt = \Delta\vec{p}$$

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

$$\vec{\tau} = rF\sin\phi\,\hat{\theta} = I\vec{\alpha} = \frac{d\vec{L}}{dt} \quad \vec{L} = \sum I_i\vec{\omega}_i \quad \vec{L}_i = \vec{L}_f \quad v_{cm} = r\omega$$

$$x(t) = A\cos(\omega t + \phi) \quad \omega^2 = \frac{k}{m} \quad T = \frac{2\pi}{\omega} = \frac{1}{f} \quad PE = \frac{1}{2}kx^2 \quad ME = \frac{1}{2}kA^2$$

$$\Delta t = \frac{\Delta t'_p}{\sqrt{1-\frac{v^2}{c^2}}} \quad L' = L_p\sqrt{1-\frac{v^2}{c^2}} \quad v'_i = \frac{v_i - v}{1-\frac{v'_i v}{c^2}} \quad v'_i = v_i - v \quad x' = x - vt \quad y' = y$$

$$\frac{dA}{dt} = 0 \quad \frac{dt}{dt} = 1 \quad \frac{dt^2}{dt} = 2t \quad \frac{d}{dt}\cos\theta = -\sin\theta \quad \frac{d}{dt}\sin\theta = \cos\theta \quad \frac{df(x)}{du} = \frac{df(x)}{dx}\frac{dx}{du}$$

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

$$\sin\theta = \frac{opp}{hyp} \quad \cos\theta = \frac{adj}{hyp} \quad \tan\theta = \frac{opp}{adj} \quad \cos^2\theta + \sin^2\theta = 1 \quad x^2+y^2+z^2 = R^2 \quad V = \frac{4}{3}\pi r^3$$

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

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-Sun distance	$1.50 \times 10^{11}\ m$	Earth's mass	$5.98 \times 10^{24}\ kg$
Earth-Moon distance	$3.84 \times 10^8\ m$	Electron mass	$9.11 \times 10^{-31}\ kg$

TABLE 10.2 Moments of Inertia of Homogeneous Rigid Objects With Different Geometries