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.

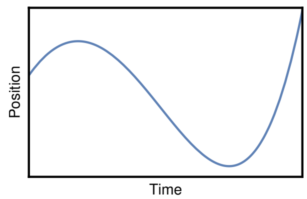
1. Consider the *Twin's Paradox* lab. As the space-faring twin's craft recedes from the Earth it is moving at a constant speed. Since no inertial frame can be considered 'better' than any other there is nothing physically inconsistent with the view that the space-faring twin is observing the Earth recede from her at a constant velocity. Hence, the space-faring twin will observe clocks on the Earth to move slowly and the Earth-bound twin will age at a slower rate than the space-faring one. Is this reasoning flawed? How?

2. What evidence can you cite to support relativistic Time Dilation? Explain how the evidence supports it.

3. In the lab entitled *Galilean Relativity* we observed the vertical component of the ball's flight was the same whether measured with a fixed origin or with a moving origin attached to the cart. How would you explain this observation to someone who had never encountered this phenomenon?

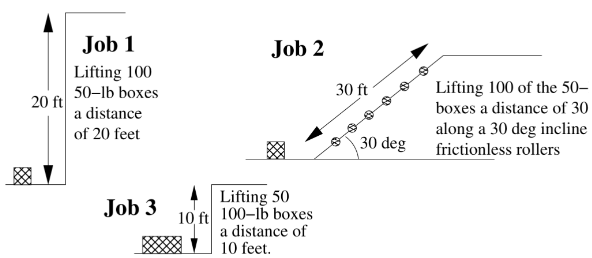
4. A solid ball and a spherical shell of the same mass and radius are released from rest at the top of an incline. Which one reaches the bottom of the incline first? Why?

5. Consider the one-dimensional position versus time plot below. Does the acceleration of the object change? If so, when is the magnitude of the acceleration largest? Explain.



6. Is the gravitational acceleration at the Earth's surface, the constant g, really a constant? Explain.

7. Suppose you are president of the Richmond Load 'n' Go Co. A local college has three jobs available and will allow you to choose which one you want to do. All three jobs pay the same amount. Examine the descriptions of the jobs shown in the figure. Which one requires the least amount of work? Explain.



8. A mass with a known mechanical energy ME is undergoing simple harmonic motion. Where is the kinetic energy of the mass greatest? Where is it least? Hint: A sketch would help.

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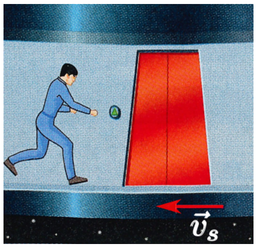
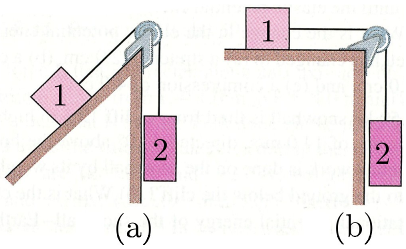
9. The figure below shows a section of a circular space station that rotates about its center to give apparent weight W_a to each crew member. One of the crew is shown at the outer wall of the station which has a velocity $\vec{v}_s$ as shown. If the astronaut runs along the outer wall in the direction opposite $\vec{v}_s$ with a speed less than the magnitude of $\vec{v}_s$ does their apparent weight W_a increase, decrease, or stay the same? Explain.



10. The figure below shows two arrangements of the same two blocks on a frictionless plane. The blocks are connected by a taut cord that runs over a massless, frictionless pulley. In each arrangement, the hanging block (#2) descends when the blocks are released. Consider the total kinetic energy of the two blocks when the hanging block has descended by a distance d. Is the total kinetic energy in arrangement (a) more than, less than, or the same as that in arrangement (b)? Explain.



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. He tells you that his craft is $\ell_1 = 20.0\ m$ long and that the identically constructed craft you are sitting in is $\ell_2 = 19.0\ m$ 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 friend's craft?

2. 8 pts. A car of mass $m_1 = 2000\ kg$ car is moving at $v_1 = 20.0\ m/s$ collides and locks together with a car with $m_2 = 1300\ kg$ at rest at a stop sign. Use Newtonian/Galilean relativity to show that momentum is conserved in a reference frame moving at $v_{fr} = 8.0\ m/s$ in the direction of the moving car.

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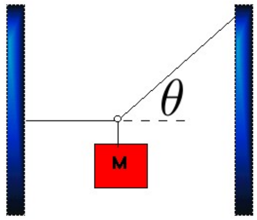
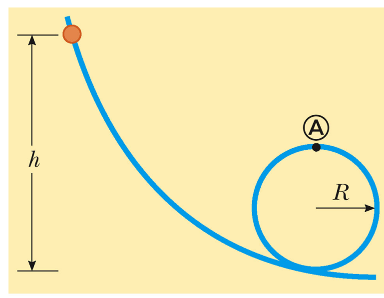
Problems (continued). Clearly show all reasoning for full credit.

3. 8 pts. A block of mass $M = 15\ kg$ is suspended at rest by two strings attached to walls, as shown in the figure. The left string is horizontal and the right string makes an angle $\theta = 50°$ with the horizontal. What is the tension T in the left string? (Assume the ring where the strings come together is massless.)

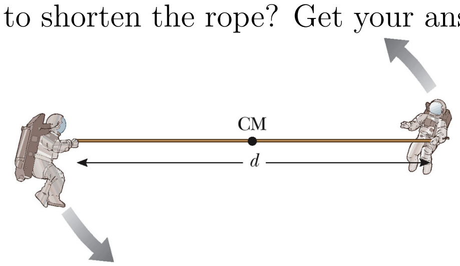


4. 8 pts. A bead slides without friction around a loop-the-loop (see the figure). The bead is released from a height $h = 3.5R$ and $R = 0.5\ m$. (a) What is its speed at point **A**? (b) How large is the normal force on it if its mass is $m = 2.0\ kg$?



5. 9 pts. A baseball player friend of yours wants to determine their pitching speed. (a) You have them stand on a ledge and throw a ball horizontally from an elevation of $y_i = 4.0\ m$. The ball lands a distance $x_f = 25\ m$ away. What is their pitching speed v_i? (b) Suppose a video analysis of their motion reveals the ball is thrown at an angle θ. What is the new v_i? Get your answer in (b) symbolically in terms of the known parameters x_f, y_i, θ.

6. 9 pts. Two astronauts (see figure), each having mass M, are connected by a rope of length d and negligible mass. They are isolated in space, orbiting their center of mass at speeds of v_i. Treating the astronauts as particles, what is (a) the magnitude of the angular momentum of the system L_i and (b) the rotational energy of the system E_i? By pulling on the rope, one of the astronauts shortens the distance between them to $d/2$. (c) What is the new angular momentum L_f of the system? (d) What are the astronauts' new speeds v_f? (e) What is the new rotational energy E_f of the system? (f) How much work W does the astronaut do to shorten the rope? Get your answers in terms of M, v_i, and d.



Physics 131-1 Final Exam Equations and Constants

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

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

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

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

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

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

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

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

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

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

$$\vec{\tau} = I\vec{\alpha} = \frac{d\vec{L}}{dt} \approx \frac{\vec{\Delta}L}{\Delta t} \quad \vec{L} = \sum I_i\vec{\omega}_i = \sum r_i m_i \vec{v}_{i\perp} \quad \vec{L}_i = \vec{L}_f \quad v_{cm} = r\omega \quad \theta = \frac{\alpha}{2}t^2 + \omega_i t + \theta_i \quad \omega = \alpha t + \omega_i$$

$$x(t) = A\cos(\omega t + \phi) \quad \omega^2 = \frac{k}{m} \quad T = \frac{2\pi}{\omega} = \frac{1}{f} \quad PE = \frac{1}{2}kx^2 \quad ME_s = \frac{1}{2}kA^2 \quad \sin\theta \approx \theta \quad \omega^2 = \frac{mg\ell}{I}$$

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

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

$$\int f(x)dx = \lim_{\Delta x\to 0}\sum f(x_i)\Delta x \quad \int dx = x + c \quad \int xdx = \frac{x^2}{2} + c \quad \left(1-\frac{v^2}{c^2}\right)^{\pm 1/2} \approx 1 \mp \frac{1}{2}\frac{v^2}{c^2}$$

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

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

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 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	$1.99 \times 10^{30}\ kg$
Earth-Sun distance	$1.50 \times 10^{11}\ m$	1 u	$1.661 \times 10^{-27}\ kg$

Moments of Inertia