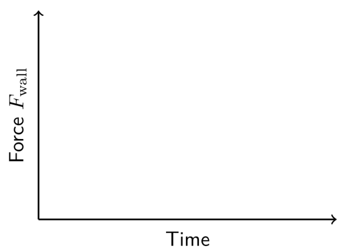
Physics 131-01 Test 3

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. You will be penalized for not following directions.

1. Draw the shape of the force the wall exerts on a moving object like a ball during a collision as a function of time on the axes below. Explain your reasoning.

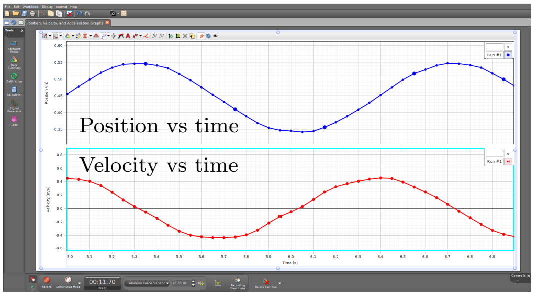


2. You are driving along a two lane highway in a loaded, moving van that weighs 8000 lbs. You are going 15 MPH when you pass a group of first graders starting to cross the road. Just as you pass the children you see a 2000-lb sports car in the oncoming lane heading straight for the children at 80 MPH. You figure that you just have time to swing into the oncoming lane and speed up a bit before making a head-on collision with the sports car. You want your truck and the sports car to crumple into a heap that sticks together and doesn't move. Can you save the children or is this a suicidal act? Explain.

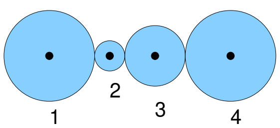
3. What is the parallel axis theorem? Describe each element or factor in your answer.

DO NOT WRITE ON THIS PAGE BELOW THE LINE.

4. Recall the measurements you made of periodic motion like the ones in the figure below. Do the position and velocity graphs have the same period? Do their peaks occur at the same times? If not, how are the peaks related in time, *i.e.* what fraction of a period is their phase difference?



5. The figure below shows four gears that rotate together because of the friction between them so they turn without slipping. Gears 1 and 4 have radius $3R$, gear 2 has radius R, and gear 3 has radius $2R$. Gear 2 is forced to rotate by a motor. Rank the four gears according to the angular speed of the gears with the greatest first. Explain your reasoning.



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

1. 15 pts. An object in simple harmonic motion has amplitude $A = 4.0\ cm$ and frequency $f = 4.0\ Hz$, and at $t = 0\ s$ it passes through the equilibrium point moving to the right. Write the function $x(t)$ that describes the object's position.

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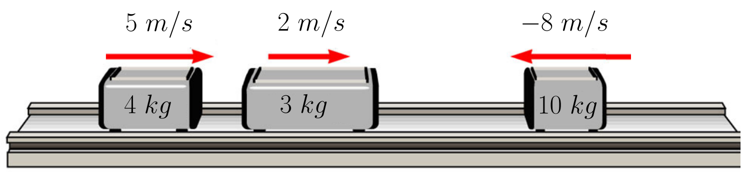
2. 20 pts. Three carts of masses $m_1 = 4.0\ kg$, $m_2 = 3.0\ kg$, and $m_3 = 10.0\ kg$ move on a frictionless, horizontal track with speeds of $v_1 = 5.0\ m/s$, $v_2 = 2.0\ m/s$, and $v_3 = -8.0\ m/s$, respectively, as shown in the figure below. Velcro couplers make the carts stick together after colliding. (a) Find the final velocity of the train of three carts. (b) Does your answer require that all the carts collide and stick together at the same time? What if they collide in a different order?



3. 25 pts. A woman of $m_w = 60.0 - kg$ stands at the rim of a horizontal turntable having a moment of inertia of $I_t = 500\ kg \cdot m^2$ and a radius $r_t = 2.0\ m$. The turntable is initially at rest and free to rotate about a frictionless, vertical axle through its center. The woman starts walking around the rim clockwise (as viewed from above the system) at a constant speed $v_w = 1.5\ m/s$ relative to the Earth. Treat her as a point particle on the rim of the table. (a) In what direction and with what angular speed w_t does the turntable rotate? (b) How much work does the woman do to set herself and the turntable into motion?

Physics 131-1 Equations and Constants, Test 3

$$\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k} \quad \Delta\vec{r} = \vec{r}_{finish} - \vec{r}_{start} \quad \Delta\vec{v} = \vec{v}_{finish} - \vec{v}_{start}$$

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

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

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

$$\vec{F}_{net} = \sum_i \vec{F}_i = m\vec{a} = \frac{d\vec{p}}{dt} \qquad \vec{F}_{AB} = -\vec{F}_{BA} \quad \vec{p} = \sum m_i\vec{v}_i \quad \vec{p}_i = \vec{p}_f \quad \Delta\vec{p} = \vec{J} = \int_{t_1}^{t_2}\vec{F}dt \quad \rho = \frac{m}{V}$$

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

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

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

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

$$\vec{L} = \sum_j I_j \vec{\omega}_j \quad \vec{L}_i = \vec{L}_f \quad \vec{\tau} = rF\sin\phi\ \hat{\theta} = I\vec{\alpha} = \frac{d\vec{L}}{dt} \approx \frac{\vec{\Delta} L}{\Delta t} \quad v_{cm} = r\omega \quad \theta = \frac{\alpha}{2}t^2 + \omega_i t + \theta_i \quad \omega = \alpha t + \omega_i$$

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

$$\frac{dA}{dt} = 0 \quad \frac{dt}{dt} = 1 \quad \frac{dt^2}{dt} = 2t \quad \frac{d}{dt}\cos\theta = -\sin\theta \quad \frac{d}{dt}\sin\theta = \cos\theta \quad \cos(\theta - \frac{\pi}{2}) = \sin\theta \quad \sin(\theta + \frac{\pi}{2}) = \cos\theta$$

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

$$\sin\theta = \frac{opp}{hyp} \quad \cos\theta = \frac{adj}{hyp} \quad \tan\theta = \frac{opp}{adj} = \frac{\sin\theta}{\cos\theta} \quad x^2 + y^2 + z^2 = R^2 \quad \rho = \frac{m}{V} \quad a^2 - b^2 = (a-b)\cdot(a+b)$$

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

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