PHYS 2211 Test 4
Fall 2015

Name(print)____ **Section #** __________________

Fenton (C), Gumbart (M), Schatz(N)			
Day	12-3pm	3-6pm	6-9pm
Monday	C02 N02	C01 M01	
Tuesday	M03 N01	M06 C03	C04 N03
Wednesday	C05 N05	M02 N06	
Thursday	M04 C06	M05 N04	

Instructions

- Read all problems carefully before attempting to solve them.
- Your work must be legible, and the organization must be clear.
- You must show all work, including correct vector notation.
- **Correct answers without adequate explanation will be counted wrong.**
- Incorrect work or explanations mixed in with correct work will be counted wrong. Cross out anything you do not want us to grade
- Make explanations correct but brief. You do not need to write a lot of prose.
- Include diagrams!
- **Show what goes into a calculation, not just the final number, e.g.:** $\frac{a \cdot b}{c \cdot d} = \frac{(8\times10^{-3})(5\times10^{6})}{(2\times10^{-5})(4\times10^{4})} = 5\times10^{4}$
- Give standard SI units with your numeric results.

Unless specifically asked to derive a result, you may start from the formulas given on the formula sheet, including equations corresponding to the fundamental concepts. If a formula you need is not given, you must derive it.

If you cannot do some portion of a problem, invent a symbol for the quantity you can not calculate (explain that you are doing this), and use it to do the rest of the problem.

Honor Pledge

"In accordance with the Georgia Tech Honor Code, I have neither given nor received unauthorized aid on this test."

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Sign your name on the line above

Period 1, December 7th (Monday) from 8:00am - 10:50am

Every semester, someone receives a zero on the final because they missed the exam. Please don't let this happen to you! We will post specific room assignments on Piazza once they are available.

Stressing over a conflict?

Did you complete "PHYS 2211 Final Exam Schedule" on WebAssign? If so, then you are all set for the conflict exam
Period 7, December 8th (Tuesday) from 2:50pm - 5:40pm.

Are you an ADAPTS Student?

Don't forget to schedule your final with the ADAPTS office. Don't delay, spaces are limited.

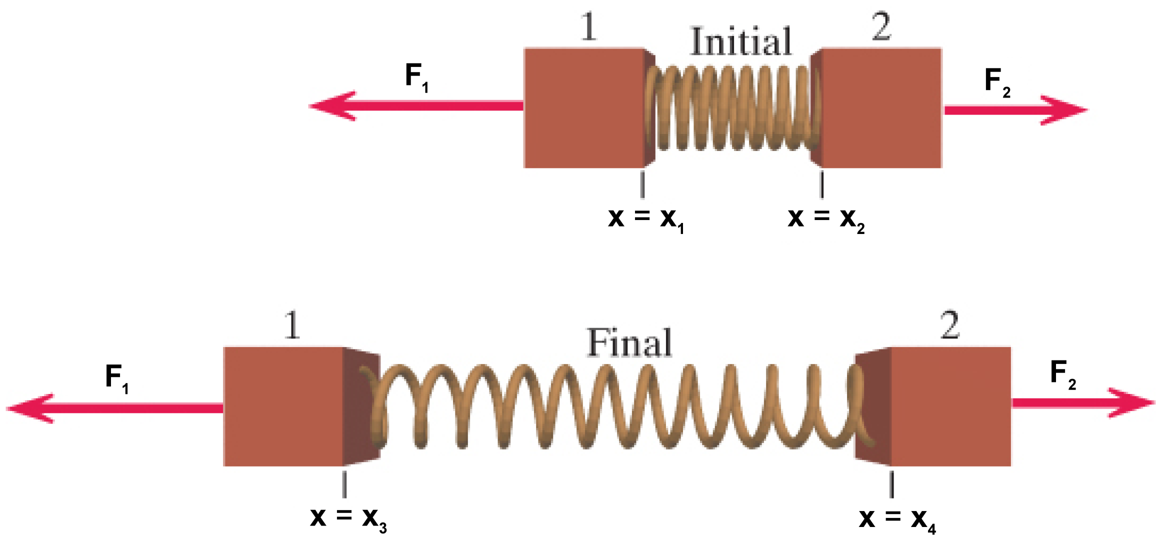
PHYS 2211

Please do not write on this page

Problem	Score	Grader
Problem 1 (25 pts)		
Problem 2 (25 pts)		
Problem 3 (25 pts)		
Problem 4 (25 pts)		

Problem 1 (25 Points)

A system of two identical blocks and spring are initially at rest. The blocks have mass M (labeled 1 and 2) are connected by an unstretched spring and slide on a frictionless surface. As shown in the upper diagram, a constant force F_1 is applied to block 1 and a constant force F_2 is applied to block 2. Initially the first block is located at $x_1 = 0$. At a later time, the blocks are in a new position as indicated in the lower diagram. Block 1 has moved to the left and block 2 has moved to the right. At this final time, the system is moving to the left, vibrating, and the spring is stretched. In this diagram, the positive x-direction is to the right.



(a 5 pts) How far did the center of mass of the extended system move?

(b 10pts) Use the point particle system (i.e. the center of mass) to determine the velocity of the center of mass for the system.

(c 10pts) Use the extended system (real system) to determine the final vibrational energy of the extended system (spring potential energy plus kinetic energy relative to the center of mass).

Problem 2 (25 Points)

(a 10pts) Professors Fenton and Gumbart are arguing over who makes the best flan and up in a flan fight! Prof. Fenton throws his flan that weights 0.55 kg with velocity $< 3, 4, 0 >$ m/s and Prof. Gumbart throws his flan that weights 0.7 kg with velocity $< -4, 3.5, 0 >$ m/s. The flans collide and stick together. Calculate the velocity of the stuck together pieces of flan.

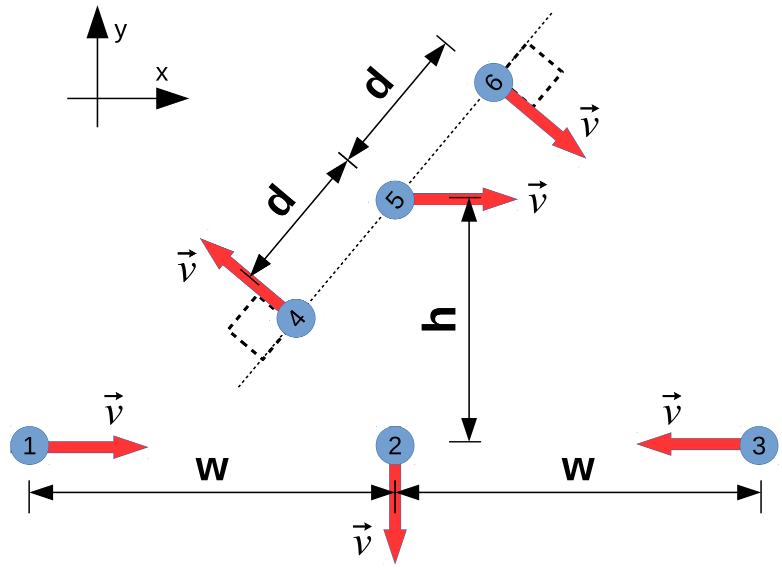
(b 5pts) What is the final kinetic energy of the the stuck together pieces of flan?

(c 5pts) Calculate the total change in internal energy (deformation, thermal, etc.) during the collision.

(d 5pts) Determine the total kinetic energy for both flans if they had not stuck together but had collided in a perfectly elastic collision.

Problem 3 (25 Points)

Each of the six particles in the figure have identical mass m and moves in the x-y plane with the same speed v as indicated in the diagram. **Take the location of particle 5 as the reference point for all angular momentum calculations when answering the following questions. Be sure to express your answer as a vector.**



(a 2pts) What is the angular momentum of particle 1?

(b 2pts) What is the angular momentum of particle 2?

(c 2pts) What is the angular momentum of particle 3?

(d 2ts) What is the angular momentum of particle 4?

(e 2pts) What is the angular momentum of particle 5?

(f 2pts) What is the angular momentum of particle 6?

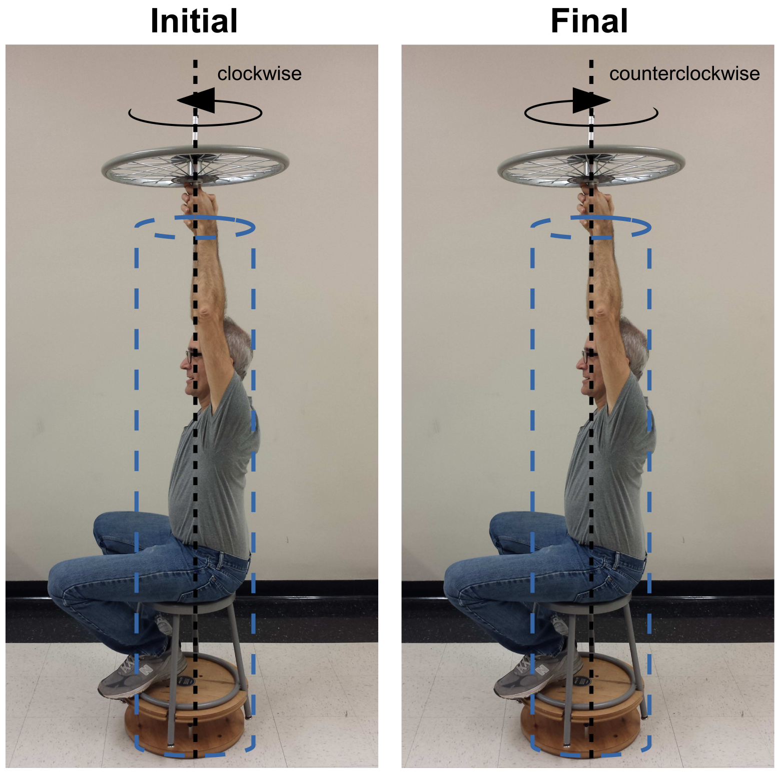
(i 4pts) Consider all six particles as a system. What is the total angular momentum of the system with respect to the location of particle 5? Express your answer as a vector in component form.

(j 5pts) Consider all six particles as a system. What is the translational angular momentum of the system with respect to the location of particle 5?? Express your answer as a vector in component form.

(k 4pts) Consider all six particles as a system. What is the rotational angular momentum of the system with respect to the location of particle 5?? Express your answer as a vector in component form.

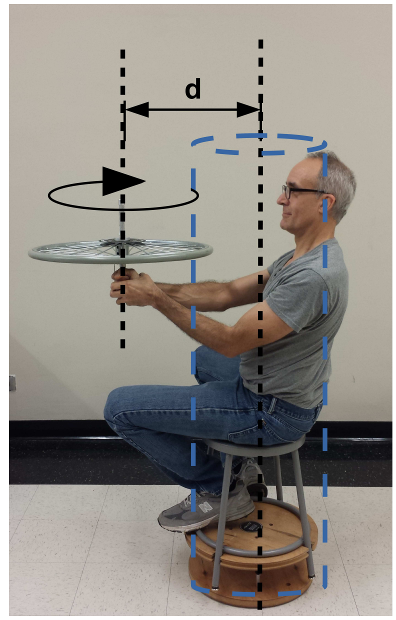
Problem 4 (25 Points)

Prof. Schatz is doing a demonstration in class in which he holds a bicycle wheel, horizontally, directly over his head. Prof. Schatz is sitting in swivel chair such that the wheel, chair, and professor Schatz all share the same symmetry axis as indicated in the figure. The wheel is spinning clockwise with constant angular speed ω when viewed from above and Prof. Schatz is at rest. The moment of inertia for the wheel is $I_w = mR^2$. Prof. Schatz and the chair can be modeled as a perfect cylinder of mass M with radius c and length L.



(a 10pts) Professor Schatz turns the wheel over while maintaining it directly overhead so that the angular speed of the wheel is unchanged but it is now rotating counterclockwise when viewed from above with speed ω. Determine the angular velocity (magnitude and direction) of Prof. Schatz. You can assume that there is negligible friction in the both axles of the wheel and chair.

(b 10pts) Now Prof. Schatz lowers the wheel so that it is directly in front of him a distance d from his axis of rotation. The wheel is still rotating counterclockwise when viewed from above. During this process there is zero net torque on the system. Determine the angular velocity (magnitude and direction) of Prof. Schatz. You can assume that there is negligible friction in both the axles of the wheel and chair. Prof. Schatz and the chair can still be modeled as a perfect cylinder of mass M with radius c and length L.



(c 5pts) Consider the situation immediately after part (b). A tangential friction force F is now applied between the wheel and its axle at a radius a from the center of the wheel. This frictional force is constant. How long does it take the wheel to come to rest with respect to its center of mass (to stop rotating)?

This page is for extra work, if needed.

Things you must have memorized

The Momentum Principle Definition of Momentum	The Energy Principle Definition of Velocity	The Angular Momentum Principle Definition of Angular Momentum
Definitions of angular velocity, particle energy, kinetic energy, and work		

Other potentially useful relationships and quantities

$$\gamma \equiv \frac{1}{\sqrt{1-\left(\frac{|\vec{v}|}{c}\right)^2}} \qquad E^2 - (pc)^2 = \left(mc^2\right)^2$$

$$\frac{d\vec{p}}{dt} = \frac{d|\vec{p}|}{dt}\hat{p} + |\vec{p}|\frac{d\hat{p}}{dt} \qquad \vec{F}_{\parallel} = \frac{d|\vec{p}|}{dt}\hat{p} \text{ and } \vec{F}_{\perp} = |\vec{p}|\frac{d\hat{p}}{dt} = |\vec{p}|\frac{|\vec{v}|}{R}\hat{n}$$

$$\vec{F}_{grav} = -G\frac{m_1 m_2}{|\vec{r}|^2}\hat{r} \qquad U_{grav} = -G\frac{m_1 m_2}{|\vec{r}|}$$

$$\left|\vec{F}_{grav}\right| \approx mg \text{ near Earth's surface} \qquad \Delta U_{grav} \approx mg\Delta y \text{ near Earth's surface}$$

$$\vec{F}_{elec} = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{|\vec{r}|^2}\hat{r} \qquad U_{elec} = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{|\vec{r}|}$$

$$\left|\vec{F}_{spring}\right| = k_s s \qquad U_{spring} = \frac{1}{2}k_s s^2$$

$$U_i \approx \frac{1}{2}k_{si}s^2 - E_M \qquad \Delta E_{thermal} = mC\Delta T$$

$$\vec{r}_{cm} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2 + \ldots}{m_1 + m_2 + \ldots} \qquad I = m_1 r_{1\perp}^2 + m_2 r_{2\perp}^2 + \ldots$$

$$K_{tot} = K_{trans} + K_{rel} \qquad K_{rel} = K_{rot} + K_{vib}$$

$$K_{rot} = \frac{L_{rot}^2}{2I} \qquad K_{rot} == \frac{1}{2}I\omega^2$$

$$\vec{L}_A = \vec{L}_{trans,A} + \vec{L}_{rot} \qquad \vec{L}_{rot} = I\vec{\omega}$$

$$\omega = \sqrt{\frac{k_s}{m}} \qquad v = d\sqrt{\frac{k_{si}}{m_a}}$$

$$Y = \frac{F/A}{\Delta L/L} \text{ (macro)} \qquad Y = \frac{k_{si}}{d} \text{ (micro)}$$

$$\Omega = \frac{(q+N-1)!}{q!\,(N-1)!} \qquad S \equiv k\ln\Omega$$

$$\frac{1}{T} \equiv \frac{\partial S}{\partial E} \qquad \Delta S = \frac{Q}{T} \text{ (small } Q\text{)}$$

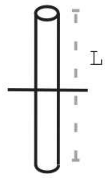
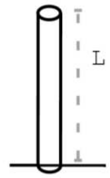
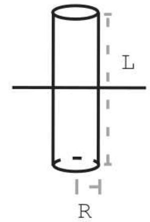
$$\text{prob}(E) \propto \Omega(E)\,e^{-\frac{E}{kT}} \qquad E_N = -\frac{13.6\text{eV}}{N^2} \text{ where } N = 1,2,3\ldots$$

$$E_N = N\hbar\omega_0 + E_0 \text{ where } N = 0,1,2\ldots \text{ and } \omega_0 = \sqrt{\frac{k_{si}}{m_a}} \text{ (Quantized oscillator energy levels)}$$

Moment of intertia for rotation about indicated axis

The cross product

$$\vec{A} \times \vec{B} = \langle A_yB_z - A_zB_y, A_zB_x - A_xB_z, A_xB_y - A_yB_x \rangle$$

				
$I = \frac{2}{5}MR^2$	$I = \frac{1}{2}MR^2$	$I = \frac{1}{12}ML^2$	$I = \frac{1}{3}ML^2$	$I = \frac{1}{12}ML^2 + \frac{1}{4}MR^2$

Constant	**Symbol**	**Approximate Value**
Speed of light	c	3×10^8 m/s
Gravitational constant	G	6.7×10^{-11} N $\cdot$ m^2/kg^2
Approx. grav field near Earth's surface	g	9.8 N/kg
Electron mass	m_e	9×10^{-31} kg
Proton mass	m_p	1.7×10^{-27} kg
Neutron mass	m_n	1.7×10^{-27} kg
Electric constant	$\frac{1}{4\pi\epsilon_0}$	9×10^9 N $\cdot$ m^2/C^2
Proton charge	e	1.6×10^{-19} C
Electron volt	1 eV	1.6×10^{-19} J
Avogadro's number	N_A	6.02×10^{23} atoms/mol
Plank's constant	h	6.6×10^{-34} joule $\cdot$ second
hbar $= \frac{h}{2\pi}$	$\hbar$	1.05×10^{-34} joule $\cdot$ second
specific heat capacity of water	C	4.2 J/g/K
Boltzmann constant	k	1.38×10^{-23} J/K

milli	m	1×10^{-3}	kilo	K	1×10^3
micro	μ	1×10^{-6}	mega	M	1×10^6
nano	n	1×10^{-9}	giga	G	1×10^9
pico	p	1×10^{-12}	tera	T	1×10^{12}