PHYS 2211 Exam 4
Spring 2016

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

Greco (K, M) and Schatz(N)			
Day	12-3pm	3-6pm	6-9pm
Monday	N07 M07	K02 K01	
Tuesday	M01 N01	M02 N02	M03 N03
Wednesday	K05 K03	K07 K04	M08 K06
Thursday	M04 N04	M05 N05	M06 N06

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.:** $\frac{a \cdot b}{c \cdot d} = \frac{(8\times10^{-3})(5\times10^{6})}{(2\times10^{-5})(4\times10^{4})} = 5 \times 10^{4}$
- 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

Final are almost here!

Period 20, May 4th (Wed) from 6:00pm - 8:50pm

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.

Do you have three final exams on May 4th and CS 1371 isn't one of them?

Please email Dr. Greco a copy of your course schedule. He will confirm that you have a conflict and you will be scheduled to take the exam May 6th (Friday) from 8:00am - 10:50am. If we do not hear from you before the start of final exams you will be required to take the exam during Period 20.

Are you an ADAPTS Student? Don't forget to schedule your final with the ADAPTS office.

`Problem 1` Grader: ______________________ Score: ______/25

Prof. Schatz, Prof. Fenton, and Prof. Gumbart each purchase a cup of coffee. Each cup contains 350 grams of coffee at 93° C. The specific heat of coffee is 4.2 J/(g·C). The cups are well insulated so that no energy is transferred between the coffee and the cup.

(a 10pts) Prof. Schatz prefers to drink his coffee at 82° C. Cream has a specific heat of 3.8 J/(g·C) and an initial temperature of 5° C. How many grams of cream should he add to bring his coffee to the desired temperature?

(b 10pts) Prof. Gumbart likes to add sugar to his coffee. Sugar has a specific heat of 1.2 J/(g·C) and an initial temperature of 20° C. Prof. Gumbart adds 16 grams of sugar to his coffee and stirs. By stirring the coffee, Prof. Gumbart is doing 15 J of work on his coffee. What is the final temperature of the coffee after the liquid comes to rest?

(c 5pts) After purchasing his coffee, Prof. Fenton decides to take a siesta. When he wakes up, he finds that his coffee has reached thermal equilibrium with the air and is at 20° C. Taking the coffee as the system, determine what the thermal transfer of energy Q was between the system and the surroundings.

`Problem 2` Grader: ________________________ Score: ______/25 ______/25

Charu has a mass m. In an experiment she crouched down, then jumped straight up. Her lab partners, Luis and Aparajita, measured the height of her center of mass above the floor at three instants: 1) h_1 when crouched down; 2) h_2 just as her feet were leaving the floor; 3) h_3 the height at the top of the jump.

(a 5pts) How fast was Charu moving when her feet left the floor? It will help if you start by first drawing a diagram of the situation.

(b 10pts) What was the average force of the floor on Charu's feet $\vec{F}_{\text{floor}}$ during the first part of her jump, that is between instances (1) and (2)?

(c 10pts) What was the change in Charu's internal energy ΔE_{int} during the complete jump, that is between instances (1) and (3)?

`Problem 3` Grader: ______________________ Score: ______/25 ______/25 ______/25

A car of mass 2500 kg collides with a motorcycle of mass 300 kg. Just after the collision, the car and motorcycle slide along stuck together. The car's velocity just before the collision was $\langle -10, 15, 0\rangle$ m/s, and the motorcycle's velocity just before the collision was $\langle 0, -40, 0\rangle$ m/s. In the following problems you can ignore the mass of the passengers for both vehicles.

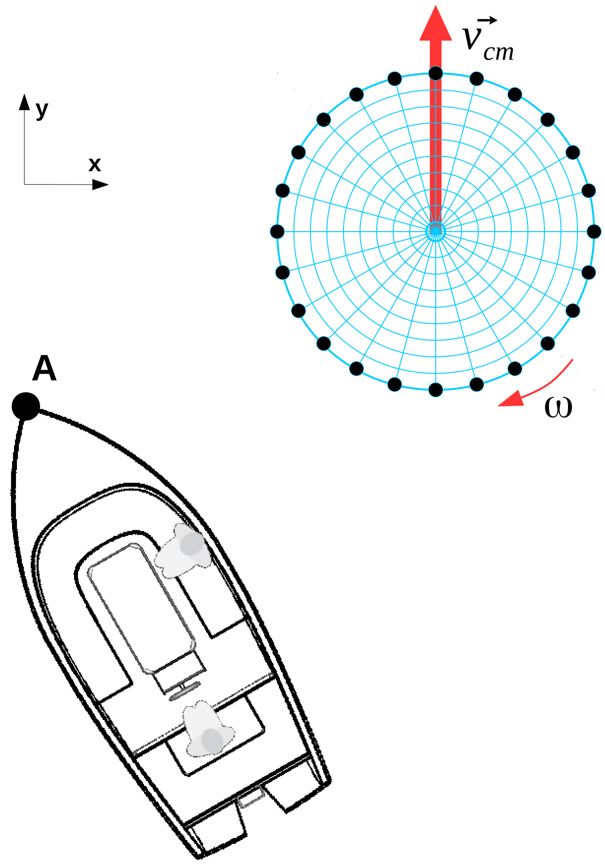
(a 10pts) Determine the velocity of the stuck-together car and motorcycle just after the collision. Drawing a figure may help with this step.

(b 10pts) Determine the change in internal energy of the car and motorcycle (thermal energy and deformation).

(c 5pts) What type of collision was this (other than painful): Elastic, Inelastic, Maximally Inelastic? Briefly justify your answer.

`Problem 4` Grader: __________________________ Score: ______/25 ______/25 ______/25 ______/25

A fisherman throws a net from a boat. As seen from above, the net is translating with a velocity $\vec{v}_{cm} =< 0, u, 0 >$ and rotating clockwise at a constant rate ω. With respect to a point A at the tip of the boat, the center of mass of the net is located at $\vec{r_A} =< r_x, r_y, 0 >$. The net is made of 24 small lead weights, each of mass m and all a distance R from the center. For the questions below, you can ignore the mass of the netting.



(a 5pts) Calculate $\vec{L}_{rot}$ for the net with respect to its center of mass.

(b 10pts) Calculate $\vec{L}_{trans,A}$ for the net with respect to point A.

(c 5pts) Calculate $\vec{L}_{total,A}$ for the net with respect to point A.

(d 5pts) The gravitational force is constant and points into the page. Calculate the torque $\vec{\tau}_{cm}$ on the net with respect to the center of mass for the net. What can you conclude about the rotation rate of the net a short time later?

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

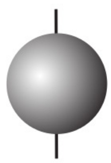
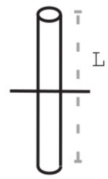
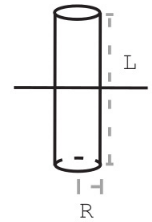
$$\text{prob}(E) \propto \Omega(E)\,e^{-\frac{E}{kT}} \qquad E_N = -\frac{13.6\text{eV}}{N^2} \text{ where } N = 1,2,3\ldots$$

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

Moment of intertia for rotation about indicated axis

The cross product

$$\vec{A} \times \vec{B} = \langle A_y B_z - A_z B_y, A_z B_x - A_x B_z, A_x B_y - A_y B_x \rangle$$

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

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}