PHYS 2211 Test 1
Spring 2014

Name(print)______________________________________ **Lab Section**__________________

Schatz(N), Bongiorno(M)					
Day	12-3pm	2-5pm	3-6pm	5-8pm	6-9pm
Monday		M01			
Tuesday	M03 N01		M06 N02		N03
Wednesday		M02 N07		M07	
Thursday	M04 N04		M05 N05		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 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

PHYS 2211

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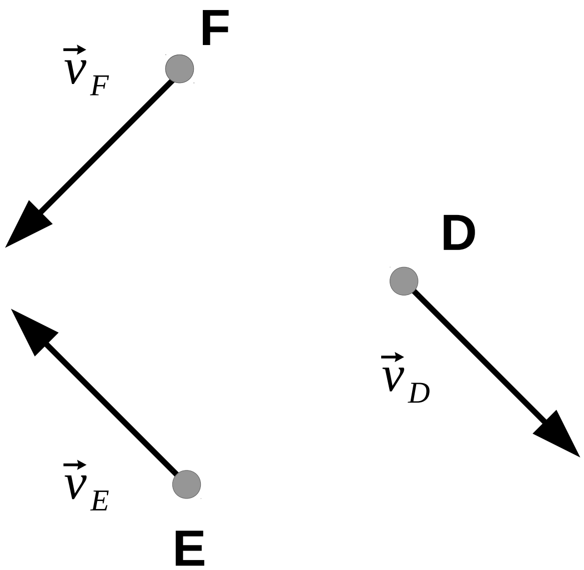
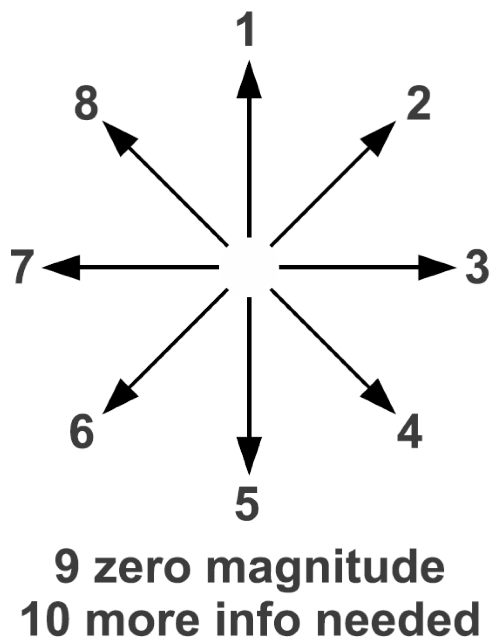
Problem	Score	Grader
Problem 1 (30 pts)		
Problem 2 (20 pts)		
Problem 3 (25 pts)		
Problem 4 (25 pts)		
Textbook (Y, N, O)		

Problem 1 (30 Points)

The position of an object at three different times is indicated by dots in the figure shown. The object is initially located at position D at time t_D. Later, the object is observed to be at E at time $t_E > t_D$. Finally, the object is observed to be at position F at time $t_F > t_E$. The arrows shown at each location represent the object's velocity at that location; the object's speed is the same for all locations shown.





(a 10pts) Using the numbered direction arrows shown, indicate (by number) which direction arrow best represents the direction of the quantities listed below. If the quantity has zero magnitude or cannot be determined, indicate using the corresponding number listed below.

The position vector at location D ______

The change in position (the displacement) between location D and location F ______

The change in velocity between location D and location F ______

The change in momentum between location D and location F ______

The average net force between location D and location F ______

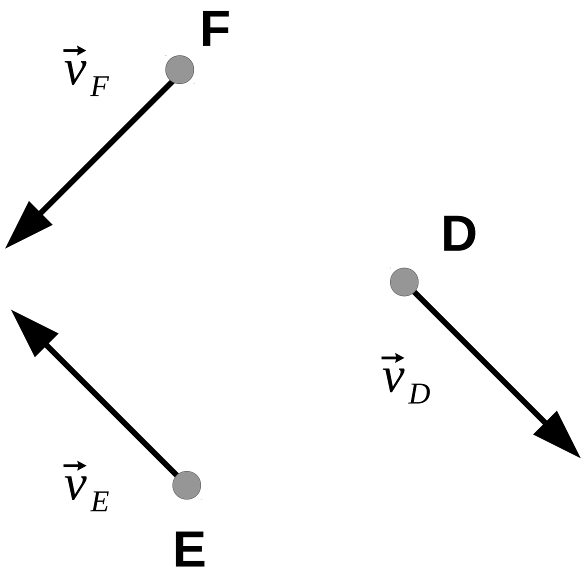
The position vector at location E ______

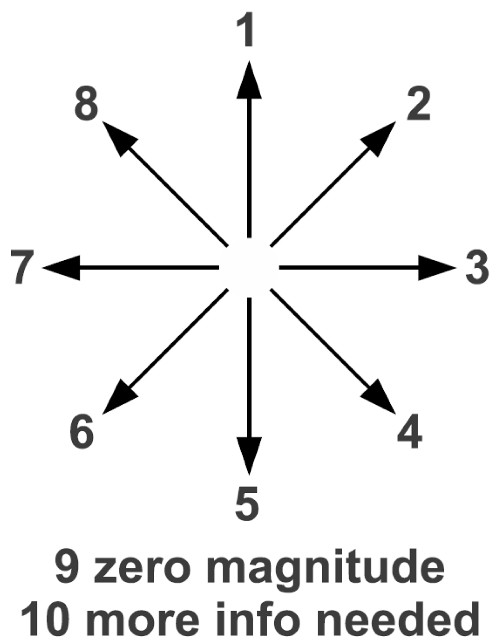
The change in position (the displacement) between location D and location E ______

The change in velocity between location D and location E ______

The change in momentum between location D and location E ______

The average net force between location D and location E ______





(b 15pts) Using the numbered direction arrows shown, indicate (by number) which direction arrow best represents the direction of the quantities listed below. If the quantity has zero magnitude or cannot be determined, indicate using the corresponding number listed below.

The position vector at location F ______

The change in position (the displacement) between location E and location F ______

The change in velocity between location E and location F ______

The change in momentum between location E and location F ______

The average net force between location E and location F ______

(c 5pts) Write “T” next to each true statement below, and write “F” for every false statement.

________ The displacement vector for an object can be in a different direction than its average velocity (during the same time interval).

________ An object’s momentum is always in the same direction as the acceleration on that object.

________ The change in an object’s momentum can be in a different direction than the net force on the object.

________ An object’s momentum and its instantaneous velocity are always in the same direction.

________ If the net force on an object is contant, then the rate of change of its momentum is constant.

`Problem 2 (20 Points)`

(a 5pts) A vector $\vec{r}$ of length 10 m lies in the xy plane at an angle of **20 degrees measured clockwise from the +y axis**. Calculate the unit vector $\hat{r}$.

(b 5pts) Write down any one of the valid forms of the momentum principle (Newton's second law). If you write more than one and any of them are incorrect, the whole problem will be marked as incorrect. Your answer must be exactly correct to receive credit, including arrows for vectors, correct subscripts, etc. There is no partial credit for this part.

(d 10pts) Standing at the top of Clough Commons you throw your textbook into the air giving it an initial momentum $\vec{p}_i =< 20, 50, 0 >$ at time $t = 0$. Some time later it lands on the ground a vertical distance of 20 m below. On the graphs below, sketch the x-component (5pts) and y-component (5pts) for the momentum of the textbook during its complete flight as a function of time. The only force acting on the textbook is due to gravity (pointing in the negative y-direction).

Problem 3 (25 Points)

You are navigating a spacecraft far from other objects. The mass of the spacecraft is m. The rocket engines are shut off, and you're coasting along with a constant velocity of $< 0, v_i, 0 >$. As you pass the location $< x_i, 0, 0 >$ you fire thruster rockets, so that your spacecraft experiences a net force of $< -F, 2F, 0 >$ for T seconds. The ejected gases have a mass that is small compared to the mass of the spacecraft. You then turn off the thruster rockets so that no net force is acting on the spacecraft. Where are you T seconds after the rockets are turned off?

Problem 4 (25 Points)

On Earth, a mass of 0.05 kg is attached to a *vertically-hanging* spring with a spring stiffness of 10.0 N/m and a relaxed length of 0.20 m. You grab the mass and throw it downward. At the instant you release the mass, the spring's length is 0.30 m and the mass is moving downward with a speed of 0.1 m/s.

(a 10pts) What is the net force on the mass in the instant after you release it? Express your final answer as a three-component vector, using the usual coordinate axes (i.e. positive x is right, positive y is up).

(b 5pts) What is the new velocity of the mass 0.01 seconds after you release it from rest? Express your final answer as a three-component vector, using the usual coordinate axes. You may assume the net force does not change much over this relatively short time period.

(c 10pts) What is the new net force acting on the mass 0.01 seconds after release? Express your answer as a three-component vector, using the usual coordinate axes.

Did you purchase a legal copy (new, used or digital) of the suggested textbook for this class?

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

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

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

$$\vec{F}_{grav}=-G\frac{m_1m_2}{|\vec{r}|^2}\hat{r} \qquad U_{grav}=-G\frac{m_1m_2}{|\vec{r}|}$$

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

$$\vec{F}_{elec}=\frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{|\vec{r}|^2}\hat{r} \qquad U_{elec}=\frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{|\vec{r}|}$$

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

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

$$\vec{r}_{cm}=\frac{m_1\vec{r}_1+m_2\vec{r}_2+\dots}{m_1+m_2+\dots} \qquad I=m_1r_{1\perp}^2+m_2r_{2\perp}^2+\dots$$

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

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

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

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

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

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

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

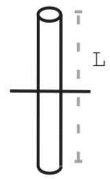
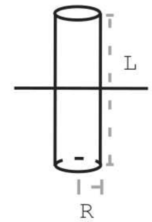
$$\text{prob}(E)\propto\Omega(E)\,e^{-\frac{E}{kT}} \qquad E_N=-\frac{13.6\text{eV}}{N^2}\text{ where } N=1,2,3\dots$$

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

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}