PHYS 2211 Test 1
Fall 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."

____

Sign your name on the line above

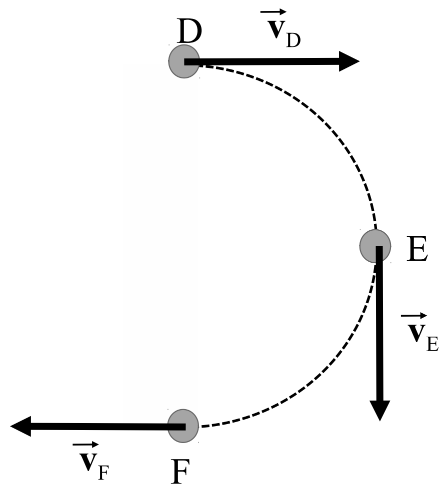
PHYS 2211

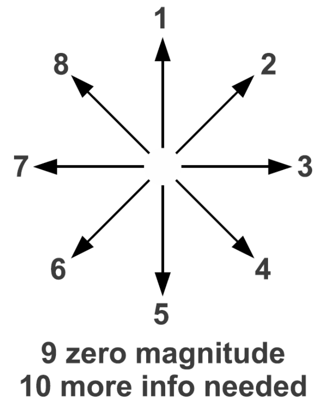
Do not write on this page!

Problem	Score	Grader
Problem 1 (30 pts)		
Problem 2 (20 pts)		
Problem 3 (25 pts)		
Problem 4 (25 pts)		

Problem 1 (30 Points)

An object moves from location D to location F on a trajectory (dotted line) in the direction indicated; arrows representing the velocities at locations D, E, and F are also indicated.





(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 _______

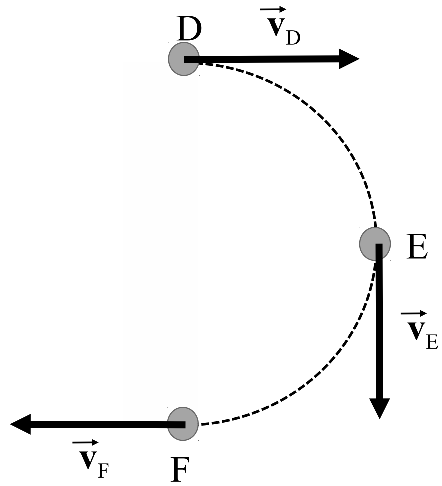
The change in position (the displacement) between location D and location E _______

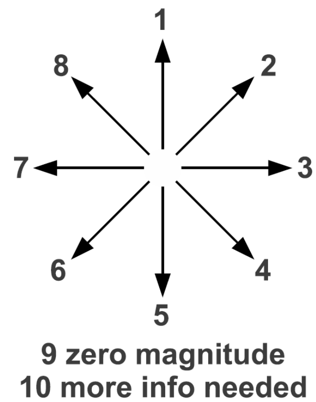
The change in velocity between location D and location E _______

The change in momentum between location D and location E _______

The average net force between location D and location E _______

An object moves from location D to location F on a trajectory (dotted line) in the direction indicated; arrows representing the velocities at locations D, E, and F are also indicated.





(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 change in an object's vector position can be in a different direction than its average velocity.

_________ An object's momentum is always in the same direction as the net force on that object.

_________ The change in an object's momentum can be in a different direction than its momentum.

_________ 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 position is constant.

`Problem 2 (20 Points)`

(a 5pts) According to Newton's second law, if an object does not interact with anything or if the effects of its interactions cancel each other out, then its velocity (and therefore momentum) must be

(a) zero.
(b) constant.
(c) positive.
(d) negative.
(e) equal to the speed of light.

(b 5pts) An astronaut uses a stopwatch to time the motion of a rock in outer space. At time $t = 5.0$ seconds, the rock is position $\langle -10, 7, -4\rangle$ m. At time time $t = 12.0$ seconds, the rock is at position $\langle 3, -4, -6\rangle$ m. What is the average velocity of the rock from $t = 5.0$ seconds to $t = 12.0$ seconds?

A. $\langle 2.60, -2.20, -0.40\rangle$ m/s B. $\langle 1.08, -0.92, -0.17\rangle$ m/s C. $\langle 1.86, -1.57, -0.29\rangle$ m/s

D. $\langle 0.43, -0.57, -0.86\rangle$ m/s E. $\langle -3.50, 1.50, -5.00\rangle$ m/s (c 5pts) A billiard ball on a billiards table has a momentum $\langle 3, 0, 4\rangle \ \text{kg}\cdot\frac{\text{m}}{\text{s}}$. What is its direction, expressed as a unit vector?

(a) $\left\langle \frac{1}{3}, 0, \frac{1}{4}\right\rangle$
(b) $\langle -3, 0, -4\rangle$
(c) $\langle 1, 0, 1\rangle$
(d) $\langle 0.6, 0, 0.8\rangle$
(e) $\langle 0.9, 0, 0.16\rangle$

(d 5pts) The velocity of a ball is observed to change uniformly with time as given below:

At $t = 0$ s, $\vec{v} = \langle 0, 0, 12\rangle$ m/s
At $t = 1$ s, $\vec{v} = \langle 0, 0, 7\rangle$ m/s
At $t = 2$ s, $\vec{v} = \langle 0, 0, 2\rangle$ m/s
At $t = 3$ s, $\vec{v} = \langle 0, 0, -3\rangle$ m/s

Which of the following statements are true about the net force acting on the ball during the time the ball is observed? ***Circle all that apply.***

A. The x component of the net force on the ball is zero.
B. The z component of the net force on the ball is zero.
C. The x component of the net force on the ball is constant.
D. The z component of the net force on the ball is constant.
E. The z component of the net force on the ball is positive.
F. The z component of the net force on the ball is negative.
G. The z component of the net force on the ball is changing with time.
H. The ball has no interaction with its surroundings during this time interval.

Problem 3 (25 Points)

Standing on Earth, you throw a small rock with a mass of 0.50 kg into the air. At the instant it leaves your hand, the rock's velocity is $\langle 0.1, 4.0, 0.3\rangle$ m/s. (Here, the y-axis is vertical and the x-axis is horizontal.) You may ignore the force of air resistance.

(a 5pts) What is the rock's initial momentum, just after it leaves your hand? Express your answer as a vector.

(b 10pts) What is the rock's momentum 0.25 seconds after it leaves your hand? ***Start from a fundamental principle (or else you will not receive full credit).*** Express your answer as a vector.

(c 5pts) Calculate the average velocity of the rock from just after it leaves your hand to 0.25 seconds later. (If you do not know how to do this, estimate a reasonable average velocity and justify your estimate). Express your answer as a vector.

(d 5pts) If the rock's initial position just as it leaves your hand is $\langle 0, 1.2, 0 \rangle$ m, find the vector position of the ball after 0.25 seconds.

Problem 3 (Flipped) (25 Points)

A spacecraft of mass $m = 15000$ kg is is located at an initial position of $\vec{\mathbf{r}}_i = < -5.8e7, 5.4e6, 0 >$ m and is moving with an initial velocity $\vec{\mathbf{v}}_i = < -604, 2795, 0 >$ m/s. The spacecraft experiences no net interactions with its surroundings. Complete the computer code (VPython script) given below by adding the statements necessary to create a model that predicts the spacecraft's motion. **Your code MUST include the use of a fundamental principle.**

```
#************BEGIN COMPUTER MODEL OF SPACECRAFT*******************
from __future__ import division
from visual import *

#VISUALIZATION and GRAPH INITIALIZATION
craft = sphere(radius= 3e6,color=color.blue)
```

(a 9pts) Add the necessary statements **here** to specify the system mass and initial conditions.

```
t = 0
deltat = 60
#CALCULATION LOOP (Motion Prediction and Visualization)
while t < 3058992:
```

(b 12pts) Add the necessary statements **here** to predict the craft's velocity and position.

```
        t = t+deltat ##Advance the clock
#************ END COMPUTER MODEL OF SPACECRAFT*******************
```

Refer to the code above to answer the following questions:
(c 2pts) At what time does the code begin predictions? (Answer should be a number with units.)

(d 2pts) The code makes motion predictions in discrete time steps. How large are those time steps? (Answer should be number with units.)

`Problem 4 (25 Points)`

On Earth, a mass of 0.05 kg is attached to a *vertically-hanging* spring with a spring stiffness of 14.81 N/m and a relaxed length of 0.20 m. You grab the hanging mass hold it so that the spring's length is 0.25 m, then you release it from rest.

(a 5pts) What is the net force on the mass just 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 10pts) 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 5pts) What is the new position of the mass 0.01 seconds after release? Express your 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.

(d 5pts) 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.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

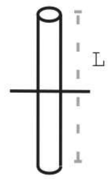
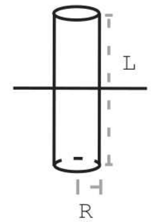
$$\text{prob}(E)\propto\Omega\,(E)\,e^{-\frac{E}{kT}} \qquad E_N=-\frac{13.6\text{eV}}{N^2} \text{ where } N=1,2,3\dots$$

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

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}