PHYS 2211 Exam 2
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.:** $\frac{a \cdot b}{c \cdot d} = \frac{(8\times10^{-3})(5\times10^{6})}{(2\times10^{-5})(4\times10^{4})} = 5\times10^{4}$
- 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

Problem 1 Grader: ____________________ Score (25pts): __________

In lab you created a computational model to predict, iteratively, the motion of a spacecraft orbiting the Earth. Below is a similar program, however, the program is missing a few lines of code. In the space provided, add the statements necessary to complete the code. Note that all numerical values of physical quantities are given in SI units.

```
GlowScript 2.0 VPython

Earth = sphere(pos=vector(1e7,-2e6,0), radius=6.4e6, color=color.cyan)
scene.range=22*Earth.radius
craft = sphere(pos=vector(-5.824e7,5.44e6,0), radius= 3e6,color=color.blue)
vcraft = vector(604,2795,0)
mEarth = 6e24
mcraft = 15000
pcraft = mcraft*vcraft

G = 6.7e-11 #Universal Gravitational Constant
deltat = 60 #timestep
t = 0
while t < 3058992:
```

(a 8pts) Add the lines of code **here** that correctly describe the net force on the spacecraft due to the Earth.

(b 6pts) Add the lines of code **here** that correctly update the momentum and the position of the ball. Approximate the average velocity using $\vec{v}_{avg} \approx \vec{v}_f$.

```
    t = t + deltat
```

Refer to the code above to answer the following questions:

(c 2pts) What is the initial position of the spacecraft? (Answer should be a vector with numerical components in the proper units.)

(d 2pts) What is the initial momentum of the spacecraft? (Answer should be a vector with numerical components in the proper units.)

(e 2pts) What is the initial net force (net force at $t = 0$ s) on the spacecraft? (Answer should be a vector with numerical components in the proper units.)

(f 5pts) Briefly explain why we do not need to update the position of the Earth (that is, why do so is a good approximation).

`Problem 2` Grader: ____________________________ Score (25pts): ______________

The position of two small, electrically charged, drops are recorded on a video. At a particular instant in time their charges, mass, and positions are measured to be:

Drop 1 has charge $q_1 = 3 \times 10^{-5}$ C, $m_1 = 0.004$ kg, and position $\vec{r}_1 =< 2, 1, 0 >$ m
Drop 2 has charge $q_2 = 2 \times 10^{-4}$ C, $m_2 = 0.008$ kg, and position $\vec{r}_2 =< 10, 3, 0 >$ m.

(a 3pts) Calculate the unit vector $\hat{r}$ that points from drop 1 to drop 2.

(b 10pts) Determine the electric force (a vector) on drop 2 due to drop 1.

(d 8pts) At their current positions, both drops are at rest. Predict the change in position of drop 2 a time $\Delta t = 1.0$ seconds later. You can ignore the gravitational interaction between drops.

(e 4pts) Calculate the change in position for drop 1 during this time interval.

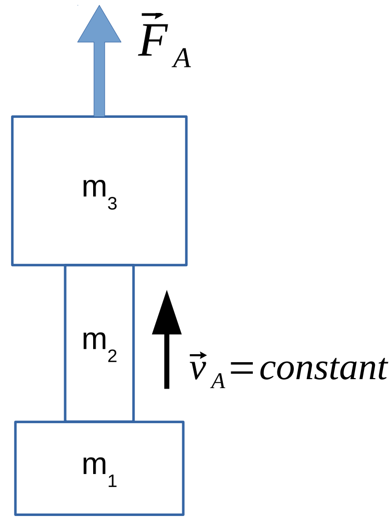
`Problem 3` Grader: ______________________ Score (25pts): ____________

A relaxed copper wire of length 1.9 m hangs from a support in the ceiling. The wire has a circular cross section with a 0.0004 m radius. When you hang a 6 kg mass from the end of the wire, you observe a stretch of 0.0019 m. Copper has a density of 8933 $kg/(m^3)$ and a molar mass of 0.0635 kg/mol.

(a 5pts) Calculate the diameter of one copper atom.

(b 10pts) What is the stiffness of the spring that is a model for the interatomic force in copper (i.e. the interatomic spring constant)?

(d 10pts) How much does the wire stretch (relative to it's rest length) if the wire had been twice as thick (a radius of 0.008 m) and three times as long?



Two blocks of mass m_1 and m_3 are connected by a rod of mass $m2$, as shown in the diagram. A constant **unknown** force $\vec{F}_A$ pulls upward on the top block while both blocks and the rod move upward at a constant velocity $\vec{v}_A$ near the surface of the Earth. The direction of the gravitational force on each block points down.

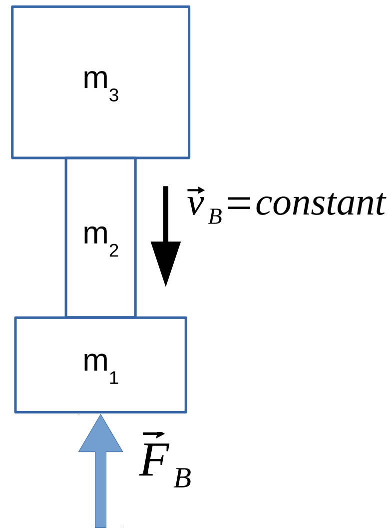
(a 3pts) Find the force $\vec{F}_A$; express your answer as vector.

(b 3pts) Find the acceleration $\vec{a}_A$; express your answer as vector.

(c 3pts) Find $\vec{F}_{2on3}$, the force exerted by the rod on the top block. Express your answer as vector.

(d 3pts) Find $\vec{F}_{2on1}$, the force exerted by the rod on the bottom block. Express your answer as vector.

Two blocks of mass m_1 and m_3 are connected by a rod of mass $m2$, as shown in the diagram. Aa constant **unknown** force $\vec{F}_B$ pushes upward on the bottom block while both blocks and the rod move downward at a constant velocity $\vec{v}_B$ near the surface of the Earth. The direction of the gravitational force on each block points down.



(e 3pts) Find the force $\vec{F}_B$; express your answer as vector.

(f 3pts) Find the acceleration $\vec{a}_B$; express your answer as vector.

(g 3pts) Find $\vec{F}_{2on3}$, the force exerted by the rod on the top block. Express your answer as vector.

(h 3pts) Find $\vec{F}_{2on1}$, the force exerted by the rod on the bottom block. Express your answer as vector.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

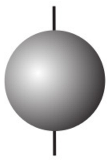
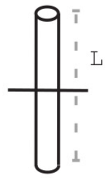
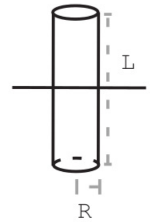
$$\text{prob}(E)\propto\Omega\,(E)\,e^{-\frac{E}{kT}} \qquad E_N=-\frac{13.6\text{eV}}{N^2}\text{ where } N=1,2,3\ldots$$

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

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}