PHYS 2211 Exam 2 - Spring 2018

Please circle your lab section and fill in your contact info below.

Section (K Curtis) and (M Fenton)		
Day	12-3pm	3-6pm
Monday	K01 M01	K02 M02
Tuesday	K03 M03	K04 M04
Wednesday	K05 M05	K06 M06
Thursday	K07 M07	K08 M08

"In accordance with the Georgia Tech Honor Code,
I have not given or received unauthorized aid on this test."

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Sign your name on the line above

Instructions

- Please write with a pen or dark pencil to aid in electronic scanning.
- Read all problems carefully before attempting to solve them.
- Your work must be legible, and the organization must be clear.
- Your solution should be worked out algebraically. Numerical solutions should only be evaluated at the last step. Incorrect solutions that are not solved algebraically will receive an 80 percent deduction.
- 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. Your symbolic answers should not have units.

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.

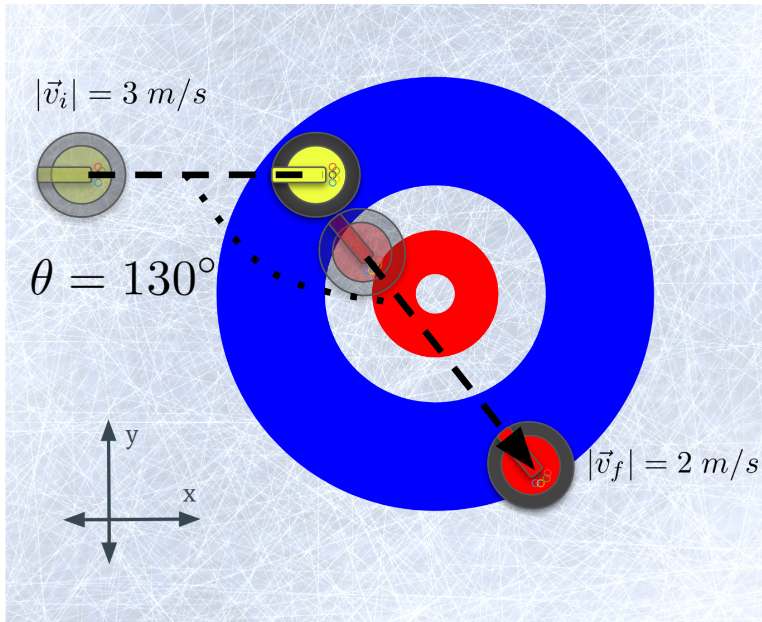
Problem 1 [25 pts] Grader & Score: ____________________

Below is a program, very similar to the one you wrote in lab, that calculates the motion of a spacecraft around the Earth and Moon. In this example, the Earth and Moon do not move. While downloading this code from your lab uploads, a few of the lines were corrupted and need to be re-entered. Please fill in the missing pieces of code with your own work.

```
GlowScript 2.7 VPython
G = 6.7e-11 #gravitational constant
mEarth = 5.97e24 #mass of Earth in kg
mMoon = 7.35e23 #mass of Moon  in kg
mFalcon = 1.4e6 #mass of spacecraft in kg
Earth = sphere(pos=vector(0,0,0), radius=6.3e6, color=color.blue)
Moon = sphere(pos=vector(3.84e8,0,0), radius=1.7e6, color=color.green)
Falcon = sphere(pos=vector(0,6.4e6,0), radius=70,color=color.red)
Falcon.p = mFalcon*vector(8e3,8e3,0) #initial momentum of spacecraft
deltat = 10
t = 0
while t < 60*365*24*60*60:
    rate(100)
    ## A. [15pts] Add statements to calculate Fnet on the Falcon spacecraft









    Fnet =

    ## B. [10pts] Add statements to update the position of the Falcon spacecraft



    craft.pos =
```

Problem 2 [25 pts] Grader & Score: ______________________

In the Olympic sport of curling, 20 kg granite stones slide across the ice towards a target. Teams take turns colliding their own stone with their opponents in the hopes of knocking a stone off target. In one such collision, a stone moving with a speed $|\vec{v}_i| = 3$ m/s collides with a stationary stone. Imminently after the collision the stationary stone is observed to slide with a speed of $|\vec{v}_i| = 2$ m/s at an angle of $\theta = 130°$, when measured clockwise, with respect to the initial velocity of the first stone as indicated in the diagram.



A. [15 pts] Determine the speed of the stone, initially moving with speed 3 m/s, immediately after the collision. You can assume that the frictional force between ice and stone is negligible.

B. [10 pts] Using a high speed camera you observe that, during the collision, the two stones were in contact for $\Delta t = 1.5 \times 10^{-3}$ s. Calculate the magnitude of the average contact force between the two stones.

`Problem 3 [25 pts]` Grader & Score: ____________________

A. [10 pts] A copper wire with an initial length of 10 m and a cross section of 1 cm^2 is used to hang a 1 kg birthday cake motionless in air. Calculate the the stretch in the wire. The interatomic distance for copper d is 2.28×10^{-10} m and the Youngs modulus is 1.32×10^{11} N/m.

B. [5 pts] How much time, in seconds, does it take for the stretch in the wire to propogate through the total length of wire.

C. [2 pts] If two birthday cakes hang from the wire, how much would the Youngs modulus change?

- $Y = Y_0/2$
- $Y = Y_0/4$
- $Y = Y_0$
- $Y = Y_0 * 2$
- $Y = Y_0 * 4$

D. [2 pts] If the copper wire used was doubled in length ($L = 2 * L0$), how much would the wire stretch?

- $\Delta L = \Delta L_0/2$
- $\Delta L = \Delta L_0/4$
- $\Delta L = \Delta L_0$
- $\Delta L = \Delta L_0 * 2$
- $\Delta L = \Delta L_0 * 4$

E. [2 pts] If the copper wire used was twice as thick ($r = 2r_0$), how much would the wire stretch?

- $\Delta L = \Delta L_0/2$
- $\Delta L = \Delta L_0/4$
- $\Delta L = \Delta L_0$
- $\Delta L = \Delta L_0 * 2$
- $\Delta L = \Delta L_0 * 4$

F. [2 pts] Four identical copper wires are connected in series. What would be the stiffness coefficient k_{eff} of an equivalent single wire in terms of the stiff of one copper wire k_0?

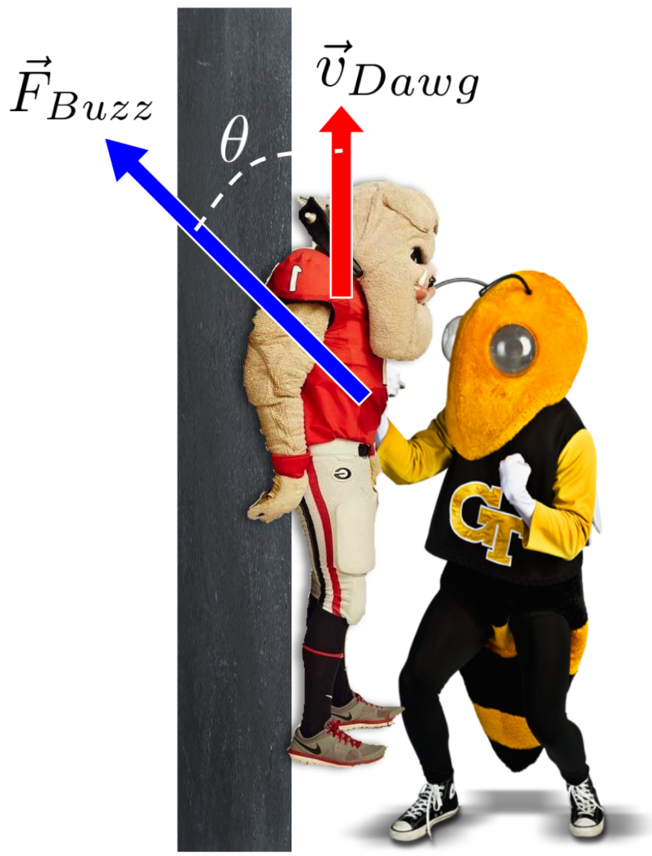
- $k_{eff} = k_0/2$
- $k_{eff} = k_0/4$
- $k_{eff} = k_0$
- $k_{eff} = k_0 * 2$
- $k_{eff} = k_0 * 4$

G. [2 pts] Four identical copper wires are connected in parallel. What would be the stiffness coefficient k_{eff} of an equivalent single wire in terms of the stiff of one copper wire k_0?

- $k_{eff} = k_0/2$
- $k_{eff} = k_0/4$
- $k_{eff} = k_0$
- $k_{eff} = k_0 * 2$
- $k_{eff} = k_0 * 4$

Problem 4 [25 pts] Grader & Score: ______________________

While attending a college football game you notice an altercation between two of the mascots which you capture on video. One of the mascots (Buzz) is lifting the other (Dawg) into the air by pressing on him with a constant force $|\vec{F}_{Buzz}|$ against a stone wall. From the video, you observe that the velocity of Dawg $|\vec{v}_{Dawg}|$ is constant and points in the opposite direction of gravity. The mass of Dawg is m and the angle between the force from Buzz and the velocity of Dawg is measured to be θ as seen in the diagram.



A. [15 pts] Determine the coefficient of friction between the Dawg and the wall.

B. [5 pts] Buzz changes the direction of the constant force (no change in magnitude) so that it is perpendicular to the velocity and pointing directly into the wall. Briefly describe what happens to the contact force (both the normal and friction components) between Dawg and the wall.

C. [5 pts] Calculate the minimum force $|\vec{F}_{Buzz}|$ that Buzz must push with to keep Dawg from sliding back down the wall. You can assume that the coefficient of friction you found early has not changed.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

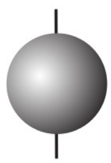
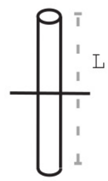
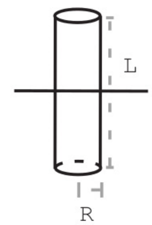
$$\text{prob}(E) \propto \Omega(E)\, e^{-\frac{E}{kT}} \qquad E_N = -\frac{13.6\text{eV}}{N^2} \text{ where } N = 1,2,3\ldots$$

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

Moment of inertia 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}