Final Exam Formulæ & Constants

$$\vec{v} = \frac{d\vec{r}}{dt}$$
$$\vec{\omega} = \frac{d\vec{\theta}}{dt}$$
$$\vec{a} = \frac{d\vec{v}}{dt}$$
$$\vec{\alpha} = \frac{d\vec{\omega}}{dt}$$
$$v_{\mathrm{sf}} = v_{\mathrm{si}} + a_{\mathrm{s}}\,\Delta t$$
$$\omega_{\mathrm{f}} = \omega_{\mathrm{i}} + \alpha\,\Delta t$$
$$s_{\mathrm{f}} = s_{\mathrm{i}} + v_{\mathrm{si}}\,\Delta t + \tfrac{1}{2}a_{\mathrm{s}}\,(\Delta t)^2$$
$$\theta_{\mathrm{f}} = \theta_{\mathrm{i}} + \omega_{\mathrm{si}}\,\Delta t + \tfrac{1}{2}\alpha\,(\Delta t)^2$$
$$s = r\theta$$
$$v = r\omega$$
$$a_{\mathrm{t}} = r\alpha$$

$$\sum \vec{F} = m\vec{a} = \frac{d\vec{p}}{dt}$$
$$\sum \vec{F}_{\mathrm{ext}} = M\vec{a}_{\mathrm{cm}} = \frac{d\vec{P}}{dt}$$
$$\sum \vec{\tau}_{\mathrm{ext}} = I\vec{\alpha} = \frac{d\vec{L}}{dt}$$
$$f_{\mathrm{s,max}} = \mu_{\mathrm{s}} n$$
$$f_{\mathrm{k}} = \mu_{\mathrm{k}} n$$
$$a_{\mathrm{r}} = \frac{v^2}{r}$$
$$\vec{w} = m\vec{g}$$
$$|\vec{F}_{\mathrm{G}}| = \frac{Gm_1m_2}{|\vec{r}|^2}$$
$$D = \tfrac{1}{2}C\rho A v^2$$
$$\vec{\tau} = \vec{r} \times \vec{F}$$

$$W = \int \vec{F}\cdot d\vec{s}$$
$$W_{\mathrm{ext}} = \Delta K + \Delta U + \Delta E_{\mathrm{th}}$$
$$K = \tfrac{1}{2}mv^2$$
$$K = \tfrac{1}{2}I\omega^2$$
$$U_{\mathrm{g}} = mgy$$
$$U_{\mathrm{s}} = \tfrac{1}{2}k\,(\Delta s)^2$$
$$U_{\mathrm{G}} = -\frac{Gm_1m_2}{r}$$
$$P = \frac{dE_{\mathrm{sys}}}{dt}$$
$$P = \vec{F}\cdot\vec{v}$$
$$\vec{J} = \int \vec{F}\,dt = \Delta\vec{p}$$
$$\vec{p} = m\vec{v}$$

$$\vec{r}_{\mathrm{cm}} = \frac{\sum \vec{r}_i m_i}{\sum m_i}$$
$$\vec{r}_{\mathrm{cm}} = \frac{\int \vec{r}\,dm}{\int dm}$$
$$I = \sum m_i r_i^2$$
$$I = \int r^2\,dm$$
$$I = I_{\mathrm{cm}} + Md^2$$
$$\vec{L} = \vec{r} \times \vec{p}$$
$$\vec{L} = I\vec{\omega}$$
$$x = A\cos(\omega t + \phi_0)$$
$$\vec{a}_{\mathrm{x}} = -\omega^2\vec{x}$$
$$\omega = \sqrt{k/m}$$
$$\omega = 2\pi f = \frac{2\pi}{T}$$

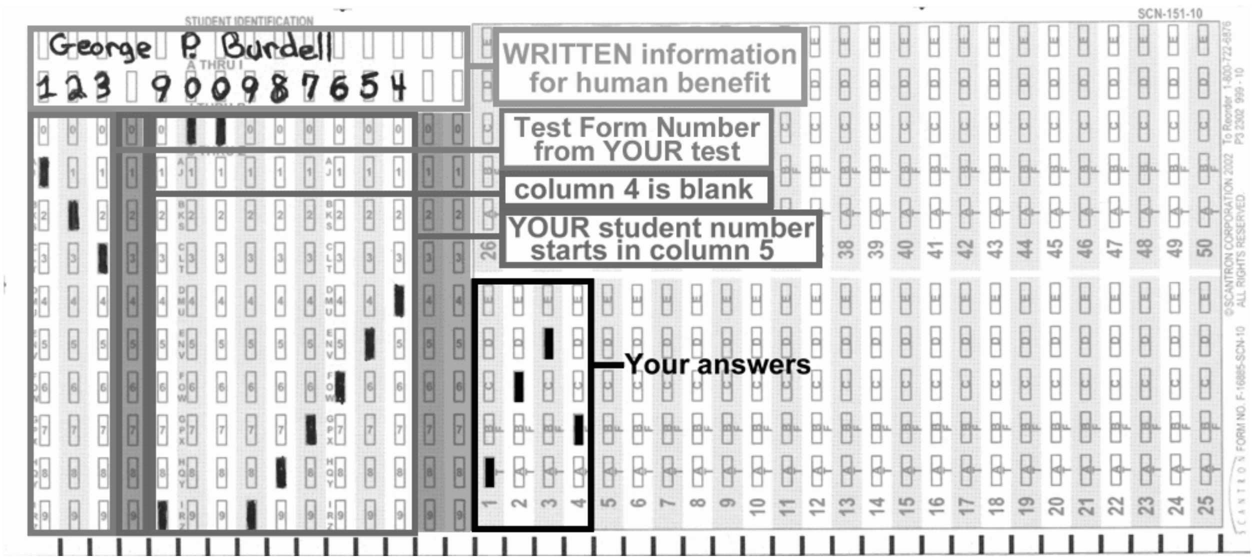
Physical Constants:

Universal Gravitation Constant $G = 6.673 \times 10^{-11}\,\mathrm{N{\cdot}m^2/kg^2}$
Gravitational Acceleration at Earth's Surface $g = 9.81\,\mathrm{m/s^2}$

Unless otherwise directed, drag is to be neglected and all problems take place on Earth, use the gravitational definition of weight, and all ropes and pulleys are ideal.

A

Please remove this sheet from your Quiz or Exam



YOUR form number is **415**

Recitation Sections

	Clough 125	Clough 127	Clough 131	Clough 325
Monday				
2:05 – 2:55 pm	B01 Gaire, Vinod	B05 Roberts, Kelli		A07 Whitley, Lee
3:05 – 3:55 pm	B02 Gaire, Vinod	C02 Roberts, Kelli		
4:05 – 4:55 pm	B06 Gaire, Vinod	B09 Pallantla, Ravi Kumar	C01 Biewer, John	
Tuesday				
2:05 – 2:55 pm	C03 Gaire, Vinod			
3:05 – 3:55 pm	B04 Gaire, Vinod		C04 Cowan, Erika	
4:05 – 4:55 pm	B03 Gaire, Vinod		A01 Cowan, Erika	
5:05 – 5:55 pm	A02 Cowan, Erika			
Wednesday				
2:05 – 2:55 pm				A03 Kim, Sirwoo
3:05 – 3:55 pm	C05 Kim, Sirwoo			
4:05 – 4:55 pm	C06 Kim, Sirwoo			A04 Biewer, John
Thursday				
2:05 – 2:55 pm	A05 Pallantla, Ravi Kumar			B07 Whitley, Lee
3:05 – 3:55 pm	C08 Pallantla, Ravi Kumar			
4:05 – 4:55 pm	C07 Pallantla, Ravi Kumar			B08 Cowan, Erika
5:05 – 5:55 pm	C10 Cowan, Erika			
6:05 – 6:55 pm	A06 Cowan, Erika	C09 Pallantla, Ravi Kumar		
7:05 – 7:55 pm				

Version Quiz #4 Form #415 Name:________________________

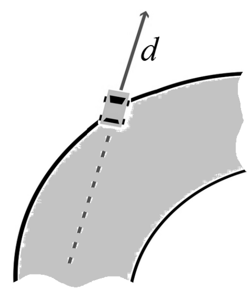
A Physics 2211 ABC Spring 2017 Recitation Section:____________________

- Print your name, quiz form number (3 digits at the top of this form), and student number (9 digit Georgia Tech ID number) in the section of the answer card labeled "Student Identification."
- Bubble the Quiz Form Number in columns 1–3, skip column 4, then bubble your Student Number in columns 5–13.
- Free-response questions are numbered I–III. For each, make no marks and leave no space on your card. Show all your work clearly, including all steps and logic. Box your answer.
- Multiple-choice questions are numbered 1–7. For each, select the answer most nearly correct, circle this answer on your quiz, and bubble it on your answer card. Do not put any extra marks on the card.
- Turn in your quiz and answer card as you leave. Your score will be posted when your quiz has been graded. Quiz grades become final when the next quiz is given.
- You may use a calculator that cannot store letters, but no other aids or electronic devices.

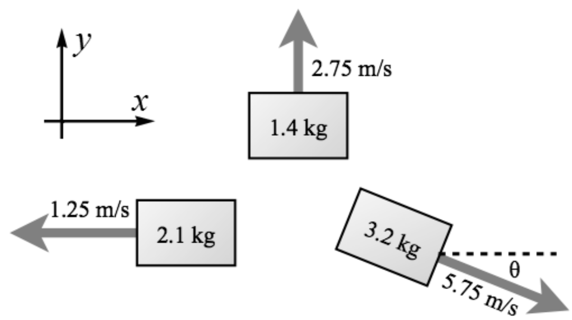
I. (16 points) Corentine is driving her car of mass m around a curve when suddenly, all systems fail! The engine quits, she can't brake, she can't steer, and the car coasts straight off the side of the road, as pictured. Fortunately, the car goes into a plowed field. As the tires sink deeper into the soft dirt, the frictional force magnitude f on the car increases according to

$$f = f_0 \frac{x}{x_0}$$

where x is the distance from where the car left the road, and f_0 and x_0 are positive constants. If the car travels a distance d before stopping in the field, how fast was the car going when it left the road? Express your answer in terms of parameters defined in the problem, and physical or mathematical constants. (*On Earth.*)



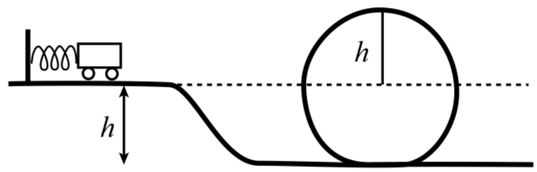
II. (16 points) An object traveling at initial velocity v_0 explodes into three pieces. Instantly after the explosion the velocities of the pieces are measured. The 2.1 kg piece has velocity $v_1 = -1.25\,\hat{x}\,\mathrm{m/s}$, the 1.4 kg piece has velocity $v_2 = 2.75\,\hat{y}\,\mathrm{m/s}$, and the 3.2 kg piece has speed 5.75 m/s and is traveling at $\theta = 22°$ below the $+x$ axis. What was the velocity of the object immediately before the explosion? (Write your answer in component form using the unit vectors $\hat{x}$ and $\hat{y}$.)



1. (6 points) After the explosion, the first piece (2.1 kg traveling at $v_1 = -1.25\,\hat{x}\,\mathrm{m/s}$) has a collision with a stationary 625 kg truck (on a frictionless surface). Assuming the collision is completely elastic, what is the velocity of the 2.1 kg object immediately following the collision? (Hint: You don't need to do any calculations.)

   (a) 3.36 m/s.
   (b) -1.21 m/s.
   (c) 2.45 m/s.
   (d) 0.04 m/s.
   (e) 1.21 m/s.

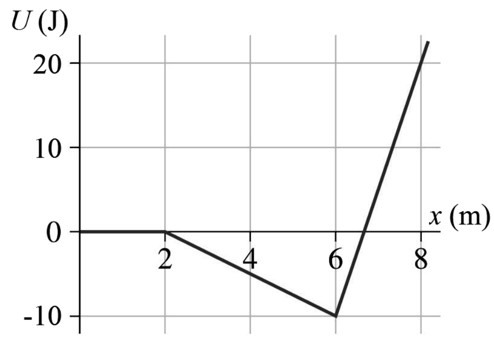
III. (16 points) Some modern roller coasters launch the riders at the beginning. A roller coaster of mass m starts at a height h above the ground and must go through a loop of radius h such that the top of the loop is twice as high as the launch point. If we model the launch mechanism as an elastic spring with Hooke's Law or Spring Constant k, how much would the launch spring have to be compressed to ensure that the roller coaster has sufficient velocity to get around the circular loop? Express your answers only in terms of m, g, h and k. (*On Earth, neglect friction.*)



2. (6 points) At what point, if any, in the launch is the power output from the launch spring at its maximum?

   (a) Just when the car is about to leave the launch mechanism.
   (b) The launch spring does not produces power because it exerts a conservative force.
   (c) The power output is the same throughout the launch.
   (d) At the start.
   (e) Sometime in the middle of the launch.

3. (8 points) The graph shows the potential energy, U, of a system as a function of the position, x, of a 2 kg particle within it. This 2 kg particle is released from rest at $x = 8\,\mathrm{m}$. If the particle can be found later at $x = 4\,\mathrm{m}$, what speed would it have at that location?

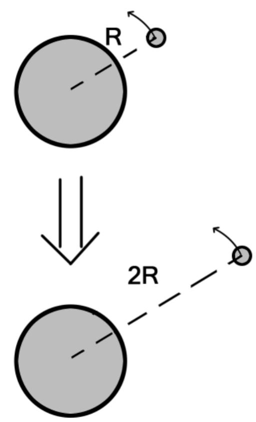


(a) The particle moves at $\sqrt{15}\,\mathrm{m/s}$ when it is at $x = 4\,\mathrm{m}$.
(b) The particle moves at $\sqrt{5}\,\mathrm{m/s}$ when it is at $x = 4\,\mathrm{m}$.
(c) The particle cannot be found later at $x = 4\,\mathrm{m}$ because $U < 0$ at that location.
(d) The particle cannot be found later at $x = 4\,\mathrm{m}$ because there is no force to accelerate it away from $x = 8\,\mathrm{m}$.
(e) The particle moves at $5\,\mathrm{m/s}$ when it is at $x = 4\,\mathrm{m}$.

4. (8 points) A ball of mass m is tossed vertically in the air with velocity v_0. It eventually reaches a height h_0. If the zero of potential energy for the Earth-ball system is chosen at the point the ball is released, what are the ball's height h and velocity v when the total energy of the system is comprised precisely of half potential energy and half kinetic energy? (*On Earth—air resistance is negligible.*)

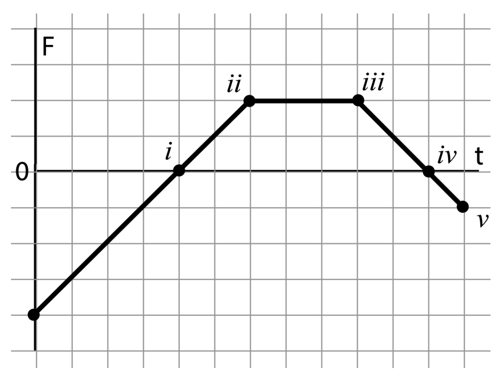
(a) $h = h_0/2$ and $v = v_0/\sqrt{2}$
(b) $h = h_0/2$ and $v = v_0/2$
(c) $h = h_0/\sqrt{2}$ and $v = v_0/2$
(d) $h = v_0^2/(4g)$ and $v = \sqrt{2gh_0}$
(e) $h = v_0^2/(2g)$ and $v = \sqrt{2gh_0}/2$

5. (8 points) A satellite goes around the Earth in a circular orbit with radius R. Its kinetic energy is E_k. A rocket engine is turned on, increasing the energy of the satellite. After this, the satellite orbits with a new radius $2R$. What is the new kinetic energy of the satellite in terms of E_k?



(a) $E_k/2$
(b) $\sqrt{E_k}$
(c) $2E_k$
(d) E_k
(e) E_k^2

6. (8 points) Voyager 2 approaches Saturn and its moon Titan. It is acted upon by a net force from the planet and its moon plotted in the figure. If Voyager 2 has a momentum of 10^7 kg·m/s at $t = 0$ s, at what later point in time does Voyager 2 have the same momentum?



(a) *iii*
(b) *iv*
(c) *i*
(d) *ii*
(e) *v*

7. (8 points) The Navy uses aircraft catapults to launch fighter jets from aircraft carriers. The aircraft catapult can be modeled by a giant spring. Two jets of mass m_1 and $m_2 = 3m_1$ are launched using the same spring, displaced by the same amount $\Delta s = d$. Compare the work done by the spring on the second plane W_2 to that done on the first plane W_1.

   (a) $W_2 = 3W_1$
   (b) $W_2 = \sqrt{3}W_1$
   (c) $W_2 = W_1$
   (d) $W_2 = W_1/\sqrt{3}$
   (e) $W_2 = 9W_1$