Final Exam Formulæ & Constants

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

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

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

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

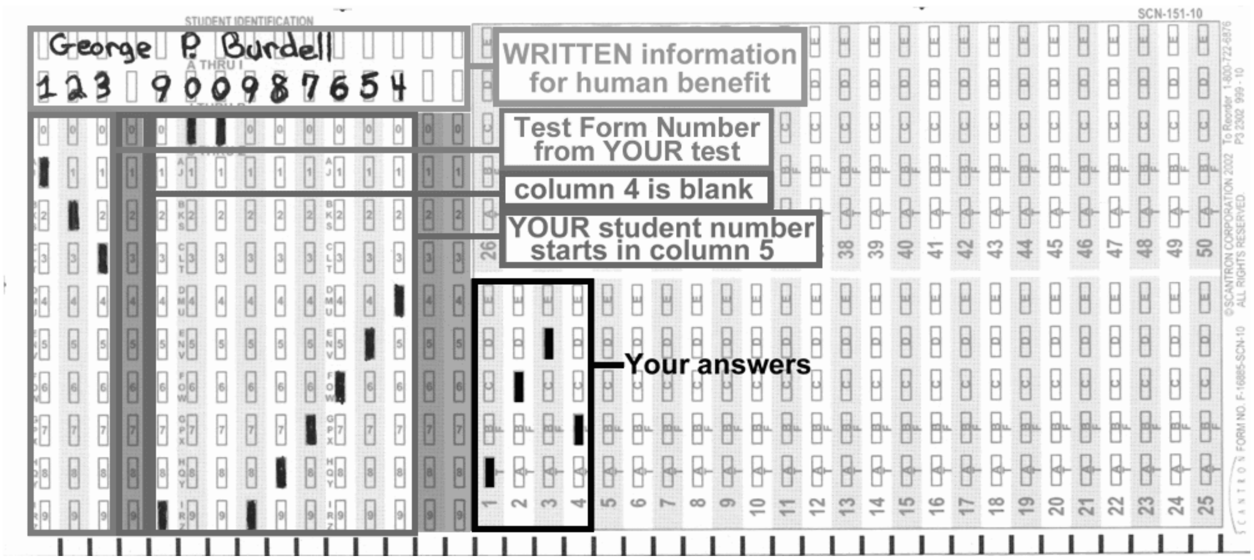
Physical Constants:

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

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

A

Please remove this sheet from your Quiz or Exam



YOUR form number is **241**

Recitation Sections

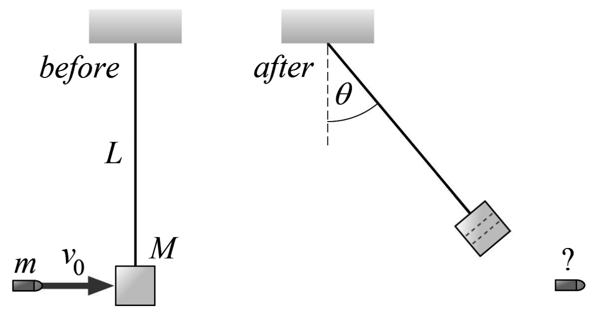
	Clough 123	Clough 125	Clough 127	Clough 131	Clough 325
Wednesday					
1:05 – 1:55 pm					B01 Roberts, Kelli
2:05 – 2:55 pm		A01 Roberts, Kelli			
3:05 – 3:55 pm				A06/B05 Gaire, Vinod	
4:05 – 4:55 pm	A02 Tregoning, Brett	A07 Whitley, Lee	B08 Biewer, John	B02 Gaire, Vinod	
5:05 – 5:55 pm				A05 Gaire, Vinod	B06 Ibnamasud, Shadman
Thursday					
1:05 – 1:55 pm					
2:05 – 2:55 pm					A03 Gaire, Vinod
3:05 – 3:55 pm		B07 Gaire, Vinod	B03 Tregoning, Brett		
4:05 – 4:55 pm	A04 Walia, Saumya	B04 Gaire, Vinod	A09 Tregoning, Brett		
5:05 – 5:55 pm	A08 Walia, Saumya				

Version A | Quiz #4 Form #241 | Name:______________

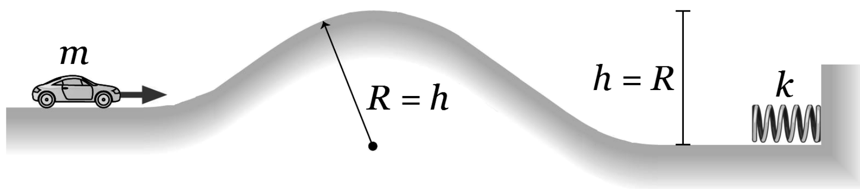
Physics 2211 A & B Fall 2016 | Recitation Section:______________

- 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) A pendulum bob of mass M is hanging at rest from an ideal string of length L. A bullet of mass m traveling horizontally at speed v_0 strikes it and passes through. The bob loses no mass, and swings up to a maximum angle θ from the vertical, as shown. What is the speed of the bullet after it emerges from the bob? Express your answer in terms of parameters defined in the problem, and physical or mathematical constants. (*On Earth.*)



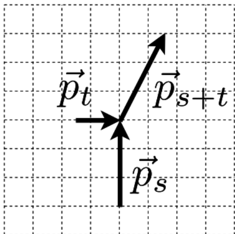
II. (16 points) A toy car with a mass $m = 220\,\text{g}$ is given a push and released on a frictionless surface. It passes over a "hill" which has a radius $R = 12\,\text{cm}$ at the top, and which is $h = 12\,\text{cm}$ above the level ground on the other side, as shown. The car then strikes a spring with Hooke's Law constant $k = 64\,\text{N/m}$. If the car remains in contact with the ground at all times (*think about the implications for the speed of the car at the top of the hill!*), what is the maximum possible compression of the spring? (*On Earth.*)

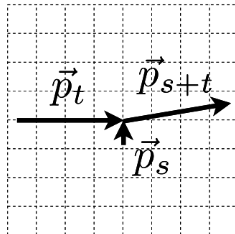


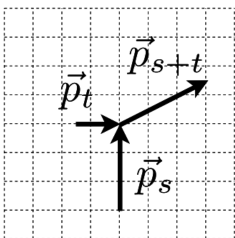
1. (6 points) In the problem above, assuming the initial push on the car is sufficient for it to go over the hill and that it still remains in contact with the ground at all times, what is the minimum possible compression of the spring, Δs_{min}, that stops the car?

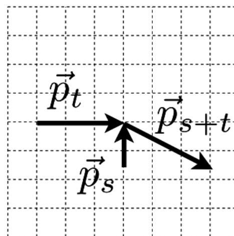
   (a) Zero.
   (b) $\Delta s_{\text{min}} = mg/k$
   (c) There is only one possible compression, so the minimum is the same as the maximum found above.
   (d) $\Delta s_{\text{min}} = \sqrt{gR}$
   (e) $\Delta s_{\text{min}} = \sqrt{2mgh/k}$

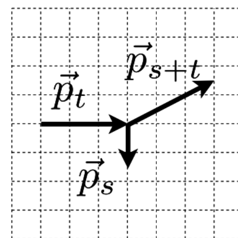
2. (6 points) A 525 kg great white shark, s, swimming due north at 9.5 m/s, ambushes a 235 kg tuna, t, swimming due east at 11 m/s, and swallows it whole. Which of the following represents the momentum vectors for this situation?

(a) 

(b) 

(c) 

(d) 

(e) 

III. (16 points) In the above scenario, what is the *speed* of the shark (with belly full of tuna) immediately after the ambush?

3. (8 points) I push two balls across a frictionless floor with the same applied force for 10 m. Ball 1 has mass $m_1 = 1\,\text{kg}$, and ball 2 has mass $m_2 = 4\,\text{kg}$, so $m_2 = 4m_1$. Compare the resulting momentum magnitude of ball 2, p_2, with that of ball 1, p_1.

(a) $p_2 = p_1$
(b) $p_2 = p_1\sqrt{2}$
(c) $p_2 = 4p_1$
(d) $p_2 = 16p_1$
(e) $p_2 = 2p_1$

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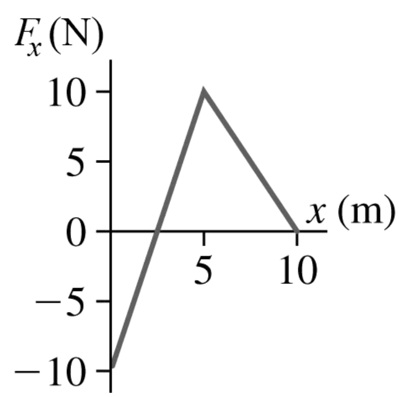
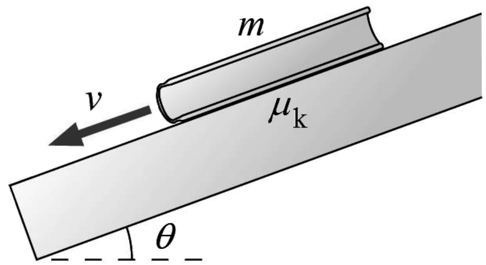
4. (8 points) A 2.0 kg object is traveling in the $+x$ direction at 7.0 m/s. When it arrives at the origin, it is subject to a varying force as shown. What is the speed of the object at $x = 10\,\text{m}$?

(a) 5.0 m/s
(b) 8.6 m/s
(c) 9.9 m/s
(d) 7.0 m/s
(e) 9.3 m/s



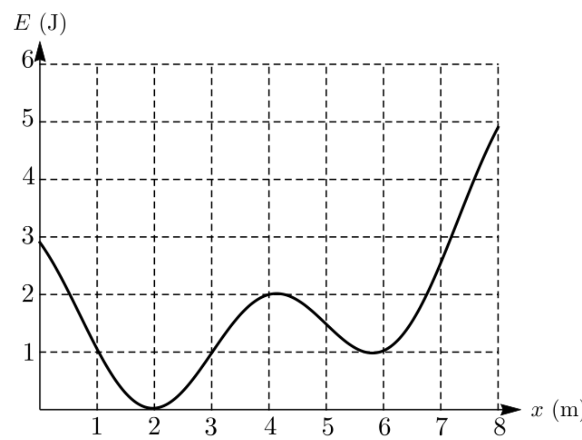
5. (8 points) A book of mass m slides down a slab that makes an angle θ with the horizontal. The coefficient of kinetic friction between the book and the slab is μ_k, so the book slides at constant speed v. At what *rate* is thermal energy increasing in the book-slab system? (*On Earth.*)

(a) $mg\,(\sin\theta - \mu_k \cos\theta)\,v$
(b) $mgv \sin\theta$
(c) mgv
(d) $\mu_k mgv$
(e) $\mu_k mgv \sin\theta$



6. (8 points) The graph shows the potential energy of a system as a function of the position, x, of a 3.0 kg particle within it. If the particle has a velocity of $\vec{v} = +1.0\,\hat{x}$ m/s at $x = 1.0$ m, where, if anywhere, does the particle turn around?

(a) The particle doesn't turn around in the range $x = 0$ m to $x = 8$ m.
(b) $x = 7$ m
(c) $x = 3$ m
(d) $x = 4$ m
(e) $x = 1$ m



7. (8 points) Consider three point masses of mass on a line. The central particle has mass m and two identical particles of mass $2m$ sit a distance d to the right and left of the central particle. With respect to zero at infinite separation, what is the universal gravitational potential energy in this system?

(a) $-5Gm^2/d$
(b) $-2Gm^2/d$
(c) $-6Gm^2/d$
(d) $-3Gm^2/d$
(e) $-4Gm^2/d$