↖ staple goes up there near the corner

Name (printed neatly) ________________________________

General Physics 121 - Exam 2 – October 28, 2016

Time started _______________

Time ended _______________

Place taken _______________

- To receive full credit for a problem, your work must convincingly demonstrate that you understand the physics involved behind the problem. That means not only providing the correct answer but showing how you obtained your answer.
- Questions represent a mix of conceptual and quantitative issues. Questions are scored according the rubric on the next page
- You may not consult the textbook, your notes, or any source of information other than the equations below.
- You may choose any continuous, uninterrupted 3-hour period in which to take this exam.
- You may use a calculator provided it is not programmed with course-specific information.
- It is important that your answers be neat and clear. Legible handwriting and clear exposition are required, not optional
- Use only one side of each page of paper.
- Box your final answers to help me locate and identify them quickly
- Use your own, lined paper. Nothing written on this exam will be graded. Do not use paper ripped from a spiral-bound notebook with jagged edges.
- Do not write your name on any of the pages other than this cover sheet.
- Start each answer on a new sheet of paper.
- Include raw algebraic equations and identify variables. Include units (m, s, m/s, etc.) in calculations and carry them through.
- When finished, place this entire exam atop your responses arranged in sequential order, straighten all the edges, and staple them together before handing them in.
- You must turn in the exam to Dr. Pontius unless other arrangements have been made.
- **I reserve the right to assign additional penalties for violating these instructions.**

Signing the honor code also affirms that you are taking the exam during a time period that does not conflict with any other academic obligations.

Honor code:

Don't Panic!

$$x = \frac{1}{2} a_x (\Delta t)^2 + v_{ix} \Delta t + x_i \qquad v_x = a_x \Delta t + v_i \qquad v_{xf}^2 = v_{xi}^2 + 2 a_x \Delta x$$

$$\sum_i \vec{F}_i = m\vec{a} \qquad \vec{F}_{12} = -\vec{F}_{21} \qquad \vec{p} \equiv m\vec{v} \qquad \tau_i \equiv F_i d_i \qquad \tau_{net} = I\alpha$$

$$W = \vec{F}\cdot\Delta\vec{x} = F d \cos\theta \qquad F_{s,max} = \mu_s F_N \qquad F_k = \mu_k F_N \qquad \Delta K_{friction} = f_k d$$

$$\Delta\theta = \frac{\Delta s}{r} \qquad \omega = \frac{v_t}{r} \qquad \alpha = \frac{a_t}{r} \qquad \omega \equiv \frac{d\theta}{dt} \qquad \alpha \equiv \frac{d\omega}{dt} \qquad a_r = \frac{v_t^2}{r}$$

$$\Delta U_g = mg\Delta h \qquad K_T = \frac{1}{2} mv^2 \qquad U_e = \frac{1}{2} k (\Delta x)^2 \qquad K_R = \frac{1}{2} I\omega^2$$

$$\vec{F}_{ave} = \frac{\Delta\vec{p}}{\Delta t} \qquad \tau_{ave} = \frac{\Delta L}{\Delta t} \qquad \vec{F}_{com} = M\vec{a}_{com} \qquad I = \sum_i m_i r_i^2$$

$$F_s = -k\,\Delta x \qquad F_g = -m\,g \qquad P = \frac{\Delta W}{\Delta t} \qquad P = Fv \qquad \vec{\boldsymbol{\tau}} = \vec{\mathbf{r}} \times \vec{\mathbf{F}}$$

$$P = \tau\omega \qquad W = \tau\,\Delta\theta \qquad \vec{\mathbf{L}} = \vec{\mathbf{r}} \times \vec{\mathbf{P}} \qquad L = I\omega \qquad I_{A\,\&\,B} = I_A + I_B$$

$$\Delta\theta = \frac{1}{2}\alpha(\Delta t)^2 + \omega_i \Delta t \qquad \omega = \alpha\Delta t + \omega_i \qquad \omega_f^2 = \omega_i^2 + 2\alpha\Delta\theta$$

$g = 9.80$ N/kg
1 N = 0.225 lb
$c = 3.00 \times 10^8$ m/s
1 mile = 1619 m
1ft = 0.305 m
1 inch = 2.54 cm
1 metric ton = 10^3 kg
1 mile = 1.609 km
1 Btu = 252 cal
$a_g = 9.80$ m/s^2
$G = 6.673 \times 10^{-11}$ N·m^2/kg^2
$m_e = 9.11 \times 10^{-31}$ kg
I, ring, axis through center = MR^2
$m_p = 1.67 \times 10^{-27}$ kg
I, solid disk, axis through center = 1/2 MR^2
Surface area of cylinder = $\pi r^2 + 2\pi r H$
I, solid ball, axis through center = 2/5 MR^2
Volume of cylinder = $\pi r^2 H$
I, thin rod, axis through center = 1/12 ML^2
Area of circle = πr^2
I, thin rod, axis through end = 1/3 ML^2
1 Newton = 0.225 pounds
1 meter = 3.281 ft

Coefficients of friction	μ_s	μ_k
Copper against steel	0.53	0.36
Wood against rubber	0.98	0.67
Rubber against concrete	0.95	0.80
Teflon against teflon	0.04	0.04

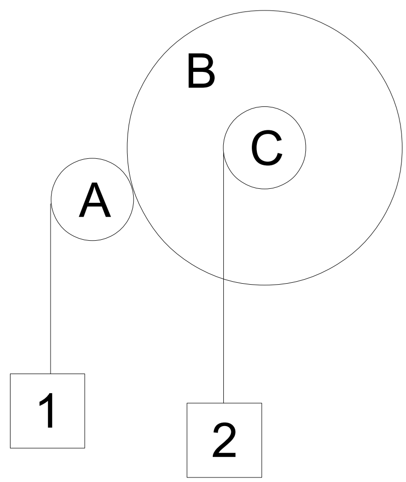
Grading rubric:

Level of demonstrated understanding	Example	Score
Complete	Correct reasoning and answer	10
	Correct reasoning; minor computational mistakes or omissions; reasonable answer	9
Partial	Some physics errors or a correct setup but no or incomplete execution; substantial omissions.	7
	Major physics errors or partial justification provided even if answer is correct; major omissions.	5
Little to none	Little of relevance or no justification provided even if answer is correct	3
	Very little of relevance	1
	Blank or just a restatement of the question	0

1. A few days ago, Dr. Pontius parked his scooter on the loading dock to the Humanities Building. He took the 3-pound bag of apples hanging from the handlebars and carried it inside the Humanities building. After climbing 40 steps (each a 7" rise) to the second floor, he walked down the corridor to a friend's office and dropped off something there. He returned to the front of the building and walked down 15 similar steps to the academic quad sidewalk, then he strolled down the walkway past the lovely gingko tree along a gentle downward 5.9° slope for a distance of 68.1 ft along the path. At the Stephens Science Center, it occurred to him that he might have done less work on the bag of apples had he left it on his scooter, then gone back after his errand and carried it directly from the scooter. That involves walking along a level path, then climbing 12 steps, and completing another level stroll to the same point at the SSC.

Compare the work Dr. Pontius actually performed on the bag of apples to the work he would have done on this alternate route. You may ignore wind resistance. Explain your reasoning thoroughly. As always, think before you calculate.

2. Consider the assemblage of disks, cords, and masses shown below. Three uniform disks can rotate on axles (not shown) through their centers. Their masses are M_A, M_B, and M_C, while their radii are R_A, R_B, and R_C, respectively. Moreover, $R_A = R_C$ and $R_B = 3\ R_C$. At the point on their rims where disks A and B are in contact, they move together without slipping, while disk B and C are welded together. In addition, there are two weights hanging down from cords. The cord attached to weight 1 with mass m_1 wraps around disk A, while the cord attached to weight 2 with mass m_2 wraps around disk C. If weight 1 is descending with linear speed v_1 at some instant, find v_2 the linear speed of weight 2 in terms of v_1, and specify its direction. Explain your logic.



3. A hallowed American tradition of grammar school involves recess, a break from classes when even the best behaved students can express their true inner hellion and run amok on the playground. Consider a merry-go-round turning with several students hanging on it. If a newcomer runs up, leaps onto it, and holds on at the outer edge, what determines how fast it rotates afterwards compared to how fast it was rotating originally? Consider two situations:

a) The new addition runs directly toward the center of the merry-go-round and jumps on

b) The new addition runs tangent to the outer edge of the merry-go-round and jumps on

Discuss this in terms of physical principles, not just based on your personal playground experience, regardless of how extensive and authoritative it might be.

4. A witch (purportedly wicked) flies from the West when she collides with a second witch (supposedly good) flying from the North at the same speed v_o. They are both knocked unconscious and fly on together with limbs entangled and broomsticks stuck together. From just before they collided until some time afterward, their magical powers ceased, and their motion was subject to the laws of Newton. Find their velocity (specifying the magnitude and its precise direction) immediately after impact in terms of their initial speed v_o. Now, as ladies of a certain age do not reveal their weights or masses, your answer may only involve variables for their masses, m_W and m_N. You may ignore the masses of their broomsticks, but you must explain your work and present your answers in a meaningful fashion.

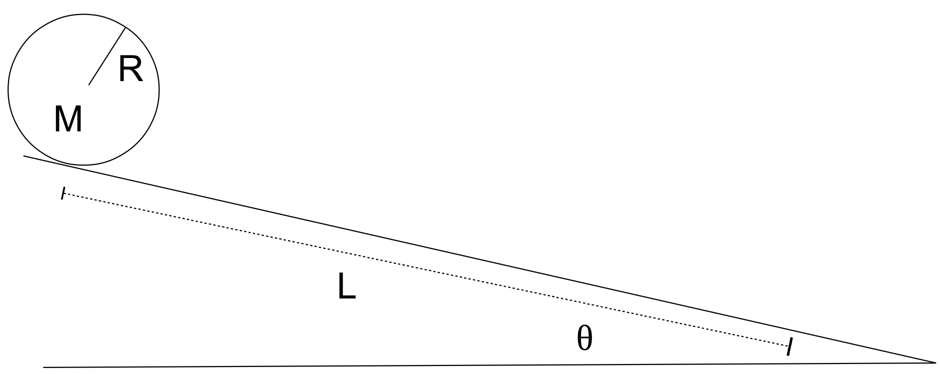
5. A uniform disk is released at rest from the top of a straight incline that is tilted at an angle of $\theta = 22°$ below the horizontal (or above the horizontal, depending on where you're standing and which way you're facing). The incline has sufficient friction that the disk rolls without slipping, and it travels a distance $L = 7.39$ m along the slope. Calculate the disk's center of mass speed at the bottom for the following situations and determine which is fastest.

a. The disk has mass $M_1 = 4.23$ kg and radius $R_1 = 2.93$ cm.

b. The disk has mass $M_2 = 1.52$ kg and radius $R_2 = 6.04$ cm

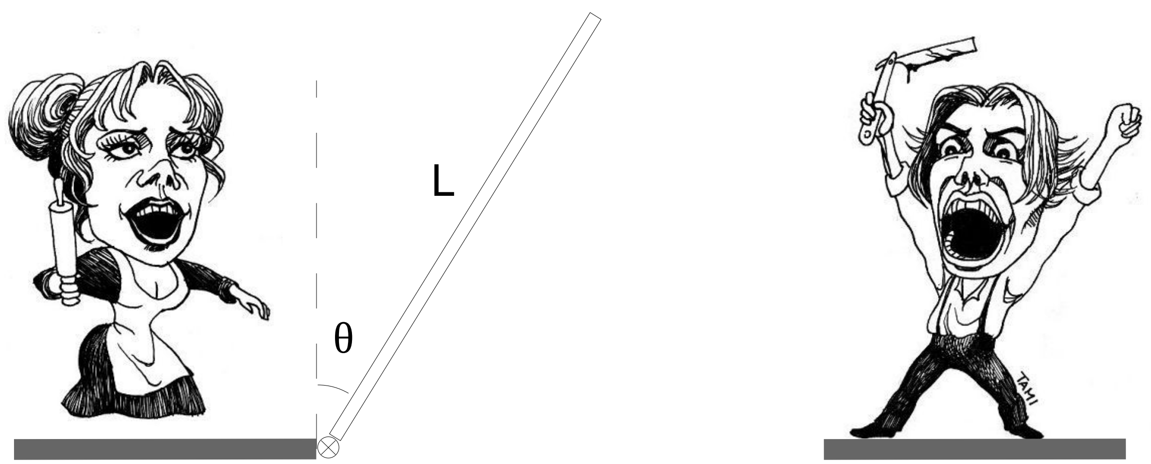
c. The disk has mass $M_3 = 3.33$ kg and radius $R_3 = 4.44$ cm

As always, explain your reasoning, particularly the part about physics.



"Inclined Plane: a study in non-impressionistic, minimalist representation," an early work by famed Flemish illustrator Joachim Ver Shakenictstiren the Younger, 1459-1526.

6. In performances of Sweeney Todd, the victims of the Demon Barber of Fleet Street were shoved through a trap door in the stage floor. They then slid to the basement where Ms. Lovett would eventually cook their bodies into tasty meat pies. (Just a little imagery for Halloween!) I saw one performance where the actor playing Sweeney (Nat Gunter, BSC 2003, fantastic voice) accidentally let go of the trap door, and it banged into the stage floor with a resounding thud!



Let the mass of the trap door be M. Its length in the direction shown is L, its thickness is T, and the width in the other direction (along the hinge, into the page) is W. The angle to the vertical is θ. The hinge at the lower end can be considered frictionless. As always, explain your reasoning for everything you do.

a) Calculate the angular acceleration as a function of the parameters given.
b) If it is dropped at rest from an initial angle θ_o, find the angular speed with which it hits the stage.
c) Can you determine the time required to close? If so, do so. If not, explain why.

Have a happy and safe Halloween!