↖ staple goes up there near the corner

Name (printed neatly) ________________________________

General Physics 121 - Exam 2 – October 31, 2014

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 exam atop your paper and staple them together with your responses to the questions in sequential order 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!

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

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

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

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

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

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

$$F_s = -k\,\Delta x \qquad F_g = -m g \qquad P = \frac{\Delta W}{\Delta t} \qquad P = Fv \qquad I = I_{cm} + M d^2$$

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

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

$g = 9.80$ 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 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, hollow sphere, axis through center = 2/3 MR^2

Area of circle = πr^2

I, pad, with Retina display, Wi-Fi, 16GB = $499

1 Newton = 0.225 pounds

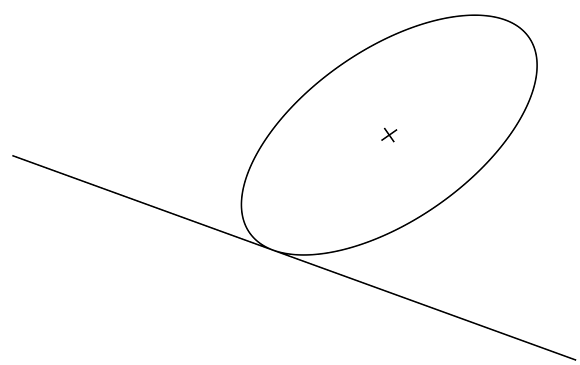
1 meter = 3.281 ft

Coefficients of friction	μ_s	μ_k
Steel against steel	0.74	0.57
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:

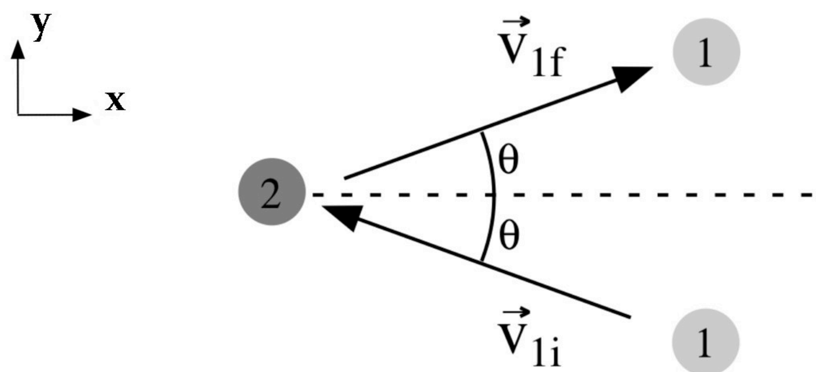
Level of demonstrated understanding	Example	Score
Complete	Correct reasoning and answer	10
	Correct reasoning; minor computational mistakes or omissions; reasonable answer	9
Partial	Some physics errors or a correct setup but no or incomplete execution; substantial omissions.	7
	Major physics errors or 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. Consider a cylinder with an elliptical cross section, an ordinary circular cylinder that has been squished out along one direction but is otherwise unaffected along its central axis. Think of a tall trash can with an elliptical base. Now, lay that thing on its side and let it roll down a slope without slipping. Yes, it's going to move unevenly, jerkily, but I'm not going to ask you to solve for its motion. Rather, at the instant when it's in the position sketched below, I want you to find all the forces and torques at the instant shown in the figure. First identify in words all the forces acting on the cylinder, then trace out this figure on your own paper. Add labeled force vectors starting from where each is applied, then draw and label the moment arm for torques about the central axis (marked with an x), which is also the center of mass. Be sure your figure is a clear and accurate representation of what is printed below. If you need, you may draw a separate figure for each force to avoid crowding.



2. Standing motionless on a window ledge 45 meters above the street, Spiderman sees his heartthrob step into the street in front of a speeding bus. He slings a line of web over a nearby stanchion (which is...I dunno, one of those handy things on buildings superheroes always find to attach things to just when they need them), then swings down, grabs her, and swings back upward to receive his osculatory reward. During the swing, Spiderman holds onto the web tightly but does not pull himself along it. If his mass is a manly 85 kg and hers is a dainty 55 kg, what is the highest level they can swing up to? Note that while Spidey has superhuman strength and a costume whose material properties stretch the bounds of credulity, he cannot violate the laws of physics. Please explain your reasoning as you work your way through this.

3. Ball 1, which has mass m, initial speed $v_{1i} = v$, final speed $v_{1f} = v$, radius r, color beige, and price $1.49, bounces off of ball 2, which is initially at rest. There is no change in ball 1's mass, speed, radius, color, or price, only its direction. The dashed line shown bisects ball 1's incoming and outgoing directions, i.e., the angles θ above and below the dashed line are equal. The final velocity vector of ball 2 is not shown, so calculate it in terms of the parameters m, v, r, and θ using the coordinate system indicated in the figure. The balls are isolated from all other external influences, but do not make any further assumptions about the nature of this collision. Explain.



4. Consider a ball that rolls without slipping down an incline. This incline has a varying, undulating slope, not a constant slope, but the height descends steadily and not so steeply that the ball might fly off of it. If the ball starts at rest and descends a vertical distant Δy, carefully explain how to determine the ball's speed at the bottom. I'm looking for a thorough explanation that shows you understand all the relevant factors. Be explicit and clear! If you talk about a force or energy, specify the bodies involved, and if you talk about some conservation law, defend its applicability in this situation.

5. A ladybug reclines on a lazily turning ceiling fan, her legs hooked through the decorative metal scroll at its outer edge 84 cm from the center. She languidly chews on an aphid and thinks about her gentleman bug. The fan was set on LOW, turning half a revolution each second. You walk into the room and flip the switch to HIGH, which in just 4.3 seconds increases the rotation rate to two revolutions per second. Calculate the magnitude of the **total** linear acceleration vector of the poor bug 2.0 seconds after you flip the switch.

6. A bucket of sand of mass $M_S = 1.48$ kg hangs from the end of a cord that is wrapped around over a pulley. While we could afford a frictionless pulley, our budget didn't cover one that was also massless, so this pulley has mass $M_P = 0.65$ kg and radius $R_P =$ 26.1 cm. The pulley is turned by an external influence at 0.14 radians/s so that the cord winds up on the pulley and the bucket is lifted. At some time, the external influence is removed. Find the bucket's acceleration after that, when the external influence is zero. Note: If you do the entire problem in terms of algebraic symbols, I won't even require a numerical answer and, of course, there's no danger in getting the units wrong that way.