⇖ staple goes up there near the corner

Name (printed neatly) ________________________________

General Physics 121 - Exam 2 – October 23, 2020

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 the location assigned by 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!

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

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

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

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

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

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

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

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

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

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 ton = 10^3 kg	1 mile = 1.609 km	1 Btu = 252 cal

$a_g = 9.80\ m/s^2$

$m_e = 9.11 \times 10^{-31}$ kg

$m_p = 1.67 \times 10^{-27}$ kg

Surface area of cylinder = $\pi r^2 + 2\pi r H$

Volume of cylinder = $\pi r^2 H$

Area of circle = πr^2

1 Newton = 0.225 pounds

$G = 6.673 \times 10^{-11}\ N{\cdot}m^2/kg^2$

I, ring, axis through center = MR^2

I, solid disk, axis through center = 1/2 MR^2

I, solid ball, axis through center = 2/5 MR^2

I, hollow sphere, axis through center = 2/3 MR^2

I, pad pro, Retina display, Wi-Fi, 128GB = $799

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
Tiger butt on merry-go-round	0.50	0.45
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; moderately interesting B. S.	1
	Blank or just a restatement of the question	0

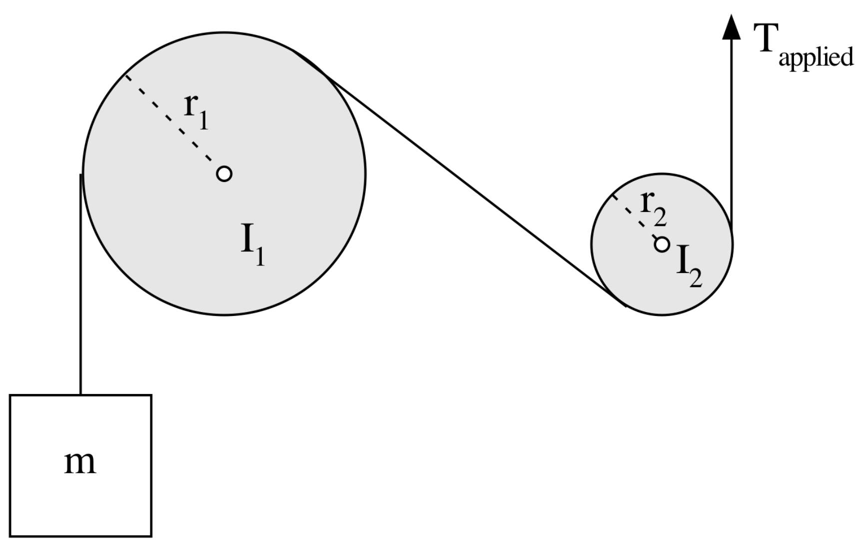
1. Consider a simple pendulum where a bob of mass m swings at the end of a light string of length L. Make a figure indicating the position at the high point of its swing θ ($< 90°$) from the vertical (label that position P) and at the bottom of the swing (label that position Q).

a) Construct free-body diagrams for the bob at both positions, correctly indicating the direction and the approximate relative magnitudes of all forces. Explain the logic guiding your drawing.

b) If the bob is instantaneously at rest at point P, could you calculate the speed at point Q? If so, outline your strategy and thoroughly explain why it works. If not, explain what technical difficulty would prevent you from doing so. (Personal difficulties are your problem, not mine.)

c) If the bob is released from rest at point P, could you calculate the time to reach point Q? If so, outline your strategy and thoroughly explain why it works. If not, explain what technical difficulty would prevent you from doing so. (See above comment!)

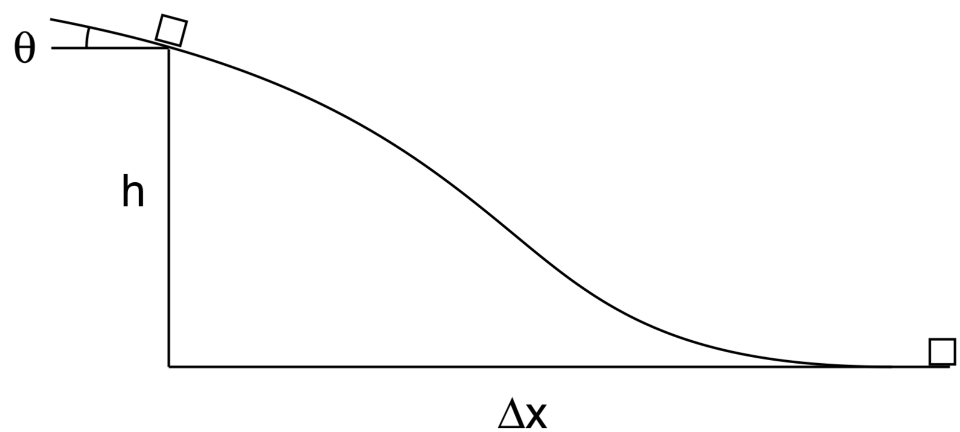
2. A cord attached to a hanging block is wrapped around a pair of pulleys rotating on fixed, frictionless axes, as illustrated below. The mass of the block is $m = 42.0$ kg, and the radii and moments of inertia of the pulleys are as follows: $r_1 = 0.350$ m, $I_1 = 1.27$ kg$\cdot$ m^2, $r_2 = r_1/2 = 0.175$ m, $I_2 = 0.675$ kg$\cdot$ m^2. (This problem is for those of you who wanted numbers! I still recommend doing the problem algebraically till the end.) At the other end of the cord, a steady tension T_{applied} is applied by some clever device not shown (patent pending). Find the tension required to raise the hanging mass with a constant acceleration of $a = 1.20$ m/s^2. Do I need to tell you to explain your work clearly? I didn't think so.



3. Can an object that is totally motionless (i.e., every point on it has a velocity of zero) at some instant have a nonzero angular acceleration at that same instant?

- If your answer is "yes", describe a physical example and explain how it satisfies those conditions. Make it a good one. (A general statement would not be sufficient).
- If your answer is "no", explain why it is not possible in general. Make it convincing. (A particular example is not sufficient.)

4. The figure below shows a block of mass M at the top of a frictionless slope. The block is released from rest at the point shown, where the local slope is inclined an angle of θ to the horizontal. The block slides down, eventually reaching the point indicated on the level area at the far right, which is displaced a vertical distance h below and a horizontal distance Δx to the right of the starting position. Air resistance is negligible.



Explain your reasoning as you solve each of the following questions. All answers should be given in terms of the parameters supplied and g, the gravitational field (sometimes affectionately known as "little g"), which should not be converted into a numerical value.

a) Calculate the final linear speed of the block.

b) Repeat, replacing the block with a solid sphere of mass M and radius R, still with no friction on the slope.

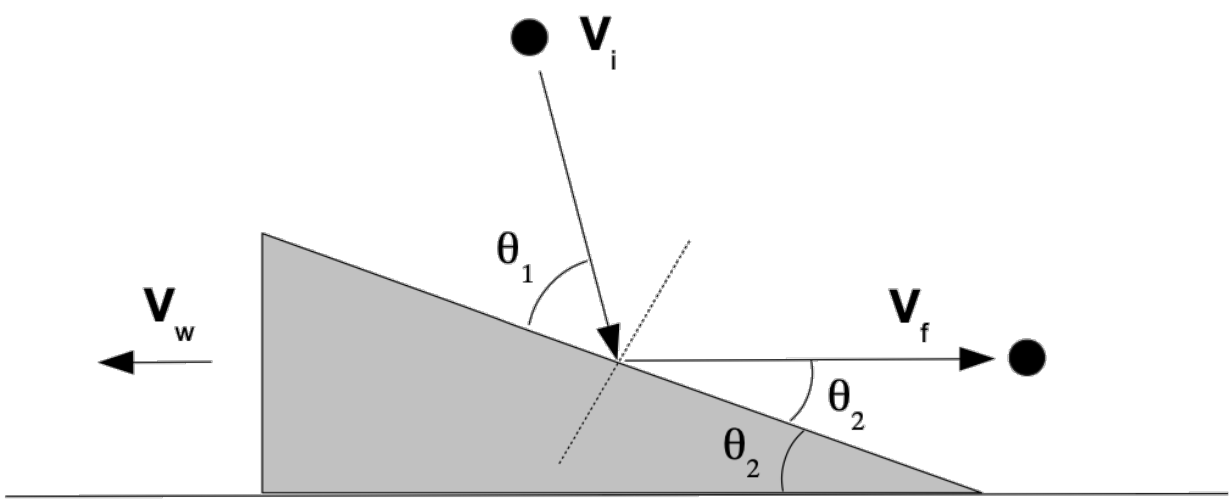
c) Repeat for the same solid sphere, but now with substantial coefficients of friction μ_k and μ_s. Explain your reasoning throughout, identifying each physical principle of relevance.

5. Calvin places Hobbes on a playground merry-go-round 0.9 meters from the center and starts to turn it by holding onto one of its supports and running around the perimeter. It takes him just half a second to get it turning at a rate of one rotation every three seconds. Find the magnitude of Hobbes' linear acceleration. Does the tiger slip or not? Give the kind of thorough explanation that Calvin's dad would find fascinating.

6. A wooden triangular wedge of mass m_w = 6.88 kg is at rest on a frictionless surface. A dense rubber ball of mass m_b = 1.72 kg moving at speed v_i = 51.44 m/s bounces from the slanted surface which is also frictionless, as shown in the figure. The outgoing speed is 42.0 m/s. (I was originally going to have you calculate that, but I decided to be kind. Please keep that in mind at evaluation time.) The arrows represent the velocity vectors immediately before and after striking. (The actual path of the ball in the air would be curved due to gravity, of course). Because the wedge is free to move, the incoming angles are not equal as they would be if it were stationary. The indicated angles are $\theta_1 = 45°$ and $\theta_2 = 30°$.

a) Determine the impulse exerted on the wedge by the ball.
b) Find the velocity of the wedge after the collision.

Explain your reasoning throughout.



Extra credit: For number 6, prove that the outgoing speed of the ball is 42.0 m/s.