⇖ staple goes up there near the corner

Name (printed neatly) ________________________________

General Physics 121 - Exam 3 – November 29, 2016

Time started ______________ (record before you start – the honor code applies!)

Time ended ______________ (remember that honor code thing)

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 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.
- 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.
- **Use only one side of each page of paper.**
- **Do not write your name on any of the pages other than this cover sheet.**
- **Start each answer on a new sheet of paper.**
- **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

Reminder: Show all your work. Explain thoroughly and justify everything.

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

$$\Delta\vec{r} = \frac{1}{2}\vec{a}(\Delta t)^2 + \vec{v}_i t \qquad \Delta\vec{v} = \vec{a}\,\Delta t \qquad v_{xf}^2 = v_{xi}^2 + 2a_x\,\Delta x \qquad \sum_i \vec{F}_i = m\,\vec{a}_{com}$$

$$f_{s,\,max} = \mu_s N \qquad f_k = \mu_k N \qquad \Delta K_{friction} = f_k\,d \qquad W = \vec{F}\cdot\vec{d} \qquad P \equiv \frac{dW}{dt} = \vec{F}\cdot\vec{v}$$

$$\vec{F}_{12} = -\vec{F}_{12} \qquad \vec{P} \equiv m\,\vec{v} \qquad \vec{\tau} \equiv \vec{r}\times\vec{F} \qquad \sum_i \vec{\tau}_i = I\,\vec{\alpha} \qquad \vec{L} \equiv I\,\vec{\omega} \qquad \vec{L} = \vec{r}\times\vec{P}$$

$$\Delta\vec{P}_{total} = 0 \qquad \Delta U_g = mg\Delta h \qquad K_t = \frac{1}{2}mv^2 \qquad U_s = \frac{1}{2}k\,x^2 \qquad K_R = \frac{1}{2}I\,\omega^2$$

$$\Delta\vec{L}_{total} = 0 \qquad \theta = \frac{s}{r} \qquad \omega = \frac{v_t}{r} \qquad \alpha = \frac{a}{r} \qquad \omega \equiv \frac{d\theta}{dt} \qquad \alpha \equiv \frac{d\omega}{dt} \qquad a_r = \frac{v_t^2}{r}$$

$$\vec{r}_{com} \equiv \frac{\sum m_i\,\vec{r}_i}{\sum m_i} \qquad F_g = G\frac{mM}{r^2} \qquad \Delta U_g = -mMG\left(\frac{1}{r_f} - \frac{1}{r_i}\right) \qquad I_{A\,\&\,B} = I_A + I_B$$

$$x = A\cos(\omega t + \phi) \qquad v = -\omega A\sin(\omega t + \phi) \qquad a = -\omega^2 A\cos(\omega t + \phi)$$

$$y = A\sin(kx - \omega t) \qquad v = -\omega A\cos(kx - \omega t) \qquad a = -\omega^2 A\sin(kx - \omega t)$$

$$F = -k\,\Delta x \qquad T = \frac{1}{f} = \frac{2\pi}{\omega} \qquad k = \frac{2\pi}{\lambda} \qquad v = \lambda f \qquad v = \sqrt{\frac{T}{\mu}}$$

$$P = \frac{F}{A} \qquad \Delta P = \rho g\Delta h \qquad \omega = \sqrt{\frac{k}{m}} \qquad \omega = \sqrt{\frac{g}{L}} \qquad E = mc^2$$

1. Musical historians have noted a curious phenomenon taking place over the course of several centuries. Performers are tuning their instruments differently than they used to, one measure of which is that the frequency assigned to the tuning note (called A') is being raised. It is currently 440 Hz, while in Bach's time it was 415 Hz. This makes violins more responsive for those irrepressible show-offs, but it also increases the stress on the instrument. (Some scholars predict we'll eventually see a Stradivarius explode on stage during a particularly vehement performance of some Paganini caprice.) If a particular violin string is tuned to A' by Bach's ear and we adjust the tension on that same string until it is tuned to A' by modern standards, by what factor has the tension changed? Explain the relevant factors and how they do or do not change and why.

2. A spring of negligible mass is suspended vertically with its top end attached to a fixed support. A metal bob of mass 250 grams is carefully attached to the bottom end while the spring is kept in its undisturbed state. That is, the mass is supported while being attached so that the spring isn't disturbed. The bob is released from rest at that point, descends a maximum distance of 0.36 meters below there, after which it continues oscillating between those two points. Carefully explain how to determine the spring constant and the period of oscillation from these data. Your logic must be excruciatingly clear and impeccably presented, so don't just equate things at random. Tip: Free-body diagrams are good things.

3. For the following waves, find the propagation velocity and explain why that works. In particular, explain what logic determines the direction of propagation. Just citing a rule you remember isn't sufficient
    a. A sine wave described by:

    $$f_1(x,t) = 1.7\text{ cm} \cdot \sin\left(0.42\text{m}^{-1} \cdot x + 2.7\text{s}^{-1} \cdot t\right)$$

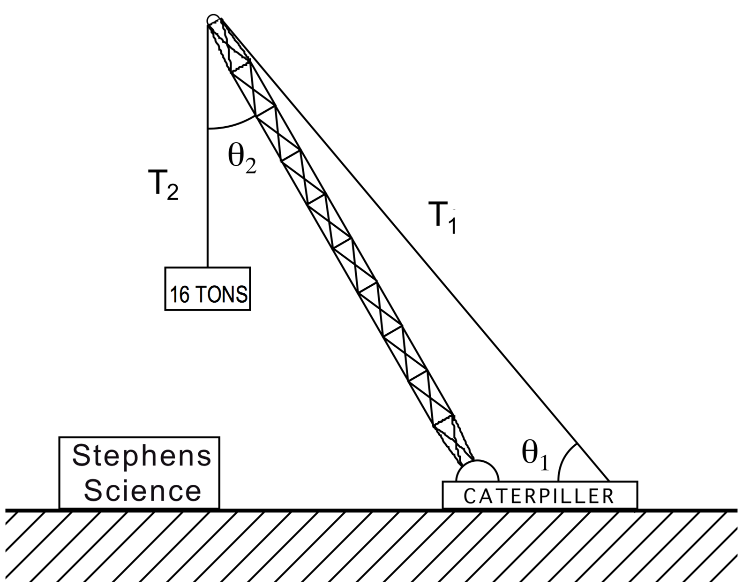
    b. A wave pulse described by:

    $$f_2(x,t) = 1.7\text{ cm} \cdot \mathrm{e}^{-\left(0.42\text{m}^{-1} \cdot x + 2.7\text{s}^{-1} \cdot t\right)^2}$$

c.

4. Our Moon's orbit is approximately circular with a radius of 400,000 km. In contrast, the International Space Station orbits at approximately 360 km above the Earth's surface. (Compared with the Earth's radius of 6400 km, the ISS is barely off the ground). Knowing that the moon takes 1 month to orbit the Earth, calculate how long it takes the ISS to complete one orbit. You must start from the equations given in the list above, not by recalling another equation from the text (though you may derive that equation and use it).

5. A load of concrete, 16 metric tons of the stuff, hangs from the end of a 52-meter long boom, as shown below. The boom's mass is 42 tons, its center of mass is at its geometric center, and its lower end is attached to a pivot on the upper deck of the main housing of the crane. There is an additional, supporting cable running from the top of the boom to the back end of the crane, where it makes an angle of $\theta_1 = 50°$ to the horizontal. The boom itself makes an angle of $\theta_2 = 30°$ to the vertical. Find the tension T_1 in the supporting cable and the total contact force exerted by the pivot on the lower end of the boom. Note: The supporting cable and the hanging cable are both attached to the top of the boom, but it's not the same cable and they don't have the same tension. FYI: 1 metric ton = 10^3 kg. Easy, ain't it?



6. Along the Eastern shore of Chesapeake Bay, sailors knew they'd reached the famous "Mucky Duck" restaurant when they spotted the finely carved wooden duck hanging over the water. For seventy-five years, the original duck hung there from a cord tied around a metal support, until lightning struck the support, which broke off and fell into the bay dragging the duck down with it into the deep water. The support now rests on the bottom of the bay with the wooden duck buoyed above it tugging upward on the cord toward the surface far above. By coincidence, the tension in the cord now has the same value as when the duck was hanging motionless in air before. Find the average density of the duck as a multiple of the density of water. Explain your logic and justify your work.