↖ your staple goes up there, alongside the original one

Full name (neatly printed) ________________________________

General Physics 122 - Exam 1 – March 1, 2019

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
- Include raw algebraic equations and identify variables. Include units (m, s, m/s, etc.) in calculations and carry them through.
- Box your final answers to help me locate and identify them quickly
- Use only one side of each page of paper.
- 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.
- When finished, place this entire exam atop your responses arranged in sequential order, straighten all the edges neatly, 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.**

Honor code:

Don't Panic!

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

Grading rubric:

Level of demonstrated understanding	Example	Score
Complete	Correct, fully justified 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

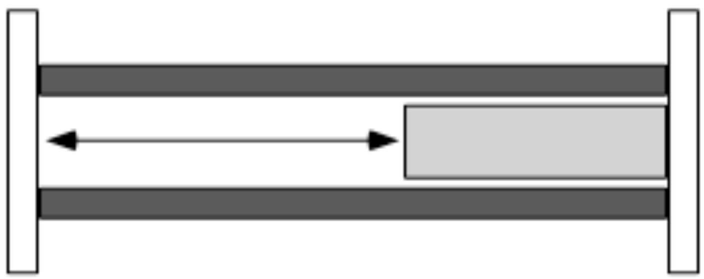
$T_K = T_C + 273.15$ $x^{n+m} = x^n x^m$ $x^{n*m} = (x^n)^m$

Coefficients of Volume expansion (1/°C)		Specific heat (J/kg °C)	Density (kg/liter)
Aluminum	72×10^{-6}	220	2.7
Iron	36×10^{-6}	108	7.87
Zinc	89×10^{-6}	93	7.14
Mercury	180×10^{-6}	140	13.6
Water	-	4186	1.000
Ice	-	2090	0.920

Latent heats	Fusion (J/kg)	Vaporization (J/kg)
Oxygen	2.55×10^4	2.13×10^5
Water	3.33×10^5	2.26×10^6
Aluminum	3.70×10^5	1.14×10^7
Copper	1.34×10^5	5.06×10^6

1. Throughout our study of thermal phenomena I've repeatedly emphasized the importance of being clear about some distinctions that ordinary language glosses over. The phrase "heating up" is particular troublesome, as it has two possible meanings, i.e., two possible implications about some physical outcome. The public at large considers those implications to be equivalent, i.e., that one always accompanies the other, but we know better.
   a. Explain what those two implications are, then describe a practical scenario involving an ideal gas in which one implication occurs but the other does not.
   b. Now describe a different practical scenario involving an ideal gas where the implication that didn't apply in (a) now does, while the one that did apply in (a) doesn't anymore.

2. For some applications, it's important to be able to construct something with a dimension that does not change as temperature rises and falls. One way to do that is to use several different materials and cleverly construct them so that the different responses compensate for each other. The design below uses two rods of iron (dark grey) and one bar of zinc (light grey). The iron rods are attached at both ends to bases, while the zinc bar is only attached at the right end. The purpose of this contraption is to keep the gap indicated by the arrows at a fixed width, regardless of temperature. If the length of the iron rods is L_{Fe} = 42 mm when the temperature is a balmy 22°C, find the required length of the zinc bar.



3. You combine 1 kg each of solid water (a.k.a. "ice") at -20°C and liquid water (a.k.a. "water") at 20°C and let them come to thermal equilibrium. Find the final state of the system, specifying the final masses and temperatures of everything. Before you start any mathematical calculations, outline your envisioned scenario of what happens and carefully explain the reasoning you will use to solve the problem.

4. You know those airline safety briefings that are repeated before every flight? No? Well, while you're playing on your phone, there's a flight attendant explaining safety procedures, which can be important. For example, what happens when there's a mechanical breach in the aircraft's hull and air rushes out? The pressure in the cabin drops rapidly from the typical value maintained during flight (state "a" - about 80% of pressure at ground level) to that of the surrounding air (state "b" - perhaps 40% of pressure at ground level) in a fraction of a second. Because of the rapid drop in pressure, any trapped volumes of air in your body respond adiabatically until they reach the new

pressure. This transition can be very painful to your ears if the Eustachian tubes in your ears are clogged and can't vent to equilibrate. After that change, the air remains at constant pressure and adjusts thermally until it is in equilibrium with its original temperature (state "c"), which is your body temperature, of course. All this takes place in a few seconds. At a gradual rate (relative to those dramatic events), the pilot flies the plane down to a lower altitude, eventually reaching an altitude where the pressure is equal to the original cabin pressure. (state "a" again)

Describe what your ears would go through if the air within them remained trapped. Draw a PV diagram depicting this cycle and carefully explain what happens during each step, indicating the direction in each stage and qualitatively explaining how all the thermodynamic variables behave. Interpret the signs of work and heat in words.

5. For the last scenario, calculate the values of pressure, volume, and temperature at all the identified states (the corners in your diagrams) using the supplied information. Calculate the heat and work associated with each stage, identifying the appropriate formulas. For the initial volume of the middle ear…I asked my wife, who is a biologist, but she says she's not that kind of biologist and that if I want to know anything about the molecular properties of the signaling pathways involved in protein expression related to the middle ear, she'd be happy to help, but she hasn't studied gross anatomy since college, so I'd probably be better off using my own experience with ears since I've had to clean out the cats' ears from time to time, and though cats are smaller, as a physicist I know how to scale appropriately, which is a good point. Call it half a milliliter for a human. As usual, explain thoroughly and justify everything.

6. One of the warm-up exercise asked what would happen if some benevolent, omnipotent, but ultimately just curious being replaced each and every particle in a gas with two new particles, while not changing volume or total internal energy. Let's revisit that again with some additional stipulations.
   a. Find the ratio of the final to initial values of pressure and temperature under the assumption that both the original and replacement particles are monatomic. Though you may show equations, argue for your conclusion in words.
   b. Now find the same ratios if the original particles are diatomic while the replacement particles are monatomic. Assume the gas is at the same initial temperature as in part Again, explain in words why these answers differ or not from the original answers.

   To be very clear, I want your explanations to describe the variations in quantities based on relevant principles. Do not just solve algebraically and then try to explain by saying something like, "in this equation, this factor increases by this much so that one decreases by that much." That's math, not physics.

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