Name ______________________________

General Physics 122 - Exam 1 – February 26, 2021

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 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

$T_K = T_C + 273.15$ $\qquad$ $T_F = (9/5)\,T_C + 32$

	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. Your job as an inspector in Alabama's Crucial Regional Apportionment Program is to measure the diameter of storm sewer access covers (a.k.a. manhole covers). Designed to be flush with the surface of city streets, these covers are iron disks (diameter = 76.2 cm) that sit within slightly larger iron rings (inner diameter 76.4 cm) set into the cushy asphalt of city streets. (Each covers rests upon a thin protruding lip that prevents it from falling.) Unfortunately, all these measurements were made when the outside temperature was 5°C. Given that solid objects tend to expand with rising temperature, how hot must it be before the disks expand enough to meet the surrounding rings and become sealed shut? Explain.

2. Consider a pair of identical vessels that are isolated from each other. They contain gases of the same pressure, number of moles, and mass per particle (i.e., they both have the same molecular weight). However, vessel A contains monatomic particles, while vessel B contains only diatomic particles. Compare and contrast the temperatures and the internal energies of these two gases, as well as the individual energies of their constituent particles. Then explain how and why their temperatures would change if the same quantity of heat were added to each.

3. It's spring break! You shovel 15 kilograms of ice at -5°C from your freezer into a remarkably well-insulated cooler and throw in 12 half-liter bottles of spring water at 22°C. Describe the state you find later when you arrive at the beach and open the cooler, after they've have time to equilibrate. Be specific and quantitative, and explain what you're doing. (Note: I am aware that you would throw more into your cooler than water bottles, but I didn't want to look up the thermal characteristics of Natty Lite.)

4. As you know, $C_P = C_V + R$, but why? First, explain what C_P and C_V are and how they're used (not just their proper names). Second, explain why C_P must be greater than C_V based on convincing physical arguments. Third, show how that particular mathematical relation between them arises.

5. Sadi Carnot, a French engineer, painstakingly considered the physics underlying heat engines and discovered a type of thermal cycle for gases that is particularly important. Now named the Carnot cycle in his honor, its key characteristic is that isothermal processes alternate with adiabatic processes. That is, the gas undergoes isothermal compression (stage *A*), adiabatic compression (stage *B*), isothermal expansion (stage *C*), then adiabatic expansion (stage *D*), arriving back at the original state. First, draw the *PV* diagram for such a process and discuss (qualitatively) the heat and work during each stage of the cycle and relate them to the changes in pressure, volume, and internal energy. Be very thorough, clear, and specific in your explanations. This section should stand alone and not reference results from the next question, which is a continuation.

6. Continuing from what you described in the last question, an ideal monatomic gas starts at the beginning of the Carnot cycle with a pressure of 1.3 atmospheres and volume of 0.60 liters. The initial isothermal compression reduces the volume to one half its original value and the isothermal processes occur in contact with heat reservoirs at 240 K and 300K. Calculate the pressure and volume at each corner of the cycle. Calculate heat and work for each stage of the cycle, and the net heat and the net work for the entire cycle. This section should stand alone and not reference arguments from the previous question.