Name (neatly printed!) ______________________________

General Physics 122 - Exam 2 – March 25, 2021

Time started ______________ Time ended ______________

Place taken ______________

PLEASE READ ALL THE INSTRUCTIONS THROUGH FIRST!!!!

- 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

Data that may or may not be of value to you:

$e = 1.60 \times 10^{-19}$ C

$k_e = 8.99 \times 10^{9}$ N·m²/C²

$\mu_o = 4\pi \times 10^{-7}$ T· m/A

$\mu F = 10^{-6}$ F

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

$R_E = 6370$ km

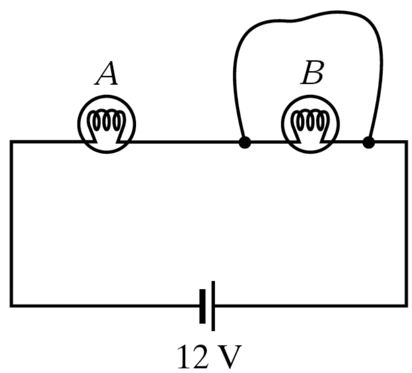
$G = 6.673 \times 10^{11}$ N·m²/kg²

$\varepsilon_o = 8.85 \times 10^{-12}$ C²/N·m²

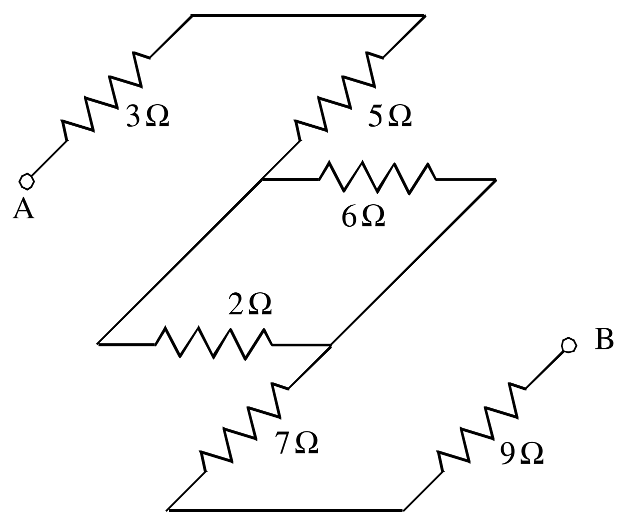
$nT = 10^{-9}$ T

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

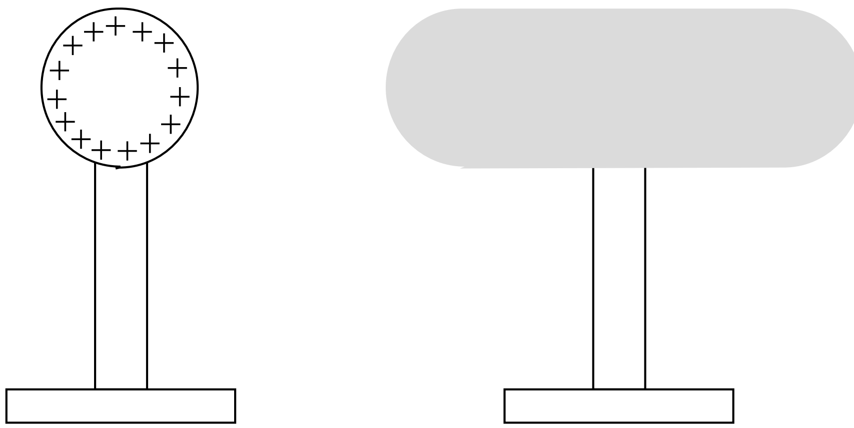
1) Consider a pair of identical light bulbs that are initially wired together in series with a constant voltage source (i.e., an ideal battery with negligible internal resistance, available for a limited time). Then, an additional wire is connected across bulb B as shown in the figure below. Discuss what happens to the brightness of each bulb and explain why carefully in English words and complete sentences, not just symbols.



2) Check out the resistor combination I came up with! Certainly, this could serve as the logo for some superhero. Your first job is to calculate the equivalent resistance between points A and B. Second, find the current through the 2Ω resistor when a potential difference of 24 volts is applied between points A and B, explaining your reasoning as you go. Third, identify an appropriate superhero (your choice of gender and super strengths) for this logo.



3) An insulating sphere has positive charges smeared evenly across its surface. As illustrated below, it is brought near an elongated metal (i.e., conducting) rod that carries no net charge.



a) Explain what happens to charges within the conductor. Describe their final state, qualitatively but correctly and thoroughly. Why does this occur?

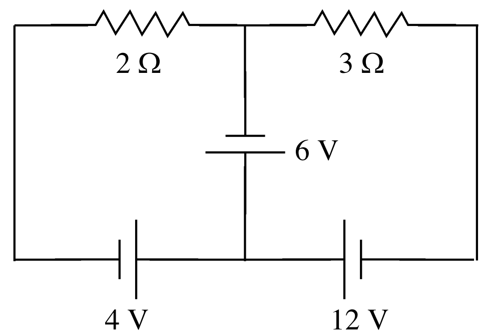
b) The sphere is now moved to a somewhat closer position. What changes occur and why?

c) With the sphere at a fixed location, discuss the net changes in energy that would be involved in moving a small positive test charge from a point on the surface of the **sphere** to the **left end of the conducting rod** (the close end), with particular attention to the type of energy involved and to interpreting the physical meaning of its arithmetic sign.

d) Now discuss the net changes in energy that would be involved in moving a small positive test charge from a point at the **left end of the conducting rod** to a point on the **right end of the conducting rod**, again with particular attention to the type of energy involved and to interpreting the physical meaning of its arithmetic sign.

e) Finally, discuss the net changes in energy that would be involved in moving a small positive test charge from a point on the surface of the **sphere** directly to a point on the **right end of the conducting rod**, without passing through the rod itself. Compare this to the prior answers.

4) The figure below shows a circuit even sillier than the one we discussed in class with two batteries in parallel with each other. Here, my friends, we have three—count 'em! —three batteries, plus a couple of resistors and wires for good measure. The values of the resistances and emf's are labeled as appropriate. Determine the direction and magnitude of the current through each battery. Explain very thoroughly what you're doing and what it all means.



5) A pair of charges are at fixed positions on the x axis, i.e., y and z are zero. The charge at $x = 0$ carries a positive charge of magnitude Q, while the charge at $x = R$ has a positive charge of magnitude $2Q$, both. In your answers to the following questions, do not restrict consideration to the x axis. While you may support your claims with equations and figures, they are insufficient without well-expressed physical arguments.

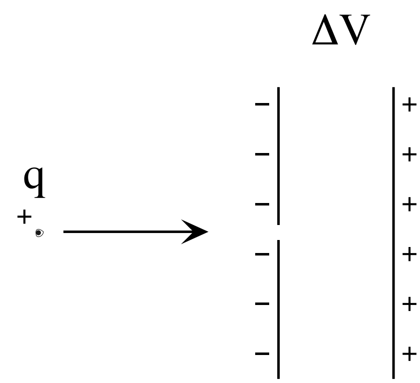
a) Are there any positions nearby (i.e, not at infinity) where the net electric field is zero? If so, explain qualitatively where they must be using physical arguments. If there is no such position, explain why.

b) Are there any nearby positions where the electric potential equals the value at infinity? If so, explain qualitatively where they must be using physical arguments and compare those positions with the answer to (a) if such exists. If there is no such position, explain why.

c) Repeat question (a) if the charge at $x = R$ is now -2Q

d) Repeat question (b) if the charge at $x = R$ is now -2Q, comparing the positions with those in part (c)

6) A charged particle carrying q = + 1.50×10^{-11} Coulombs enters a region between charged capacitor plates through a tiny hole in one plate, as shown. The potential difference between the plates is 3000V, and the kinetic energy of the particle as it passes through the hole is 5.0×10^{-8} J. The surface area of each plate is 27.7 cm^2 and they are separated by 4.2 mm.



a) Find the electric field between the plates (magnitude & direction), before the particle enters.
b) How much charge is stored on each plate?
c) How much energy is stored in the capacitor?
d) Does the charged particle reach the opposite plate?
e) If the potential difference remains unchanged but the plates are pulled apart to twice this separation before the next charge is fired in with the same initial energy, how do each the above answers change? Give numerical values for the final/initial ratios.