Principles of Physics II (PHY 112)
Spring 2004

Final Exam

Question 1 (4 points) If the electric field is zero in a region of space, must the electric potential be zero there as well? If so, explain why. If not, give a counterexample.

Question 2 (4 points) Consider the following statement: "Gauss's Law says that the charge inside a region is proportional to the electric field on the surface of the region." Explain why you agree or disagree with this statement.

Question 3 (4 points) Jill is given three identical resistors. She could put two in series and then put the third in parallel with this series combination. Alternatively, she could put two resistors in parallel and then put the third resistor in series with this combination. Draw circuit diagrams for these two situations, and indicate which one has the higher equivalent resistance.

Question 4 (4 points) Make a graph of electric potential as a function of position inside and outside of a parallel-plate capacitor. (If the plates are parallel to the x axis, your graph would show electric potential as a function of x.) Indicate on your graph where the capacitor plates are and whether they have positive or negative charge on them.

Question 5 (4 points) Consider a circular wire loop in the plane of the page. If a magnetic field points out of the page and is decreasing, what is the direction of the induced emf? Explain how you know in terms of ideas like the induced magnetic field.

Question 6 (4 points) (a) A stationary electron sits in a uniform electric field pointing upward. Draw a picture of this, and indicate the direction of the force felt by the electron from the electric field. (b) A stationary electron sits in a uniform magnetic field pointing upward. Draw a picture of this, and indicate the direction of the force felt by the electron from the magnetic field.

Question 7 (4 points) What is the difference between resistance and resistivity? Are they related? If so, how?

Question 8 (4 points) You are invited over to the King's palace on Saturday night. After a sumptuous vegetarian meal, you offer to help clean the enormous serving dishes used during the feast. One of these dishes is a perfectly hemispherical silver bowl one meter in diameter. After cleaning the bowl, you can see your reflection in it. From far away, your reflection is upside down. As you get closer, there is a place where your reflection becomes right side up. How far from the bowl surface does your reflection change from upside down to right side up? Why does this happen?

Question 9 (4 points) List the four theories of light that we talked about in class.

Question 10 (4 points) On a P-V diagram, draw a thermodynamic cycle for a refrigerator. Briefly describe the thermodynamic processes that make up the cycle.

Problem 1 (14 points) Consider the following thermodynamic cycle. An ideal gas with $C_V = \frac{5}{2}nR$ begins with a pressure of 150 kPa, a temperature of 200 K, and a volume of 5 L. The gas goes through the following processes.

(a) Isothermal compression to a volume of 2 L

(b) Adiabatic compression to a volume of 1 L

(c) Isobaric expansion to a volume of 5 L

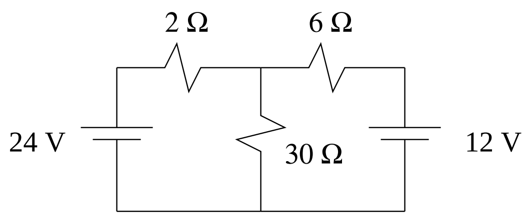
(d) Constant volume cooling back to the initial conditions

The heat capacity at constant volume for the gas has the same value at all temperatures. Complete the following tables. Don't forget to include appropriate units (at least at the top of each column).

State	P	V	T	E_{int}
initial				
after process (a)				
after process (b)				
after process (c)				

Process	ΔE_{int}	Q_{in}	W_{on}
(a)			
(b)			
(c)			
(d)			

Problem 2 (10 points) Analyze the circuit below. Give the voltage across each resistor and battery and the current through each resistor and battery in the box provided.



	Voltage across	with high potential on which side? (left, right, top, bottom)	Current through	with current flowing toward what direction? (left, right, up,down)
2 Ω				
6 Ω				
30 Ω				
24 V battery				
12 V battery				

Problem 3 (8 points) Consider two identical objects with mass 20 kg and charge 3 mC located at $\mathbf{r} = (-1\text{ m})\hat{\mathbf{i}} + (2\text{ m})\hat{\mathbf{j}}$ and $\mathbf{r} = (-1\text{ m})\hat{\mathbf{i}} - (2\text{ m})\hat{\mathbf{j}}$. These two objects are held fixed and not allowed to move. Now, if we place a third object with mass 0.5 kg and charge 5 μC at the origin and let it go, it will move out along the positive x-axis in response to the repulsion it feels from the other two fixed positive charges. How fast will this object be moving when it has reached the point $\mathbf{r} = (10\text{ m})\hat{\mathbf{i}}$?

Problem 4 (8 points) Consider three long parallel straight wires. Each carries a current of 10 A in the same direction and each is a distance of 0.1 m from the other two. (They form an equilateral triangle.) Calculate the force per unit length on one of these wires produced by the other two. What is the direction of this force?

Problem 5 (8 points) An object is placed 10 cm in front of a converging lens with focal length 20 cm. Where is the image formed? Is the image on the same side as the object or the opposite side? Is the image real or virtual? Is the image upright or inverted?

Problem 6 (8 points) You wish to make an anti-reflective coating from a material with index of refraction 1.3 to put on top of glass with an index of refraction 1.5. What is the minimum thickness of the coating that will produce destructive interference for light of wavelength 600 nm?