

CHUKA



UNIVERSITY

## UNIVERSITY EXAMINATIONS

EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE IN  
COMPUTER SCIENCE, EDUCATION SCIENCE AND APPLIED COMPUTER SCIENCE

## PHYS 241: ELECTRICITY AND MAGNETISM 1

STREAMS: BSC

TIME: 2 HOURS

DAY/DATE: FRIDAY 01/09/2023

2.30 P.M. – 4.30 P.M

## INSTRUCTIONS:

*Answer all the questions*

## Question One

- a. Two fixed particles, each of charge  $5.0 \times 10^{-6} \text{ C}$ , are 24 cm apart. What force do they exert on a third particle of charge  $-2.5 \times 10^{-6} \text{ C}$  that is 13 cm from each of them  
(6 marks)
- b. (a) How much energy is stored in the electrical fields in the capacitors (in total) shown below? (b) Is this energy equal to the work done by the 400-V source in charging the capacitors?

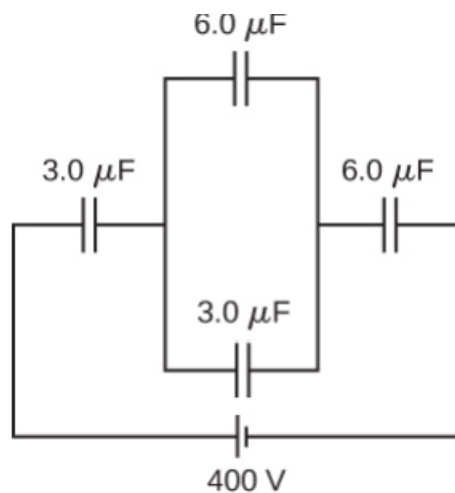


Figure 1

(6 marks)

- c. A high-energy proton accelerator produces a proton beam with a radius of  $r = 0.90 \text{ mm}$ . The beam current is  $I = 9.00 \mu\text{A}$  and is constant. The charge density of the beam is  $n = 6.00 \times 10^{11}$  protons per cubic meter. (a) What is the current density of the beam? (b) What is the drift velocity of the beam? (c) How much time does it take for  $1.00 \times 10^{10}$  protons to be emitted by the accelerator (6 marks)
- d. A 20.00-V battery is used to supply current to a 10-k  $\Omega$  resistor. Assume the voltage drop across any wires used for connections is negligible. (a) What is the current through the resistor? (b) What is the power dissipated by the resistor? (c) What is the power input from the battery, assuming all the electrical power is dissipated by the resistor? (d) What happens to the energy dissipated by the resistor (6 marks)
- e. Consider the circuit shown below. Find  $V_1$ ,  $I_2$ , and  $I_3$ .

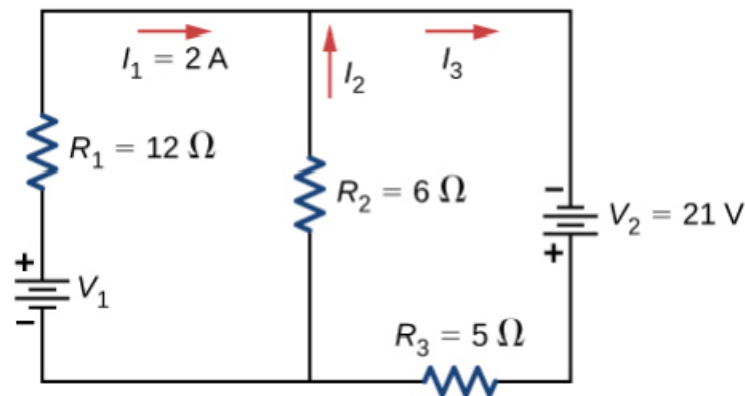


Figure 2

(6 marks)

Question Two

- a. Three equal positive charges  $q$  are at the corners of an equilateral triangle of side  $a$  as shown in Figure 3
- (i) Assume that the three charges together create an electric field. Sketch the field lines in the plane of the charges. Find the location of a point (other than  $\infty$ ) where the electric field is zero.
- (ii) What are the magnitude and direction of the electric field at  $P$  due to the two charges at the base?

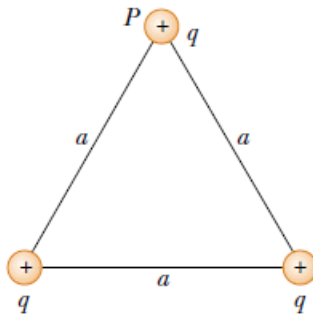


Figure 3

(8 marks)

- b. A proton moves at  $4.50 \times 10^5$  m/s in the horizontal direction. It enters a uniform vertical electric field with a magnitude of  $9.60 \times 10^3$  N/C. Ignoring any gravitational effects, find
- (i) the time interval required for the proton to travel 5.00 cm horizontally,
  - (ii) its vertical displacement during the time interval in which it travels 5.00 cm horizontally, and
  - (iii) the horizontal and vertical components of its velocity after it has traveled 5.00 cm horizontally.
- (12 marks)

**Question Three**

- a. Two capacitors,  $C_1 = 5.00 \mu\text{F}$  and  $C_2 = 12.0 \mu\text{F}$ , are connected in parallel, and the resulting combination is connected to a 9.00-V battery.
    - (i) What is the equivalent capacitance of the combination? What are
    - (ii) the potential difference across each capacitor and
    - (iii) the charge stored on each capacitor? (10 marks)
  - b. A 500-W heating coil designed to operate from 110 V is made of Nichrome wire 0.500 mm in diameter.
    - (i) Assuming that the resistivity of the Nichrome remains constant at its  $20.0^\circ\text{C}$  value, find the length of wire used.
    - (ii) Now consider the variation of resistivity with temperature. What power will the coil of part (a) actually deliver when it is heated to  $1200^\circ\text{C}$ ? (10 marks)
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