THE COUNCIL OF COMMUNITY COLLEGES OF JAMAICA

ASSOCIATE OF SCIENCE EXAMINATION

SEMESTER II – 2019 MAY

PROGRAMME: ENGINEERING

COURSE NAME: PHYSICS II

CODE: PHYS1201

YEAR GROUP: ONE

DATE: FRIDAY, 2019 MAY 10

TIME: 9:00 A.M. – 11:00 A.M.

DURATION: 2 HOURS

EXAMINATION TYPE: FINAL

This Examination Paper has **8** *Pages*

INSTRUCTIONS:

1. **THIS PAPER CONSISTS OF SIX (6) QUESTIONS. ANSWER ANY FOUR (4)**

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO

SECTION A

Instruction: In the booklet provided, answer any FOUR (4) questions from this section.

Question 1

A. Two (2) point charges, $Q_1 = +10\ \mu C$ and $Q_2 = -20\ \mu C$ are 1.2 m apart in a vacuum. Sketch the field pattern around the charges. *(2 marks)*

B. Determine the:

i. force on Q_1 due to Q_2, *(3 marks)*

ii. electric field (magnitude and direction) at a point P, midway between the charges *(5 marks)*

iii. electric potential at point P, due to Q_1 and Q_2 *(4 marks)*

C. Outline **ONE (1)** application and one hazard of electrostatics in industry. *(6 marks)*

$k = 9 \times 10^9\ Nm^2/C^2$ **$\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/Nm^2$**

(Total 20 marks)

Question 2

A. A 9 μF capacitor is connected in series with two capacitors, 4 μF and 2 μF respectively, which are connected in parallel. Determine the capacitance of the combination. ***(4 marks)***

B. If a p.d. of 20 V is maintained across the combination in part A, determine the voltage across each capacitor. ***(4 marks)***

C. *"A defibrillator is a device that applies a strong electric shock to the chest over a time of a few milliseconds. The device contains a capacitor of several microfarads, charged to several thousand volts. Electrodes called paddles, about 8 cm across and coated with conducting paste, are held against the chest on both sides of the heart. Their handles are insulated to prevent injury to the operator, who calls "Clear!" and pushes a button on one paddle to discharge the capacitor through the patient's chest."*

i. Except for the defibrillator, outline one other industrial use of capacitors. ***(3 marks)***

ii. Assume that the capacitor in the defibrillator is 20.0 μF and is charged to 4,000 Volts. How much charge is stored in the capacitor before it is discharged? ***(3 marks)***

iii. How much energy is released when the capacitor is discharged? ***(3 marks)***

iv. If the capacitor completely discharges in 2.0 ms, what is the average current delivered by the defibrillator? ***(3 marks)***

(Total 20 marks)

Question 3

A. Four resistors, R_1, R_2, R_3 and R_4 are connected as shown in **Figure 1**. Determine:

i. Their combined resistance *(3 marks)*

ii. The voltage across the 50Ω resistor *(2 marks)*

iii. The current in the 30Ω resistor *(2 marks)*

iv. The energy dissipated by R_1 in 2 minutes *(3 marks)*

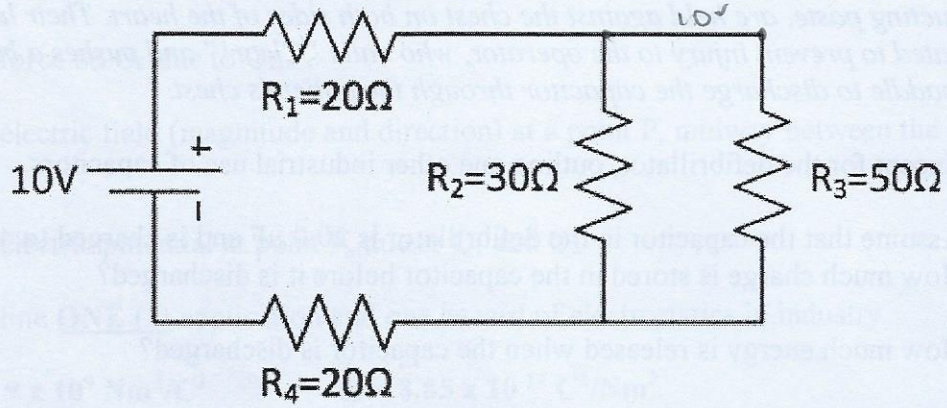


Figure 1

B. A cell (power supply) of emf, ε and internal resistance, r is connected to a load, R. Write an equation showing the relationship between ε, r and R. *(2 marks)*

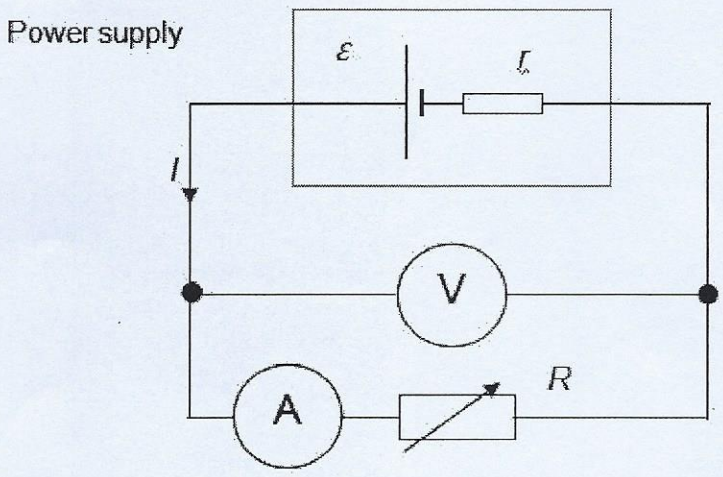


Figure 2

C. The lights and starting motor of a car are connected in parallel across the car's battery. When the lights of a car are switched on, the current in the lamp is 5.75 A and a voltmeter connected across them reads 12.0 V. When the electric starting motor is then turned on, the current in the lamp drops to 4.80 A and the lights dim somewhat. Assume that:

1. the internal resistance of the battery is 0.0696 Ω and that of the ammeter is negligible.

2. The resistances of the starting motor and the lamp are 0.10 Ω and 2.09 Ω, respectively.

i. With reference to your answer to (**B.** part **i.**), explain why a car's headlight goes dim when the engine is switched on. ***(2 marks)***

ii. determine the emf of the battery and ***(3 marks)***

iii. the current through the starting motor when the lights are on ***(3 marks)***

(Total 20 marks)

Question 4

A. Five resistors are connected to a 5V and a 10V supply as shown in the circuit in **Figure 3**. Given that $R_1 = 1\ \Omega$, $R_2 = 2\ \Omega$, $R_3 = 3\ \Omega$, $R_4 = 4\Omega$ and $R_5 = 5\Omega$, determine the current flowing in each resistor. ***(10 marks)***

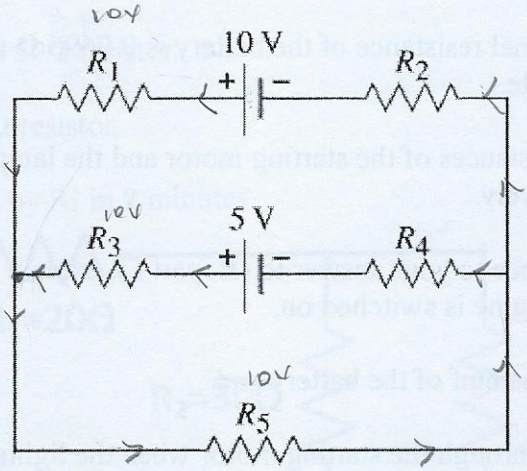


Figure 3

B. An ac current in a 10 Ω resistance produces thermal energy at a rate of 360 W. Determine the:

i. rms values of the current and voltage ***(4 marks)***

ii. peak voltage ***(3 marks)***

C. Sketch a diagram of the Wheatstone bridge circuit and briefly explain one of its use in industry. ***(3 marks)***

(Total 20 marks)

Question 5

A. A DC power line for a light-rail system carries 1000 A at an angle of 30.0^0 to the Earth's 5.00×10^{-5} T field.

i. What is the force on a 100-m section of this line? ***(3 marks)***

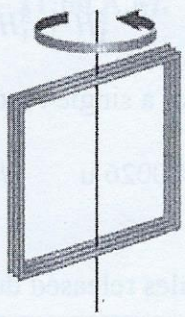
ii. Should the engineer be concerned with any practical implications that this force on the wire? Give a reason for your answer. ***(2 marks)***

B. i. Draw labelled diagram to show the magnetic field about a long straight current-carrying wire. ***(2 marks)***

ii. Draw labelled diagram to show the magnetic field about a current-carrying solenoid. ***(2 marks)***

C. i. State Faraday's law of electromagnetic induction and describe an experiment to demonstrate this law. ***(5 marks)***

ii. A square coil of 40 turns with a side of length 20 cm is perpendicular to a magnetic field of flux density 50 mT. What is the average emf induced in the coil when it is rotated through 90° in ¼ of a second? (The axis of rotation connects the midpoints of opposite sides of the square, as shown.)



(6 marks)

(Total 20 marks)

Question 6

A. *"A leak in an underground industrial pipe can be found by adding a radioactive tracer to the liquid in the pipe. A detector is moved along the ground above where the pipe is buried. The count rate will be found to increase where the pipe is leaking as a larger amount of liquid containing the radioactive tracer will collect there."*

Explain why a gamma emitter with a short half-life would be needed for this tracer. ***(4 marks)***

B. Tellurium, Te_{52}^{127} is a gamma emitter with a half-life of 9.35 hours.

i. Write a balanced equation for the gamma decay of Te. ***(2 marks)***

ii. Define half-life. ***(1 mark)***

iii. Calculate the activity of Te. ***(2 marks)***

iv. Tellurium was used as a tracer to detect a leak in a water pipe by introducing 10 grams of the isotope at the source. What is mass of this radioactive isotope that will remain in the water 24 hours later when it reaches the consumers. ***(4 marks)***

C. Consider the following nuclear fusion reaction that uses deuterium and tritium as fuel.

$$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n$$

i. Determine the mass defect of a single reaction, given the following information.

$^{2}_{1}H = 2.0141$ u $\quad ^{4}_{2}He = 4.0026$ u $\quad ^{3}_{1}H = 3.016049$ u $\quad ^{1}_{0}n = 1.0087$ u

(2 marks)

ii. Determine the energy in joules released during a single fusion reaction.

($u = 1.66 \times 10^{-27}$ kg $\quad c = 3.00 \times 10^{8}$ m/s)

(5 marks)

(Total 20 marks)

END OF EXAMINATION