CHUKA UNIVERSITY
FACULTY OF SCIENCE, ENGINEERING & TECHNOLOGY
DEPARTMENT OF PHYSICAL SCIENCES
EB1 – [BSc – COMPUTER SCIENCE]
Year 2 semester 2 Exam –April/June 2021
PHYS 342 – ELECTRICITY & MAGNETISM II
Time 2 hours

Instructions To Candidates

Answer question **ONE** and any other **TWO.**
Question **ONE** carries **30** marks, all other questions carry **20** marks
Where necessary use the following constants

Permeability of free space(μ_o)	$4\pi \times 10^{-7}$ *henry/meter*
Permittivity of free space(ε_o)	$8.85\times10^{-12} C^2.N^{-1}.m^{-2}$
Velocity of light (c)	3.0×10^{8} ms^{-1}
Mass of electron (m_e)	9.11×10^{-31} *kg*
Mass of proton (m_p)	1.67×10^{-27} *kg*
Charge on an electron	$-1.6\times10^{-19}C$
Charge on a proton	$1.6\times10^{-19}C$

Question One

a. Write the Laplace an Poison equations (2 marks)

b. What are the four Maxwell equations in differential form and which law does each represent? (4 marks)

c. A single-loop circuit contains two resistors and two batteries as shown in Figure 1 below.(Neglect the internal resistances of the batteries.) Find the current in the circuit. (4 marks)

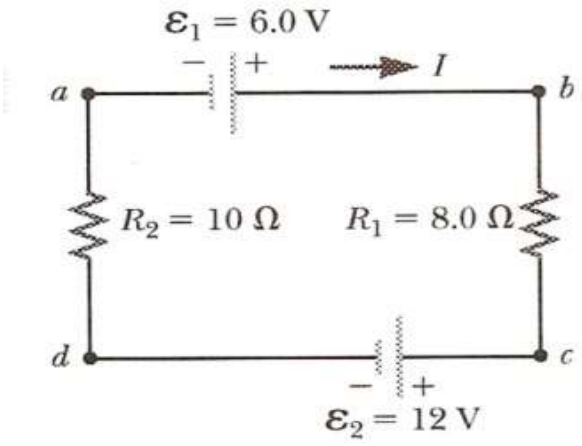

Figure 1

d. A 200 resistor is connected in series with a 5.0-microF capacitor. The voltage across the resistor is v =(1.20 V)cos(2500 rads/sec)t.

i Write an expression for the circuit current. (2 marks)

ii Determine the capacitive reactance of the capacitor. (2 marks)
iii Derive an expression for the voltage across the capacitor. (2 marks)

e. The maximum working flux density of a lifting electromagnet is 1.6 T and the effective area of a pole face is circular in cross-section. If the total magnetic flux produced is 353mWb, determine the radius of the pole face. (3 marks)

f. Electronic gadgets today use transistors in place of vacuum tubes which were popular in the past. Highlight any three advantages of transistors over vacuum tubes. (3 marks)

g. Consider a uniform electric field $\vec{\mathbf{E}}$ oriented in the x direction in empty space. A cube of edge length, l, is placed in the field, oriented as shown in Figure 2 below. Find the net electric flux through the surface of the cube. (4 marks)

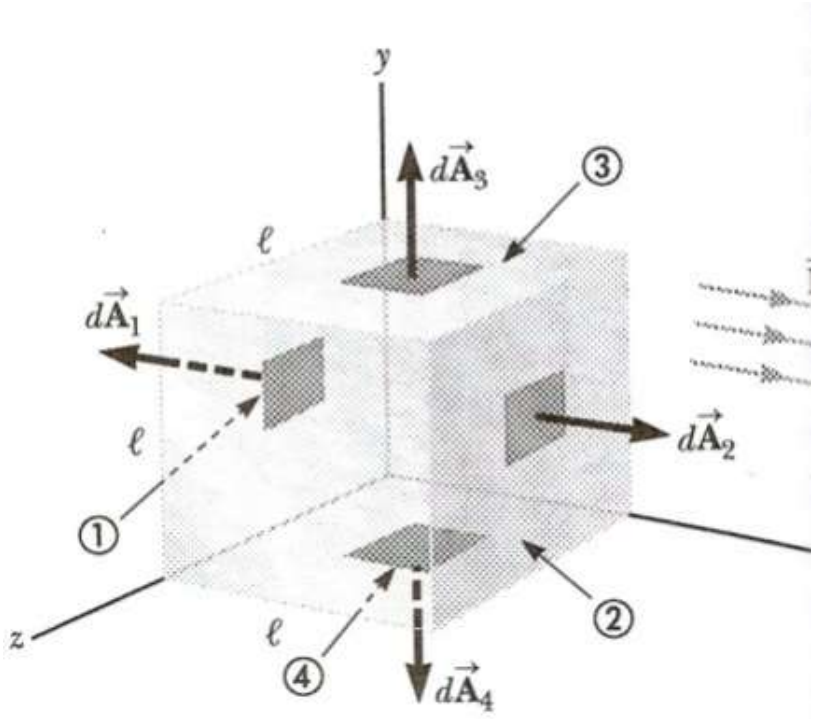

Figure 2

h. Starting from Vcc = IcRc + Vce, where the symbols have their usual meanings, obtain the equation for a transistor loadline of a CE amplifier and show that it is the equation of a straight line. (4 marks)

Question Two

a. In the circuit shown in Figure 3, the 6.0Ω resistor is consuming energy at a rate of 24 J/s when the current through it flows as shown.

(i) Find the current through the ammeter A.

(ii) What are the polarity and emf ε of the battery, assuming it has negligible internal resistance?

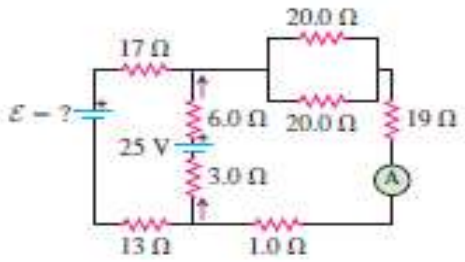

Figure 3

(12 marks)

b. A resistor with R=850Ω is connected to the plates of a charged capacitor with capacitance C=4.62μF Just before the connection is made, the charge on the capacitor is 6.90mC

(i) What is the energy initially stored in the capacitor?

(ii) What is the electrical power dissipated in the resistor just after the connection is made?

(iii) What is the electrical power dissipated in the resistor at the instant when the energy stored in the capacitor has decreased to half the value calculated in part (a)?

(8 marks)

Question Three

a. A sine wave with amplitude 20Vpp is connected to a 10 kΩ resistor. Calculate the peak, the rms, and the average currents through the resistor. What power rating should the resistor have?

(4 marks)

b. Derive the magnetic force $\mathbf{F_B}$ on a wire of length L and cross sectional area A, carrying a current I in a uniform magnetic field **B.** (3 marks)

c. A photon has momentum of magnitude, 8.24×10^{-28} Kg ms^{-1}.

(i) What is the energy of this photon? (Give your answer in J and in eV) (6 marks)

(ii) What is the wavelength of this photon? (3 marks)

(iii) In what region of the electromagnetic spectrum does it lie? (1 mark)

d. A capacitor that is initially uncharged is connected in series with a resistor and an emf source with ε =110V and negligible internal resistance. Just after the circuit is completed, the current through the resistor is 6.5×10^{-5}A . The time constant for the circuit is 5.2s. What are the resistance of the resistor and the capacitance of the capacitor? (3 marks)

Question Four

a. Consider a uniformly wound solenoid having N turns and length *l*. Assume *l* is much longer than the radius of thewindings and the core of the solenoid is air.

i)Find the inductance of the solenoid. (3 marks).

ii) Calculate the inductance of the solenoid if it contains 300 turns, its length is 25.0 cm, and its cross-sectional areais 4.00 cm^2. (2 marks).

iii) Calculate the self-induced emf in the solenoid if the current it carries decreases at the rate of 50.0 A/s. (2 marks).

b. A transformer connected to a 120-V (rms) ac line is to supply 13,000 V (rms) for a neon sign. To reduce shock hazard, a fuse is to be inserted in the primary circuit; the fuse is to blow when the rms current in the secondary circuit exceeds 8.50 mA.

(i) What is the ratio of secondary to primary turns of the transformer?

(ii) What power must be supplied to the transformer when the rms secondary current is 8.50 mA?

(iii) What current rating should the fuse in the primary circuit have? (8 marks)

c. Show that for an L-R-C series circuit the power factor is equal to R/Z . (2 martks)

d. An L-R-C series circuit has phase angle -31.5° . The voltage amplitude of the source is 90.0 V. What is the voltage amplitude across the resistor? (3 marks)

Question Five

a) State Gauss' law. (1mark)

b) Explain why extrinsic semiconductors behave essentially as intrinsic semiconductors at high temperatures. (2 marks)

c) In an *L-R-C* series circuit, R = 300Ω, L = 0.4000H and C = 6 .0 x 10^{-8}F. When the ac source operates at the resonance frequency of the circuit, the current amplitude is 0.500 A.

(i) What is the voltage amplitude of the source? (4 marks)

(ii) What is the amplitude of the voltage across the resistor, across the inductor, and across the capacitor? (4 marks)

(iii) What is the average power supplied by the source? (4 marks)

d) The 19th-century inventor Nikola Tesla proposed to transmit electric power via sinusoidal electromagnetic waves. Suppose power is to be transmitted in a beam of cross-sectional area 100m^2. What electric- and magnetic-field amplitudes are required to transmit an amount of power comparable to that handled by modern transmission lines (that carry voltages and currents of the order of 500 kV and 1000 A)? (5 marks)