UNIVERSITY OF SWAZILAND 15

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MAIN EXAMINATION 2010/11

TITLE O F PAPER:	INTRODUCTORY PHYSICS II
COURSE NUMBER:	P102
TIME ALLOWED:	THREE HOURS
INSTRUCTIONS:	ANSWER ANY FOUR OUT OF FIVE QUESTIONS
	EACH QUESTION CARRIES 25 MARKS
	MARKS FOR EACH SECTION ARE IN THE RIGHT HAND MARGIN
	GIVE CLEAR EXPLANATIONS AND USE CLEAR DIAGRAMS IN YOUR SOLUTIONS. MARKS WILL BE LOST WHERE IT IS NOT CLEAR HOW THE EQUATIONS USED WERE OBTAINED

THIS PAPER HAS SEVEN PAGES INCLUDING THE COVER PAGE

THE LAST PAGE CONTAINS INFORMATION THAT MAY BE USEFUL IN SOME QUESTIONS

DO NOT OPEN THE PAPER UNTIL PERMISSION HAS BEEN GRANTED BY THE CHIEF INVIGILATOR

QUESTION 1

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(a) A sound source produces sound of power $P = 1$ W.

(i) Determine the sound level in dB at a distance $r = 5$ m. **(4 marks)**

(ii) What should be the power if the sound level has to be increased to 105 dB at the distance of 5 m?. **(6 marks)**

(iii) Use the results from (i) and (ii) to compare the power increase to the sound level increase. **(2 marks)**

(b) A glass rod of refractive index $n_r = 1.48$ floats on water of refractive index $n_w = 1.33$. Above the rod is air. The arrangement is shown in Figure 1. A light ray enters the rod at an angle $\theta =$ 50° with the normal. Determine completely by calculation the path of the light ray. **(8 marks)**

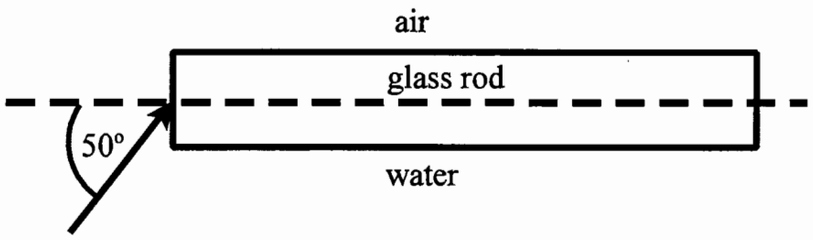

Figure 1.

(c) A student uses a lens of focal length $f = 12.5$ cm to observe a small object as a simple magnifier. The image is formed a distance $s' = 30$ cm from the lens. Determine the object distance and magnification. **(5 marks)**

QUESTION 2

17

(a) Two small spheres each of mass $m = 2$ g are suspended by strings of negligible mass each of length $l = 10$ cm. One sphere has a charge $q_1 = -5 \times 10^{-8}$ C and the other has charge $q_2 = 5 \times 10^{-8}$ C. A uniform electric field of magnitude E_E is applied in the positive x direction. The spheres are each found to be in equilibrium at angle $\theta = 10°$ as shown in Figure 2. Gravity is in the negative y direction.

(i) Make a resolved force diagram for the charge on the right. **(4 marks)**

(ii) Determine the force equations for the charge on the right. **(2 marks)**

(iii) Find the electric field E_E. **(8 marks)**

(iv) Find the scalar values of the electric field at point O (where the strings are attached) due to each of the charges. **(2 marks)**

(v) Find the unit vectors of the electric field due to each charge at point O. **(2 marks)**

(vi) Find the electric field due to the two charges at point O **(4 marks)**

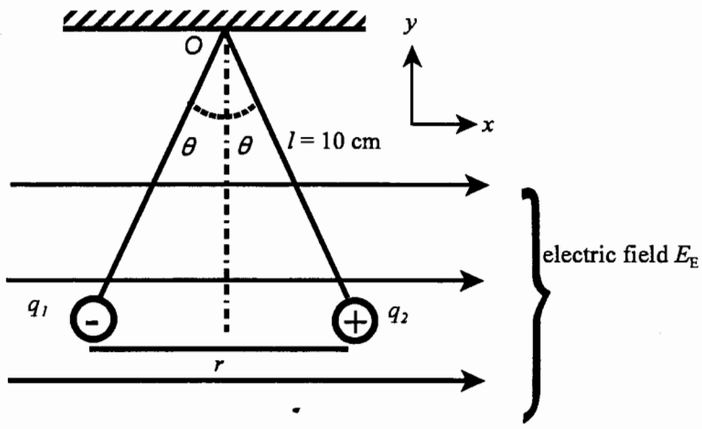

Figure 2.

(b) An electron is accelerated from rest over a potential difference $\Delta V = 1000$ V. Determine the final velocity it attains. **(3 marks)**

QUESTION 3 18

(a) Assume that all the given data in this problem are exact and use full calculator accuracy in the calculations and round each result to 5 significant figures.

(i) A resistor $R = 180\ \Omega$ is connected across a battery of emf $\varepsilon = 6$ V and internal resistance $r = 20\ \Omega$ as shown in Figure 3(a).Find the current in the resistor and the potential difference across the resistor? **(4 marks)**

(ii) An ammeter and a voltmeter of resistance $R_A = 0.5\ \Omega$ and $R_V = 20\ 000\ \Omega$, respectively, are added to the circuit as shown in Figure 3(b). Find the reading of each instrument, I for the ammeter and ΔV for the voltmeter. **(5 marks)**

(iii) If the ammeter is moved to the position shown in Figure 3(c) find the new meter readings. **(5 marks)**

(iv) Find the absolute values of the percentage differences between the values obtained in part (i) to those obtained in parts (ii) and (iii) for I and ΔV and comment on the results. **(6 marks)**

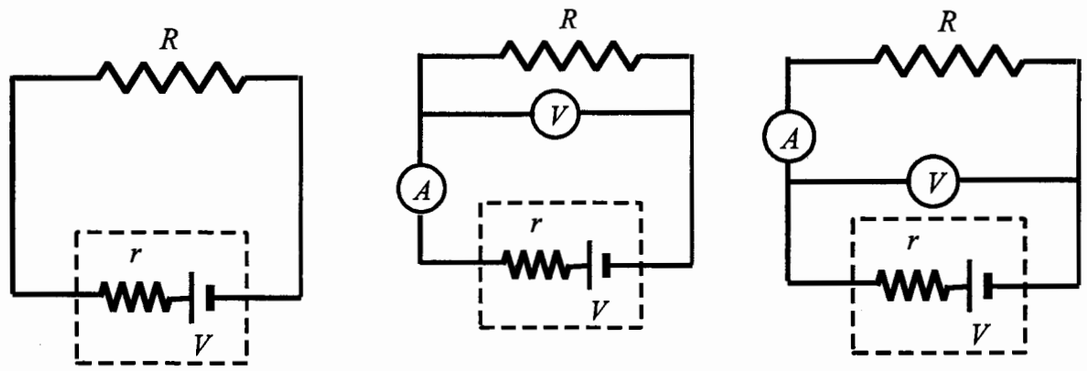

Figure 3. **(a)** **(b)** **(c)**

(b) In Figure 4 the galvanometer of internal resistance 50 Ω is to be used as ammeter and requires a current of 0.500 mA for full scale deflection. What should be the shunt resistor R_s to make an ammeter with a full-scale deflection of 0.500 A? **(5 marks)**

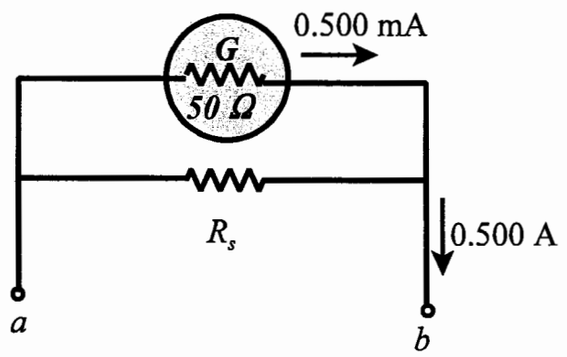

Figure 4.

QUESTION 4

19

(a) A capacitor of capacitance $C = 6\ \mu F$ is charged by an emf $\varepsilon = 9$ V through a charging resistor $R = 4.7\ k\Omega$, and then discharged through a discharging resistor $r = 0.1\ \Omega$.

(i) Determine the energy stored in the capacitor after one time constant of charging. **(4 marks)**

(ii) Find the average battery charging power in one time constant of charging the capacitor. **(2 marks)**

(iii) Find the power delivered by the capacitor when discharged for one time constant after being charged as in part (i). **(3 marks)**

(iv) Compare the power of discharging to the power of charging the capacitor by taking the ratio of the discharging power to the charging power. **(2 marks)**

(b) The strong rectangular wire loop shown in Figure 5 carries a current I in the anticlockwise direction. It is placed in a region of a magnetic field $\boldsymbol{B}$ out of the page. Use the cross product to determine how the wire will move if it will move at all. **(8 marks)**

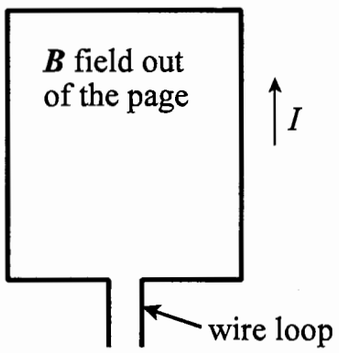

Figure 5.

(c) Charged particles of charge q are accelerated through a potential difference ΔV and enter a uniform magnetic field B perpendicular to their velocities. Find the radius of their circular path in terms of B, m, q, and ΔV. **(6 marks)**

QUESTION 5 20

(a) Consider an inductor connected to a DC emf source as shown in Figure 6. Initially the switch is in the off position *o*.

(i) Write down the equation for the behavior of the current when the switch is moved to position *a*, and sketch the corresponding labeled current-time graph. **(4 marks)**

(ii) Suppose that the switch is kept at position *a* for a very long time, and then moved to position b. Write down the equation for the behavior of the current and sketch the corresponding labeled current-time graph. **(4 marks)**

(iii) From your graphs in (i) and (ii) discuss the circuit effects of an inductor to fast changes in current. **(4 marks)**

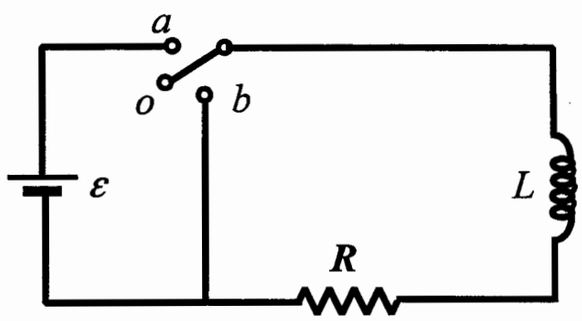

Figure 6.

(b) An electric motor with total resistance $R = 20\ \Omega$, with a total inductance $L = 50$ mH and is powered by a voltage source $\Delta V = 622.25$ V peak to peak at 50 Hz.

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

(ii) Determine the power factor. **(2 marks)**

(iii) Find the capacitor to be added in series to make the power factor 1? **(3 marks)**

(iv) What will the current be reduced to, to maintain the power as before the inclusion of the capacitor? **(4 marks)**

GENERAL DATA SHEET

Speed of light in vacuum $c = 2.9978 \times 10^8$ m/s
Speed of sound in air $\upsilon_s = 343$ m/s
Gravitational acceleration = 9.80 m/s^2
Universal gravitational constant $G = 6.67 \times 10^{-11}$ N. m^2/kg^2
Density of mercury = 1.36×10^4 kg/m^3
Density of water = 1000 kg/m^3
Standard atmospheric pressure = 1.013×10^5 Pa
Boltzmann's constant $k_B = 1.38 \times 10^{-23}$ J/K
Stefan-Boltzmann constant $\sigma = 5.67 \times 10^{-8}$ W/(m^2.K^4)
Gas constant $R = 8.314$ J/(mol.K)
Avogadro's number $N_A = 6.022 \times 10^{23}$ mol^{-1}
Threshold of hearing $I_0 = 10^{-12}$ W/m^2
1 calorie = 1 c = 4.186 J
1 food calorie = 1 Calorie = 1C = 10^3 calories = 4.186×10^3 J

c(*water*) = 4186 J/(kg.K) c(*ice*) = 2090 J/(kg.K) c(*steam*) = 2079 J/(kg.K)
L_f(*ice*) = 3.33×10^5 J/kg L_v(*water*) = 2.260×10^6 J/kg

$$k_e = \frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9 \text{ N.m}^2/\text{C}^2$$

Charge of an electron = -1.6×10^{-19} C
Charge of a proton = $+1.6 \times 10^{-19}$ C
1 atomic mass unit = 1 amu = 1 u = 1.66×10^{-27} kg
Electron mass, $m_e = 9.109 \times 10^{-31}$ kg
Proton mass, $m_p = 1.673 \times 10^{-27}$ kg
Neutron mass $m_n = 1.675 \times 10^{-27}$ kg
$\epsilon_0 = 8.85 \times 10^{-12}$ C^2(N.m^2)
1 Ci = 3.7×10^{10} decays/s
1Bq = 1 decay/s