UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF PHYSICS

MAIN EXAMINATION 2015/2016

TITLE O F PAPER:	INTRODUCTORY PHYSICS II
COURSE NUMBER:	PHY102
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

IF IN DOUBT, RAISE YOUR HAND AND ASK

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

QUESTION 1

(a) What is the frequency range of hearing for a normal human ear? **(1 mark)**

(b) A machine produces isotropic noise. At a distance of 8.00 m the sound level measured is120 dB. What is the power of the sound produced? Also state the significance of the sound level of 120 dB. **(7 marks)**

(c) A light ray enters a flat block of glass ($n = 1.45$) at an angle of $\theta_1 = 30.0°$ with the normal (See Figure 1). Find the angles θ_2 and θ_3. **(7 marks)**

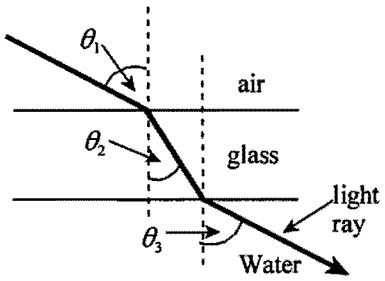

Figure 1.

(d) An object 5.00 cm high is placed in front of a thin lens of focal length 12.0 cm and the image is observed at a distance of 14 cm from the lens.

i. Find the object distance. **(3 marks)**
ii. Find the magnification of the image. **(1 mark)**
iii. Find the image height. **(1 mark)**
iv. State with justification the nature of the object. **(2 marks)**

(e) The near point of a person is 2.50 m. What must be the focal length of the spectacle lenses for the person to read a newspaper at a distance of 24.0 cm? **(3 marks)**

QUESTION 2

Three point charges are placed along the x-y plane as shown in Figure 2. The charges are placed as follows: $q_1 = 4.00 \times 10^{-6}$ C is at $x = -30.0$ cm, $q_2 = -5.00 \times 10^{-6}$ C at $x = 40.0$ cm, and $q_3 = 2.00 \times 10^{-6}$ C at $y = 30.0$ cm.

(a) Find the scalar value of the force on q_3 due to each of the two charges. **(4 marks)**

(b) Find the unit vectors that give directions from the location of the charge q_1 to the location of the charge q_3, $\hat{r}_{1,3}$ and that from the location of the charge q_2 to the location of the charge q_3, $\hat{r}_{2,3}$. **(4 marks)**

(c) Find the vector force on the charge q_3 due to the other two charges q_1 and q_2. **(3 marks)**

(d) Find the electric field vector at the location of the charge q_3 due to the charges q_1 and q_2. **(4 marks)**

(e) Use the electric field obtained in (d) above to find the vector force on q_3 due to the other two charges. **(2 marks)**

(f) Find the electric potential at the origin. **(3 marks)**

(g) What charge must q_3 be replaced by to make the electric potential at the origin to be 2000 V? **(5 marks)**

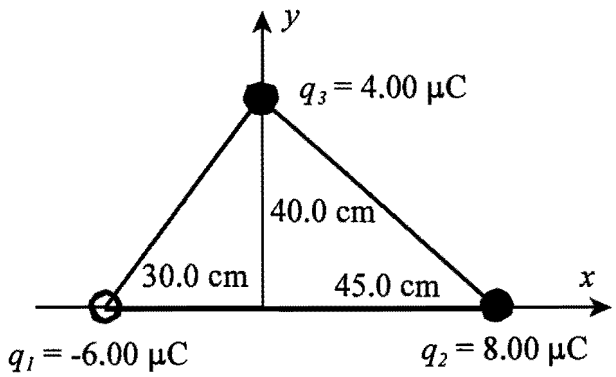

Figure 2.

QUESTION 3

(a) Compare by calculation the velocities of an electron and a proton accelerated through an electrical potential difference of 1000 V. **(2 marks)**

(b) Consider the circuit shown in Figure 3. Use Kirchoff's laws and a diagram to obtain any three equations that can enable you to obtain the currents I_1, I_2 and I_3 given all the other quantities. ***Do not solve for the currents.*** **(6 marks)**

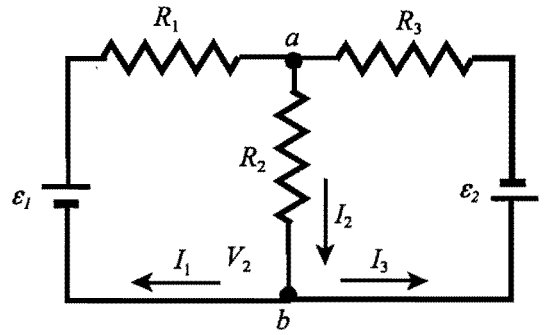

Figure 3.

(c) Consider the network shown in the Figure 4 below.

i. Find the effective resistance between points *a* and *b*. **(2 marks)**

ii. Find the effective resistance between points *b* and *c*. **(3 marks)**

iii. Find the effective resistance of the network. **(2 marks)**

iv. What is the total current through the network? **(2 marks)**

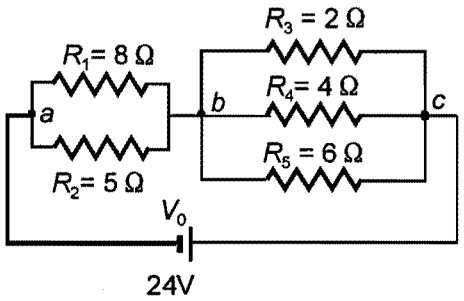

Figure 4.

(d) A galvanometer of internal resistance 50.0 □ is to be used a voltmeter and requires a current of 0.500 mA for full scale deflection.

i. Draw a sketch that illustrates how a galvanometer can be made into a voltmeter. **(2 marks)**

ii. What should be the value of the resistor required to make a voltmeter with a full-scale deflection of 10.00 V. **(3 marks)**

iii. How is a voltmeter connected to measure the potential difference and what is the main electrical characteristic of an ideal voltmeter? **(3 marks)**

QUESTION 4

(a) A 20.0 μF capacitor is charged for one time constant with an *emf* source of 15.0 V, through a resistor of 12.0 kΩ. It is then discharged through the same resistor for one time constant.

i. Find the charge after one time constant. **(3 marks)**

ii. Find the energy stored in the capacitor after one time constant. **(2 marks)**

iii. Find the energy left after discharging the capacitor for one time constant. **(2 marks)**

iv. Find the charging power and discharging power and compare the two. **(4 marks)**

(b) Current $I = 5.00$ A is passed through a rod of length $l = 15.0$ cm placed along the y-axis in a region with a magnetic field of magnitude B=1.72 T in the z-direction. The direction of the current is towards the positive y-axis.

i. Find the direction of the force on the rod. **(5 marks)**

ii. Find the magnitude of the force on the rod. **(3 marks)**

(c) Show by derivation that if a particle of charge q is directed with a velocity v into a region with a perpendicular magnetic field B its radius of curvature is given by $r = \frac{mv}{qB}$. **(6 marks)**

QUESTION 5

(a) Consider the circuit shown in Figure 5 when the switch is moved to position a.

i. Find the time constant for the circuit. **(1 mark)**

ii. Calculate the current at $t = 2.00$ ms. **(3 marks)**

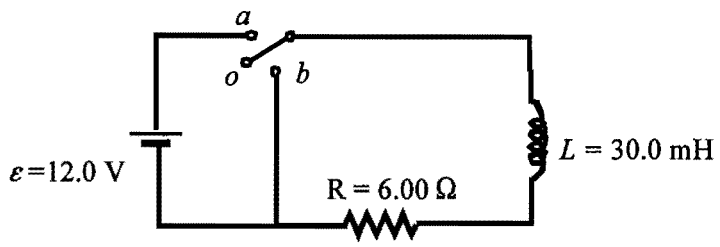

Figure 5.

(b) step-down transformer is used for recharging a home appliance battery. The turns ratio in the transformer are 33:1 and is used with a 220 V (rms) household service. The transformer draws a current of 0.0556 A from the house outlet.

i. What is the voltage supplied to the battery? **(3 marks)**

ii. What is the current supplied to the battery? **(2 marks)**

iii. How much power is delivered to the battery? **(2 marks)**

(c) An inductor ($L = 1.25$ H), a capacitor ($C = 3.50\ \mu$F) and a resistor ($R = 425\ \Omega$) are connected in series. A 60.0 Hz AC source produces a peak current of 200 mA in the circuit.

i. What is the angular frequency of the power source? **(1 mark)**

ii. What is the reactance of the inductor? **(1 mark)**

iii. What is the reactance of the capacitor? **(1 mark)**

iv. What is the impedance of the network? **(2 marks)**

v. What is the required voltage? **(2 marks)**

vi. What is the power factor for this network? **(2 marks)**

vii. Find the apparent power consumed by the network. **(2 marks)**

viii. Find real power consumed by the network. **(1 mark)**

ix. Compare the real power to I^2R and comment. **(2 marks)**

DATA SHEET

General data

Air refractive index = 1.00
Avogadro's number $N_A = 6.022 \times 10^{23}$ mol^{-1}
Boltzmann's constant $k_B = 1.38 \times 10^{-23}$ J/K
Coulomb constant $k_e = 8.9875 \times 10^9$ N·m^2/C^2
Density of mercury = 1.36×10^4 kg/m^3
Gas constant $R = 8.314$ J/(mol.K)
Gravitational acceleration $g = 9.80$ m/s^2
Speed of light in vacuum $c = 2.997\,8 \times 10^8$ m/s
Speed of sound in air $v_s = 343$ m/s
Standard atmospheric pressure = 1.013×10^5 Pa
Stefan-Boltzmann constant $\sigma = 5.67 \times 10^{-8}$ W/(m^2·K^4)
Threshold of hearing $I_0 = 10^{-12}$ W/m^2
Universal gravitational constant $G = 6.67 \times 10^{-11}$ N·m^2/kg^2
1 calorie = 1c = 4.186 J
1 food calorie = 1Calorie = 1C = 10^3 calories = 4.186×10^3 J

Water data

c(*water*) = 4186 J/(kg.K) *c*(*ice*) = 2090 J/(kg.K) *c*(*steam*) = 2079 J/(kg.K)
L_f(*ice*) = 3.33x10^5 J/kg L_v(*water*) = 2.260x10^6 J/kg
ρ (water) = 1000 kg/m^3 refractive index $n_w = 1.333$

Electricity and nuclear data

Alpha particle mass = 6.644 657 x 10^{-27} kg
Charge of an electron = -1.6 x 10^{-19} C
Charge of a proton = $+1.6$ x 10^{-19} C
Coulomb's constant $k_e = 8.987\,5 \times 10^9$ Nm^2/C^2
Deuteron mass = 3.343 583 x 10^{-27} kg
Electron mass, $m_e = 9.109 \times 10^{-31}$ kg
Neutron mass $m_n = 1.675 \times 10^{-27}$ kg
Proton mass, $m_p = 1.673 \times 10^{-27}$ kg
1 atomic mass unit = 1 amu = 1 u = 1.66 x 10^{-27} kg
1 Ci = 3.7 x 10^{10} decays/s
1Bq = 1 decay/s