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) A wave is described by the following equation:
$y = A\sin(\omega t - kx + \phi)$.
State what the symbols A, ω, k, and ϕ are, and include the correct units of ω, k, and ϕ. **(4 marks)**

(b) Use your knowledge of the sound intensity for a human ear at the threshold of hearing and threshold of pain, and considering that the typical area of the human eardrum is 5.00×10^{-5} m^2. Find the power at the eardrum in each of the two extreme intensities. **(4 marks)**

(c) At what distance would a 0.800 W isotropic sound source be placed to produce a sound intensity of 85.0 dB? Also state the significance of the sound level at 85.0 dB.**(6 marks)**

(d) A light ray enters oil of refractive index 1.48 from air at an angle $\theta_a = 80.0°$ with the normal. The oil floats on water of refractive index 1.33. Fully determine the path of the light ray after it enters the oil. Make calculations and give explanations in words. **(7 marks)**

(e) An object is placed 4 cm from a thin lese of focal length 8 cm. Find the image distance and state with justification the nature of the object. **(4 marks)**

QUESTION 2

Three point charges are placed along the x-y plane as shown in Figure 1. 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)**

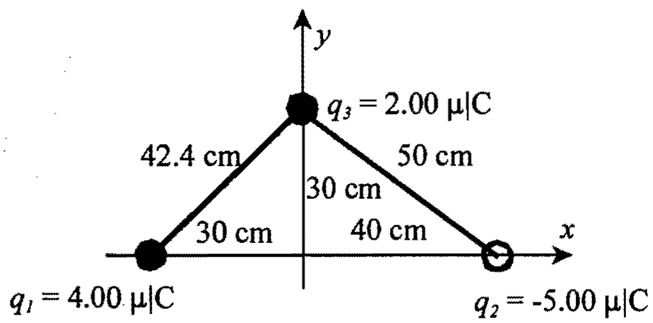

Figure 1.

QUESTION 3

(a) Find the velocity of an electron accelerated through an potential of 1000 V. **(2 marks)**

(b) A tungsten light bulb element has a resistance of 19.0 Ω at a temperature of 20.0°C, and when it is powered on its resistance increases and stabilises at 140 Ω at a temperature of 1.44×10^3°C. Find the temperature coefficient of resistivity for tungsten assuming that the resistance varies linearly over a large temperature range. **(4 marks)**

(c) In the circuit shown in Figure 2 the ammeter reads 2.00 A. Use Kirchhoff's rules to find the currents I_1, and I_2, and the *emf* ε_2. **(10 marks)**

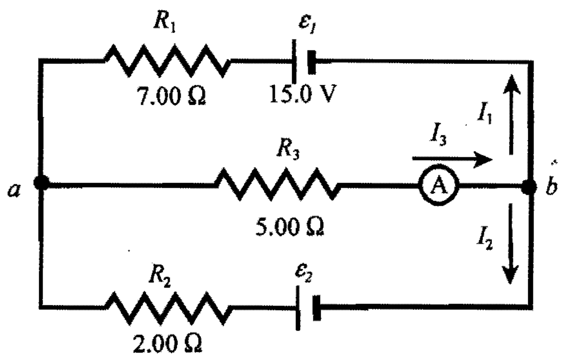

Figure 2.

(d) A galvanometer of internal resistance 50.0 Ω is to be used as ammeter 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 an ammeter. **(2 marks)**

ii. What should be the value of the resistor required to make an ammeter with a full-scale deflection of 5.00 A. **(3 marks)**

(e) List (with respect to what happens to the human body) two ways in which electricity can have harmful effects on a person, and give the respective currents at which such occurs. **(4 marks)**

QUESTION 4

(a) Consider charging and discharging a capacitor:

i. Write down the equation for the charge $q(t)$ on a capacitor of capacitance C, charging through a resistor R, by an *emf* ε and make a sketch the associated graph. **(5 marks)**

ii. Write down the equation for the current of a charging capacitor as described in i. above, and draw a sketch of the associated graph. **(4 marks)**

iii. Give an explanation of how these two graphs relate. **(4 marks)**

(b) A conducting rod of length l, and length density $\lambda = 0.0400$ kg/m is suspended by two light flexible wires as shown in Figure 3. The rod is in a region with a magnetic field in a direction out of the paper. An *emf* source ε supplies current through the rod.

i. Find the magnitude of the current through the rod. **(4 marks)**

ii. Find the direction of the current. **(3 marks)**

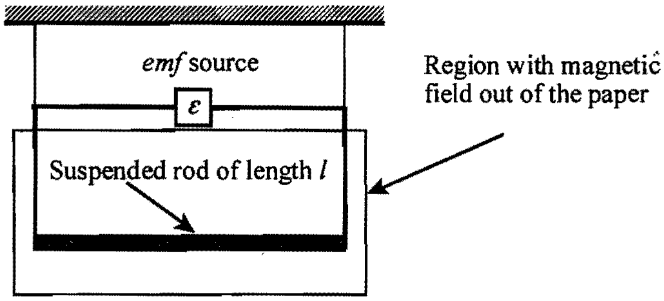

Figure 3.

(c) Singly ionized uranium ^{238}U ions are accelerated to a velocity of 1.27×10^3 m/s and enter a uniform magnetic field of 1.20 T directed perpendicular to their velocities. Determine the radius of their circular path. Fully show how you obtain your answer. **(5 marks)**

QUESTION 5

(a) Consider the circuit shown in Figure 4. Initially the switch is in position O for off. It is then put in position a allowing current to flow from the *emf* source ε though the resistor R and the inductor L. After the switch is in this position for a time period much greater than the time constant for the circuit it is then moved to position b, allowing current to flow from the inductor through resistor R. Sketch and explain the behavior of the current through the circuit in the whole process. **(5 marks)**

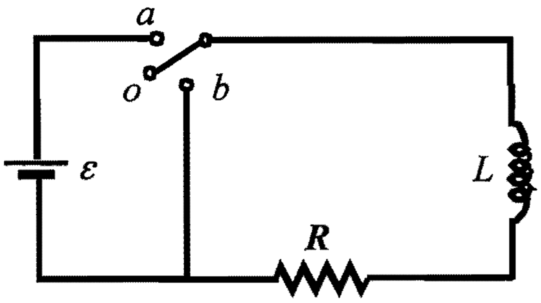

Figure 4.

(b) An inductor (L = 400 mH), a capacitor (C = 4.43 μF), and a resistor (R = 500 Ω) are connected in series. A 50.0 Hz AC source produces a peak current of 250 mA in the circuit.

i. Calculate the applied peak voltage ΔV_{max}. **(5 marks)**
ii. Determine the phase angle for the circuit. **(3 marks)**
iii. State with explanation which is ahead of the other between the current and voltage. **(2 marks)**
iv. What is the power factor for this circuit? **(1 mark)**

(c) A power company produces 60.0 MW of electricity and transmits it to a substation through wires of a resistance of 4.00 Ω. The power is generated at 11 KV and transmitted at 440 KV. The generation cost for the electricity is E1.25 per kWh.

i. Find the turns ratio, secondary to primary, of the transformer used. **(1 mark)**
ii. Find the total current through the transmission wires. **(1 mark)**
iii. Find the energy consumed by the wires per day in kWh. **(2 marks)**
iv. Find the cost of the energy lost in a day in transmission. **(1 mark)**
v. What would be cost of the lost energy if the power was transmitted at the generation voltage? **(4 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 x 10^9 Nm^2/C^2
Deuteron mass = 3.343 583 x 10^{-27} kg
Electron mass, m_e = 9.109 x 10^{-31} kg
Neutron mass m_n = 1.675 x 10^{-27} kg
Proton mass, m_p = 1.673 x 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