UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MAIN EXAMINATION 2007/08

TITLE O F PAPER:	INTRODUCTORY PHYSICS I
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 DATA THAT MAY BE USEFUL IN SOME QUESTIONS

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

QUESTION 1

(a) The sound level at a particular point r from an isotropic sound source is 70.0 dB.

(i) What is the sound intensity at that point? **(3 marks)**

(ii) Find the sound power P generated if the source is 500 m away? **(3 marks)**

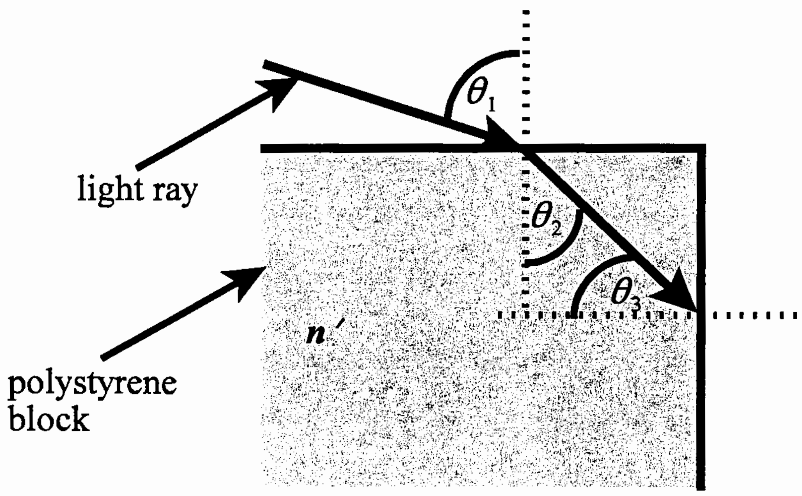
(iii) By what factor must the power be increased so that the sound level is 80.0 dB at the same point? **(3 marks)**

(b) An explosion occurs at a large distance from you. Explain why you would feel the tremor before hearing the sound of the explosion. **(5 marks)**

(c) The measured sound frequency from an approaching ambulance is $\nu' = 560$ Hz. After it passes the measurement point the measured frequency is $\nu'' = 480$ Hz. Determine the speed of the ambulance υ_0. Convert the speed of the ambulance to km/hr. **(6 marks)**

(d) A light ray is incident from air at an angle θ_1 to a polystyrene block as shown in Figure 1. The refractive index n' of polystyrene is 1.49. Determine whether the light can escape from the block at the side on the right side. *Hint: Start by finding the critical angle for polystyrene and work backwards.* **(5 marks)**

Figure 1.



QUESTION 2

(a) Two small spheres of equal mass m are suspended from strings of length $l = 50$ cm at a common point O, as shown in Figure 2. One sphere has charge $Q_1 = 2 \times 10^{-6}$ C, the other has charge $Q_2 = 4 \times 10^{-6}$ C. Each string makes an angle $\theta = 15°$ with the vertical.

(i) Make a resolved force diagram for one sphere. **(2 marks)**
(ii) Write down the force equations for the chosen sphere in (i). **(2 marks)**
(iii) Find the mass of each sphere. **(3 marks)**
(iv) What are the x- and y-components of the electric field due the two spheres at point O. **(8 marks)**
(v) What is the electric potential at point O? **(2 marks)**

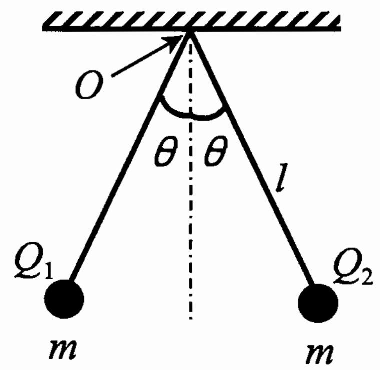


Figure 2.

(b) An air-filled capacitor consists of two parallel plates, each with an area of 7.60 cm^2, separated by a distance of 1.80 mm. A 20.0 V potential difference is applied to these plates. Calculate

(i) the electric field between the plates, **(2 marks)**
(ii) the surface charge density, **(2 marks)**
(iii) the capacitance, and the **(2 marks)**
(iv) the charge on each plate. **(2 marks)**

QUESTION 3

(a) A certain toaster has a heating element made of Nichrome wire ($\alpha = 0.4 \times 10^{-3}\ ^{\circ}C^{-1}$). When the toaster is first connected to a 120 V source at a temperature of 20.0°C, the initial current reaches 1.80 A. When the toaster reaches the final operating temperature, the current is 1.53 A.

(i) Find the power delivered to the toaster at the operating temperature? **(1 mark)**

(ii) What is the final temperature of the heating element? **(5 marks)**

(b) In the circuit shown in Figure 3,

(i) use Kirchoff's laws and a diagram to obtain three equations to determine the currents I_1, I_2, and I_3, and **(6 marks)**

(ii) determine the currents I_1, I_2, and I_3. **(10 marks)**

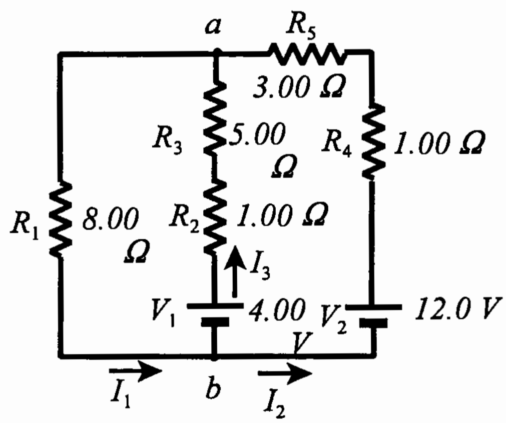


Figure 3.

(c) A galvanometer G requires a current of $i = 1.50$ mA for full-scale deflection and has a resistance of $r_g = 75\ \Omega$. What resistor R_s must be wired in series with the galvanometer to make a voltmeter that measures a voltage of $V_{ab} = 25.0$ V full-scale deflection? (See Figure 4).

(3 marks)

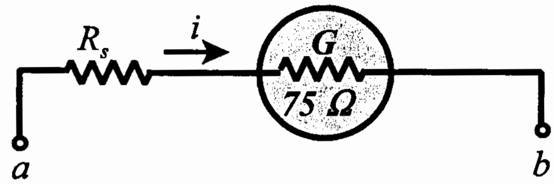


Figure 4.

QUESTION 4

(a) A capacitor of capacitance $C = 1.00\ \mu F$ is connected in series with a resistor of resistance $R = 2.00 \times 10^6\ \Omega$, a battery of $emf = 10.0$ V and a switch S.

(i) What is the general equation for a discharging capacitor through R? **(1 mark)**

(ii) What is the general equation for the energy U_0 of a fully charged capacitor, in terms the total charge Q_0?. **(1 mark)**

(iii) Find an expression for the energy left in a capacitor after discharging for a time t, in terms of the original stored energy U_0? **(2 marks)**

(iv) In the given problem, what is the energy stored in the capacitor when fully charged? **(1 mark)**

(v) Compare the average power when the fully charged capacitor in the given problem is discharged through the charging resistor and through a resistor of resistance $r = 2.50\ \Omega$. **(4 marks)**

(b) Figure 5 is a diagram of the Bainbridge mass spectrometer. Positively charged particles of mass m and velocity υ enter the region with an electric field E to the right and magnetic field of magnitude B out of the page, and pass through to the electric field free region with the magnetic field B' out of the page. Determine an expression for the radius of curvature r of the charged particles in the electric field free region with the magnetic field B' in terms of m, E, B, B', and q. **(7 marks)**

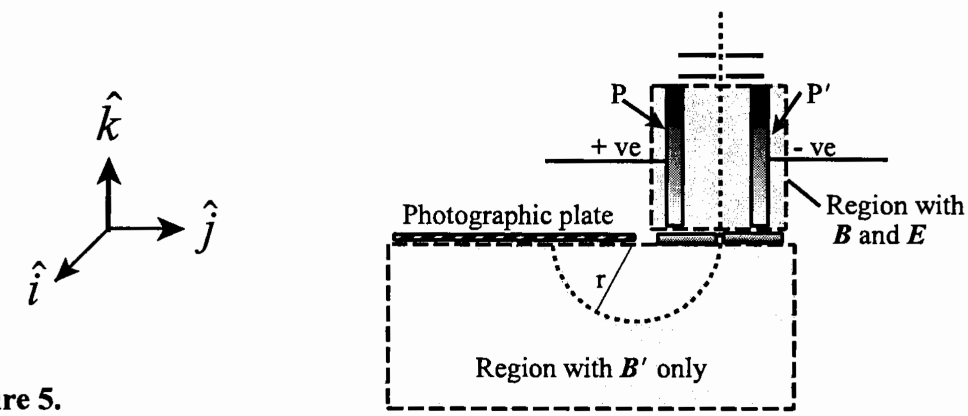


Figure 5.

(c) In Figure 6 the distance l between the parallel rails is 1.20 m, the resistor $R = 6.00\ \Omega$, and a magnetic field of $B = 2.50$ T is into the page and the conducting bar slides without friction on the rails towards the right at 2.00 m/s.

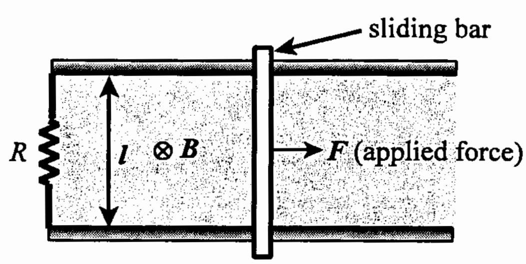
(i) Determine the emf across the bar. **(3 marks)**

(ii) What is the current through the resistor? **(1 mark)**

(iii) What is the applied force? **(3 marks)**

(iv) What is the power due to the force? **(2 marks)**

Figure 6



QUESTION 5

(a) In alternating currents and voltages the power is given by $P = I_{rms}\Delta V_{rms}\cos\phi$.

(i) Fully explain what is meant by the rms values of voltage and current. **(6 marks)**

(ii) Why would an electrical company penalise your company if your apparent electrical power consumption was due to a high ϕ? **(4 marks)**

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

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

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

(iii) What is the impedance of the network? **(1 mark)**

(iv) What is the required voltage? **(1 mark)**

(v) Find the apparent power and real power consumed by the network. **(4 marks)**

(c) A certain sample has 2.39×10^{13} radioactive nuclei. After 4 hours it has 1.92×10^{13} nuclei.

(i) Find the decay constant for this isotope. **(4 marks)**

(ii) What is the half life for this isotope? **(3 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}
$I_0 = 10^{-12}$ 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*) = 3.33x10^5 J/kg L_v(*water*) = 2.260x10^6 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