UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF PHYSICS

MAIN EXAMINATION 2017/2018

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) State the meaning of each of the terms in wave motion: *period, wave length and amplitude*. Also include diagrams that illustrate these terms. **(6 marks)**

(b) The sound level from an isotropic source 6.25 m away is found to be 94.5 dB. Find the power of the sound source. **(5 marks)**

(c) Comment on the energy, wavelength and frequency of ionising electromagnetic radiation as compared to non-ionising electromagnetic radiation, and state why such radiation is of concern to human health. **(4 marks)**

(d) A light ray in water reaches the air-water surface at an angle of 75.0° with the normal. Determine by calculation what happens to the light ray when it reaches the air-water interface. **(3 marks)**

(e) An object 5.00 cm high is placed 4.00 cm in front of a lens of focal length 8.00 cm.

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

QUESTION 2

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

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

ii. Find $\hat{r}_{1,3}$ the unit vector that give direction from the location of the charge q_1 to the location of the charge q_3. **(2 marks)**

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

iv. Find the electric field vector at the location of the charge q_3 due to both the charges q_1 and q_2 using the definition of the electric field. **(3 marks)**

v. Use the electric field obtained in (d) above to find the vector force on q_3 due to the other two charges, and compare with the result from part (c). **(2 marks)**

vi. Find the electric potential at the point P which is along the x-axis directly below the location of charge q_3. **(3 marks)**

vii. What charge must q_3 be replaced by to make the electric potential at point P to be 100 volts? **(5 marks)**

(b) Can a thunderstorm continue indefinitely? Explain your answer. **(3 marks)**

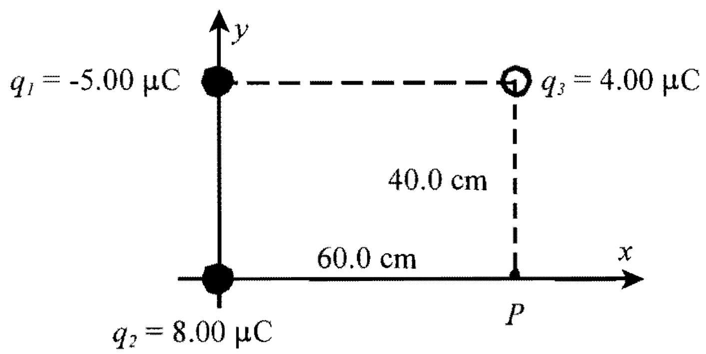

Figure 1.

QUESTION 3

(a) The resistance of a platinum wire is to be calibrated for low-temperature measurements. A platinum wire with a resistance of 1.000 Ω at 20.0°C is immersed in liquid nitrogen and its resistance is found to be 0.153 Ω at that temperature. If the temperature response of the platinum wire is linear, what is the temperature of liquid nitrogen? The temperature coefficient of resistivity for platinum is $\alpha = 3.92 \times 10^{-3}/°\text{C}$. **(4 marks)**

(b) In the circuit shown in Figure 2 use Kirchhoff's rules to determine any four equations that can be used to find the currents I_1, I_2, I_3, and I_4. Include a diagram that shows how you obtain the equations. **(8 marks)**

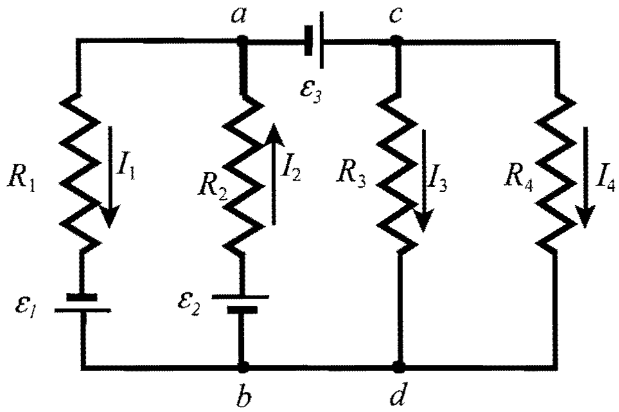

Figure 2.

(c) An uncharged capacitor and a resistor are connected in series with a battery. If the *emf* source of the battery is 12.0 V, the capacitance is 5.00 μF and the resistance is $8.00 \times 10^5\ \Omega$.

i. Find the time constant for the circuit, **(1 mark)**
ii. the total charge after charging for one time constant, **(2 marks)**
iii. the total energy stored after charging for one time constant and **(1 mark)**
iv. the charging power within one time constant. **(2 marks)**
v. Find the maximum charge that can be stored in the capacitor, **(1 mark)**
vi. the maximum current, **(1 mark)**
vii. the maximum energy that can be stored, **(1 mark)**
viii. the charge left after discharging for one time constant from full charge, and **(2 marks)**
ix. the discharging power within one time constant from full charge. **(2 marks)**

QUESTION 4

(a) Positively charged particles of charge $q = 3.20 \times 10^{-19}$ C move with a velocity $\vec{v} = (2\hat{\imath} + 3\hat{\jmath} - \hat{k})$ m/s through a region where both a uniform magnetic field and uniform electric field exist. Calculate the total vector force on each moving charged particle taking $\vec{B} = (2\hat{\imath} + 4\hat{\jmath} + \hat{k})$ T and $\vec{E} = (4\hat{\imath} - \hat{\jmath} - 2\hat{k})$ V/m.
Hint: *Find the force due to the electric field and the force as a vector due to the magnetic field and add the two.* **(6 marks)**

(b) State Faraday's law by words and with an equation. **(4 marks)**

(c) The system shown in Figure 3 consists of two ends of a bar magnet facing each other with a wire loop in between them. The wire loop is rotating with angular frequency ω, and the magnitude of the magnetic field between the to ends of the magnet is B.

i. Find an expression for the magnetic flux through the loop. **(2 marks)**
ii. What is the maximum *emf* produced by the system. **(2 marks)**

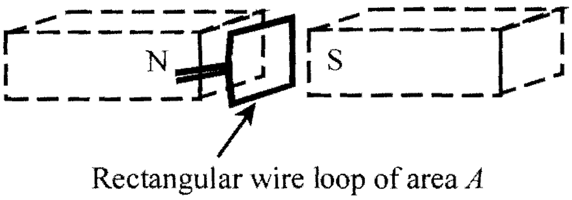

Figure 3

(d) Consider a circuit where an *emf* source, a resistor and inductor are connected is series with a switch.

i. If the switch was originally off and is turned on, (1) write an expression of how the current varies with time, (2) also make a sketch of the associated graph how and (3) show the value of the current at one time constant. **(4 marks)**
ii. If the switch is kept on for a long time and then switched off, (1) write down an expression for the variation of the current with respect to time, (2) sketch the graph and (3) show its value after one time constant. **(4 marks)**
iii. On observing the behavior of the current after switching on and off the circuit what can you say about the effect on current of an inductor in a circuit. Also give one example of the application of an inductor. **(3 marks)**

QUESTION 5

(a) In the calculations of AC power consumption, why are the root mean square values of current and voltage used instead of the average quantities in a cycle? **(2 marks)**

(b) Consider the circuit shown in Figure 4. The peak current is 250 mA and the frequency of the source is 50.0 Hz.

i. Find the reactance for the inductor, **(1 mark)**
ii. the reactance for the capacitor, and **(2 marks)**
iii. the impedance for the circuit. **(2 marks)**
iv. What is the maximum potential difference ΔV_{max}? **(1 mark)**
v. Find the phase angle between the voltage and current. **(2 marks)**
vi. State with justification which is ahead of the other between current and voltage for this circuit **(2 marks)**
vii. Find the power consumed by the circuit. **(1 mark)**
viii. Find the apparent power consumed by the circuit. **(1 mark)**
ix. What is the power factor for the circuit? **(1 mark)**
x. Why is the power factor important for the power supply company? **(1 mark)**

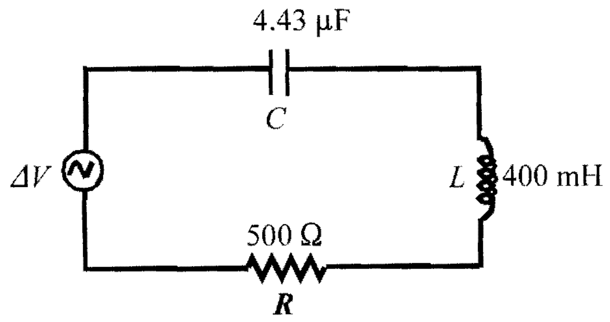

Figure 4.

(c) A local power station generates 200 MW of power at 11.0 kV from renewable energy resources and has a customer 650 km away. The power is transmitted at 440 kV, the transmission lines have a resistance of 0.0646 Ω/km. The generation cost is sixty cents per kWh.

i. Find the turns-ratio, secondary to primary, of the transformer used to step-up the voltage for transmission. **(2 marks)**
ii. Find the secondary current. **(2 marks)**
iii. Determine the cost of the power lost in transmission per week. **(5 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 $k_e = 8.9875 \times 10^9$ $N{\cdot}m^2/C^2$
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 $\sigma = 5.67 \times 10^{-8}$ $W/(m^2{\cdot}K^4)$
Threshold of hearing $I_0 = 10^{-12}$ W/m^2
Universal gravitational constant $G = 6.67 \times 10^{-11}$ $N{\cdot}m^2/kg^2$
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)
$L_f(ice) = 3.33 \times 10^5$ J/kg	$L_v(water) = 2.260 \times 10^6$ 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