UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF PHYSICS

MAIN EXAMINATION 2018/2019

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 NINE 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 $y = 15.5 \sin\left(2\pi t - \frac{2}{\pi}x + \frac{\pi}{4}\right)$ m. All your answers must include correct units.

i. Write down the amplitude and **(1 mark)**
ii. the phase of the wave. **(1 mark)**
iii. Find the angular frequency, **(2 marks)**
iv. frequency, **(1 mark)**
v. period, and **(1 mark)**
vi. the velocity of the wave. **(1 mark)**

(b) An explosion occurs on the ground above which there is air at a temperature of 25.0°C. Find the velocity of the sound in air and that of the vibration in the ground if the bulk modulus and density of the ground are, 2 700 kg/m^3 and 38.0×10^9 Pa, respectively. **(2 marks)**

(c) A audiophile (person who highly appreciates the quality of sound reproduction) wants to choose between two music systems, one rated at 80.0 W and the other 100 W priced at E13,499.95 and E15,999.95, respectively. The speakers for both systems are 0.800% efficient. The student wants to sit at a distance $r = 5.00$ m from the speakers.

i. What is the sound level at a distance r from each system? **(4 marks)**
ii. Recommend with full justifications based on physics the best choice system for the individual. **(2 marks)**

(d) Two pieces of cloth of the same size are cut from the same fabric. Cloth *A* is exposed to light from the sun under dry conditions and the other one *B* is exposed to only visible light of the same intensity as

that from the sun for the same length of time. If the exposure time is made long enough, which piece of cloth will change in colour first and why? **(2 marks)**

(e) A microscope is made such that the focal lengths of the objective and eyepiece are 6.00 mm and 50.0 mm, respectively and the two lenses are separated by a distance of 230 mm. The object is placed 6.20 mm from the objective lens. Find

i. the image distance of due to the objective lens s_o', **(3 marks)**
ii. the image distance due to the eyepiece s_e', and **(2 marks)**
iii. determine the total magnification of the system. **(3 marks)**

QUESTION 2

(a) Explain why a thunderstorm cannot continue indefinitely? **(3 marks)**

(b) Three point charges are placed along the x-y plane at the vertices of an equilateral triangle as shown in Figure 1.

i. Find the scalar value of the force on q_3 due to each of the two charges. (Scalar value here means the actual value and not the absolute value.) **(4 marks)**

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

iii. Find the vector force on the charge q_3 due to the other two charges q_1 and q_2. **(2 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. **(4 marks)**

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

vi. Find the electric potential at the point P which is along the y-axis directly to the left of 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 zero volts? **(3 marks)**

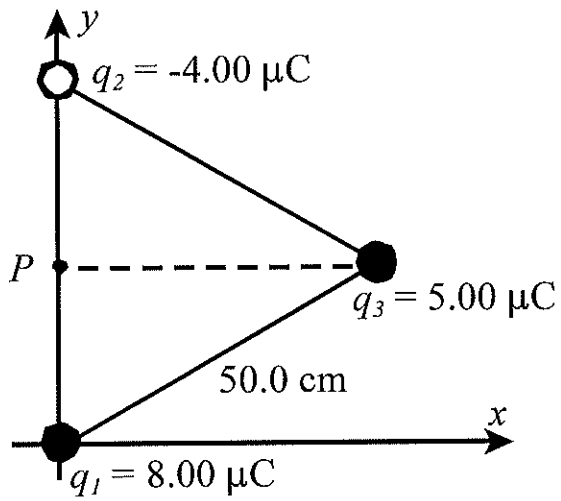

Figure 1.

QUESTION 3

(a)A platinum resistance thermometer has a resistance $R_0 = 50.0\ \Omega$ at $T_0 = 20.0\ °C$ °C. The temperature coefficient of resistivity α for platinum is $3.92 \times 10^{-3}\ (°C)^{-1}$. The thermometer is immersed in a vessel containing melting tin, at which point R increases to 91.6 Ω. What is the melting point of tin? **(4 marks)**

(b) From your understanding of materials, explain how the resistance for copper and silicon change with temperature and why they behave the way they do. **(4 marks)**

(c)Figure 2 shows a circuit diagram for this problem.

i. Use Kirchhoff's rules to determine any four equations that can be used to find the currents I_1, I_2 and I_3. Include a diagram that shows how you obtain the equations. **(6 marks)**

ii. Find the potential difference across the capacitor ΔV_{cap}, and the total charge Q. **(2 marks)**

iii. Explain why the segment *bd* has the same current as the segment *ca* in this circuit? **(2 marks)**

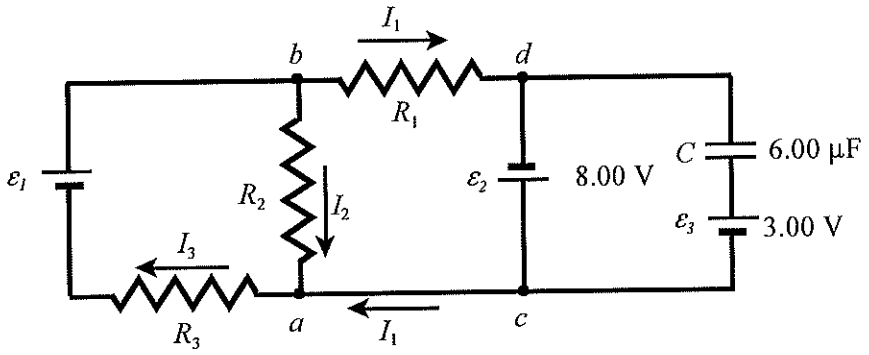

Figure 2.

(d) Three light bulbs when connected directly to a 220 V source are rated at 60 W, 100 W and 200 W.

i. Determine by calculation which lamp will be brightest if they are connected in series with a 220 V power source.

(5 marks)

ii. Suppose the same light bulbs are connected in parallel across the same power source. Explain which lamp will be brightest.

(2 marks)

QUESTION 4

(a)Singly positively charged uranium ions ^{238}U are accelerated through a potential difference ΔV. They are then directed to a velocity selector with an electric field of 2 500 V/m and a magnetic field of 0.0350 T both in the velocity selector and in the deflection region (electric field free region). In answering the questions below derive the equations used to get the answer.

i. Determine the velocity of the particles that go through un-deflected. **(4 marks)**

ii. What is the potential difference ΔV though which the ions are accelerated? **(3 marks)**

iii. Find the radius of curvature of the particles. **(3 marks)**

(b) Figure 3 illustrates a metal bar of mass $m = 0.235$ kg placed on two frictionless conducting parallel rails separated by a distance $l = 12.0$ cm. A current $I = 48.0$ A passes from one end of the bar to the other (in the $\hat{k}$ direction). The rails are in a magnetic field region of magnitude $B = 0.240$ T in the $\hat{\imath}$ direction.

i. Find the direction of the force on the wire. **(3 marks)**

ii. Find the magnitude of the force on the bar and its acceleration. **(4 marks)**

(c)In the metal bar and rail system described in part (b), suppose that there was no applied current but instead a force was applied to move the bar to the right with a constant velocity of 1.00 m/s. Also assume that the left ends of the rails are connected by a resistor $R = 6.00$.

i. What is the *emf* generated by the system while the bar is on the rails? **(5 marks)**

ii. How much current goes through the bar? **(1 mark)**

iii. Discuss how the *emf* is generated by this system and also state which of the physics laws is applicable. **(2 marks)**

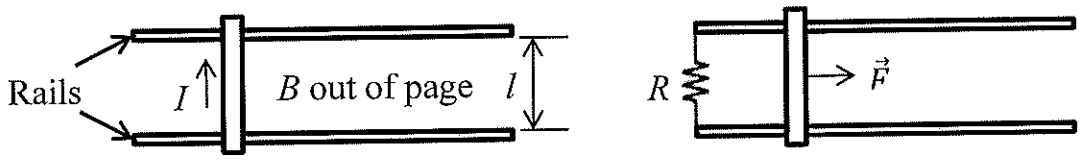

Figure 3.

QUESTION 5

(a)Consider the circuit shown in Figure 4.

i. If the switch has been in the off-position for a very long time write down the equation for the current behavior as a function of time after the switch is put in the on-position and sketch the respective graph. Also indicate the value of the current after one time constant. **(3 marks)**

ii. The switch is left in the on position for a very long time. Write down the equation for the current as a function of time and sketch the respective graph indicating the current at one time constant. **(3 marks)**

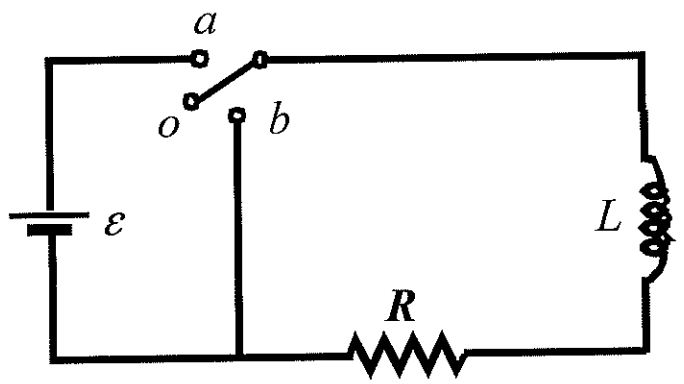

Figure 4.

(b) A sinusoidal voltage $\Delta V = (40.0\ V)\sin(100t)$ is applied to a series RLC circuit with $L = 160$ mH, $C = 99.0$ μF, and $R = 68.0\ \Omega$.

i. Make a circuit diagram for this circuit. **(3 marks)**

ii. Find the frequency of the applied voltage. **(1 mark)**

iii. Find the reactance of the capacitor and that of the inductor. **(2 marks)**

iv. Determine the impedance of the circuit. **(2 marks)**

v. What is the maximum current I_{max}. **(1 mark)**

vi. Find the phase angle and the power factor for the circuit. **(2 marks)**

vii. State with justification which is ahead of the other between current and voltage for this circuit. **(2 marks)**

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

ix. Find the apparent power consumed by the circuit. **(1 mark)**

(c)A step down transformer is to be used to reduce the voltage from the 220 V rms wall socket voltage to 9.00 V rms in order to operate a cell phone charger that supplies 1 000 mA.

i. What is the turns-ratio of secondary to primary in the transformer? **(2 marks)**

ii. What is the current drawn from the wall socket? **(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 $= 1.36 \times 10^4$ 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 $= 1.013 \times 10^5$ 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)
$L_f(ice) = 3.33 \times 10^5$ 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