MACHAKOS UNIVERSITY

University Examinations for 2021/2022 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (TELECOMMUNICATION INFORMATION TECHNOLOGY)

SPH 311: IONOSPHERIC PHYSICS

DATE: 29/8/2022   **TIME: 2.00-4.00 PM**

INSTRUCTIONS:

Answer question and any other two questions.

USEFUL CONSTANTS

Charge of an electron and mass of an electron e = 1.6 x $10^{-19} C$ m = 9.1 x $10^{-31} kg$ respectively, earth's magnetic field B = 5 x $10^{-5} Wb/m^2$ or 0.5 G or 0.5X10Wb/cm^{-2}. μ_o is the permeability of free space = $4\pi \ x \ 10^{-7} T.m/A$

QUESTION ONE (30 MARKS)

a)   Electromagnetic spectrum is an important study area in all descplines of physics, show

   i.   the position of radio waves in the electromagnetic spectrum.   (3 marks)

   ii.   Which way frequency and wavelength decrease   (2 marks)

b)   Define the electromagnetic wave using a drawing   (2 marks)

c)   With a well labelled diagram, illustrate how the

   i.   Atmosphere is stratified and show the temperature profile   (4 marks)

   ii.   Position of ozone layer in the atmspher   (2 marks)

   iii.   Position of ionosphere in the atmosphere and how it is also stratified   (4 marks)

   iv.   The temperature in the troposphere increases with altitude, give a reason   (2 marks)

d)   In thermosphere, the diatomic gases exist as monoatomic, give a reason   (3 marks)

e)   In kilometres, state the altitude range where the ionsphere is domicile   (3 marks)

f)   In the ionosphere the F layer remains during the day and night, explain why   (3 marks)

g)   Explain what is meant by a "radio widow"   (2 marks)

QUESTION TWO (20 MARKS)

a)   In magneto ionic theory regarding motions of ions in the presence of static fields,

   i.   Show that $m\ddot{x} = eE$ (3 marks)

   ii.   Explain how we get $\dot{x} = \frac{e}{m} E t$ (2 marks)

   iii.   Then show that the current density is $J = \frac{Ne^2}{m} Et$ (3 marks)

   iv.   Lastly show the electric field is given by $E = -\frac{Ne}{\varepsilon_o} x_2$ (2 marks)

   v.   Consequently derive angular plasma frequency   (3 marks)

b)   Maximum Usable Frequency (MUF) determines when skip happens

   i.   Define the MUF   (2 marks)

   ii.   Write down the condition necessary for the radio wave to be reflected by the ionosphere   (2 marks)

c)   Define an ionoside and virtual height   (3 marks)

QUESTION THREE (20 MARKS)

a) State the name of the following equation

    i. $F = eV \times B$ (1 mark)

    ii.   explain the reason why the equation is sometimes written as $F = eVB\sin\theta$

        (2 marks)

    iii.   State the hand rule used in the above equation and what the thumb, first and third finger stand for   (3 marks)

    iv.   Figure 1 shows magnetic field directed into the page, V is the velocity of a charge q. Show direction of the force experienced by the charge   (2 marks)
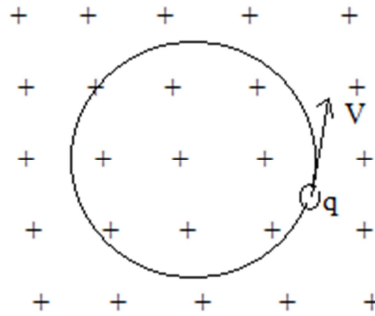

Figure 1

b) With a well labelled diagram,

    i.   define duct propagation of a radio wave   (3 marks)

    ii.   explain its mechanism of operation and conditions for it to take place   (3 marks)

c) Derivation of the chapman layer is based on the following 4 assumptions

    i.   List the assumptions   (2 marks)

    ii.   Write down the chapman function   (4 marks)

QUESTION FOUR (20 MARKS)

a) An electron in the ionosphere experiences earth's magnetic field

    i.   Derive the equation for the angular plasma frequency and that $\omega_H \cong 8.923 \times 10^6$ Hz

        (5 marks)

    ii.   Show that Gyrofrequency $f_H = 1.42 \times 10^6$ c/m^{-1} (5 marks)

b) Calculate the air pressure at the ionosphere 800 km from the earth surface (sea level) at a temperature of $86^o C$ (5 marks)

c) With a drawing show the magnetic north as well as the geographic north pole   (3 marks)

d) Define skip distance   (2 marks)

QUESTION FIVE (20 MARKS)

The barometric formula expresses pressure P as function of height h

a)   Write down the barometric formula   (1 mark)

b)   Elaborate further what it is all about   (1 mark)

c)   Show that $dP = -\rho g dh$ and explain the minus sign   (3 marks)

d)   Express density in terms of pressure as $\rho = \dfrac{MP}{RT}$ (5 marks)

e)   Derive the scale height   (5 marks)

f)   Using integration by separation of variables method derive the barometric formula

(5 marks)