MACHAKOS UNIVERSITY

University Examinations 2020/2021 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (TELECOMMUNICATION AND INFORMATION TECHNOLOGY)

SPH 311: IONOSPHERIC PHYSICS

DATE: 16/8/2021 **TIME: 8.30-10.30 AM**

INSTRUCTIONS:

Answer question one 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 0.5x10 Wb/cm^{-2}. μ_o is the permeability of free space = $4\pi\ x\ 10^{-7}T.m/A$

SECTION A

QUESTION ONE (30 MARKS)

a) State four assumptions made in the formation of the chapman's layer (4 marks)

b) Using a diagram, show how temperature of the atmosphere varies with height (3 marks)

c) Distinguish virtual height from actual height using a diagram (4 marks)

d) Explain why at night, even after disappearance of the sun, the ionosphere is continued to be charged, although not as strongly as during the day. (4 marks)

e) Explain how man-made electromagnetic waves (radio waves) can be generated, transmitted and be received over a large distance (6 marks)

f) Write down the continuity equation in terms of electron effective rates of production and disappearance. (3 marks)

g) Explain the following

i. The D layer reduces after sunset but remains at night (3 marks)

ii. E layer starts to disappear after sun set (3 marks)

SECTION B

QUESTION TWO (20 MARKS)

a) State and explain two factors that determine whether an electromagnetic wave penetrates the atmosphere or not. (4 marks)

b) Show that

i. The Barometric formula is given by $P = \rho g h$ (3 marks)

ii. The Scale height $H = \frac{RT}{Mg}$ (5 marks)

iii. $P = C\, exp(-\frac{M}{RT} gh)$ (4 marks)

iv. Barometric formula $P = P_0\ exp(-\frac{M}{RT} gh)$ (3 marks)

c) In 1901, Marconi, Father of Wireless," demonstrated transatlantic communication by receiving a signal in St. John's Newfound land that had been sent from Cornwall, England. Explain how this was possible (1 mark)

QUESTION THREE (20 MARKS)

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

b) An ion of charge e and mass m travel in an electric field E V/m,

i. Write down its equation of motion (2 marks)

ii. Derive its equation of velocity (3 marks)

iii. If the ion concentration is N (per cubic meter), the current density created is $J = \frac{Ne^2}{m} Et$ (4 marks)

iv. Consider now a slab of plasma in which the light electrons and the heavy positive ions are displaced, as shown in figure 2.4, by a distance X2.

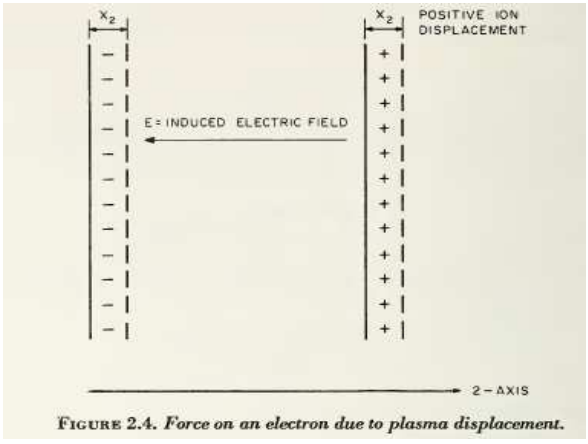

FIGURE 2.4. *Force on an electron due to plasma displacement.*

If the surface charge density is Nex_2 show that the field is given by

$$E = -\frac{Ne}{\varepsilon_o}\, x_2$$ (2 marks)

i. Hence derive $\ddot{x}_2 + \frac{Ne^2}{\varepsilon_o m} x_2 = 0$ (4 marks)

ii. Finally deduce $\omega_N = \frac{Ne^2}{\varepsilon_o m}$ and state what this quantity stands for (3 marks)

QUESTION FOUR (20 MARKS)

a) With an aid of a diagram define an electromagnetic wave (3 marks)

b) Draw the electromagnetic spectrum showing

i. which way frequency and wavelength increase. (2 marks)

ii. position of radio waves (1 mark)

c) With a diagram illustrate how the atmosphere is stratified, hence position the ionosphere, clearly showing the layers D, E, F_1 and F_2 (6 marks)

d) The numerical value of gyro frequency f_g is of great importance in radio wave propagation.

i. Derive a mathematical expression for the gyro frequency (4 marks)

ii. Hence show that

$f_g = 2.84\ x\ 10^{10}\ and\ \ B = 3.57\ x\ 10^4$ (4 marks)

QUESTION FIVE (20 MARKS)

a) Define the following terms

i. Skip distance (3 marks)

ii. MUF (maximum usable frequency) (3 marks)

iii. Duct propagation (3 marks)

iv. Magneto-Ionic Theory (3 marks)

b) Derive the Chapman's formula (8 marks)