MACHAKOS UNIVERSITY

University Examinations 2019/2020Academic 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: 5/12/2019 **TIME: 8.30-10.30 AM**

INSTRUCTIONS TO CANDIDATES

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

b) Draw the electromagnetic spectrum showing (2 marks)

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

ii. position of radio waves (1 mark)

c) Explain how density of air in the atmosphere changes as altitude decrease (3 marks)

d) Explain what is meant by a "radio widow"

e) State two factors that determines whether an electromagnetic wave penetrates the atmosphere or not. (2 marks)

f) Distinguish between ground and sky waves (4 marks)

g) Define the following terms

i. Skip distance (2 marks)

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

iii. Duct propagation (3 marks)

iv. Magneto-Ionic Theory (2 marks)

h) In 1899,.in a landmark experiment on December 12, 1901, Marconi, who is often called the "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 (3 marks)

QUESTION TWO (20 MARKS)

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

b) Define an ionosode and give the equation used to determine virtual height (3 marks)

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

d) The relationship between pressure P and density ρ at any height h is given by the "barometric equation,"

i. Derive the barometric equation (8 marks)

ii. Consequently, define Scale height (2 marks)

QUESTION THREE (20 MARKS)

a) 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)

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

c) Write down the continuity equation in terms of electron effective rates of production and disappearance. (2 marks)

d) Explain why the

i. The D layer reduces after sunset but remains at night (2 marks)

ii. E layer starts to disappear after sun set (2 marks)

e) Figure 1 shows the regions of the atmosphere. Redraw the figure and position the ionosphere, clearly showing the layers D, E , F_1 and F_2 (2 marks)

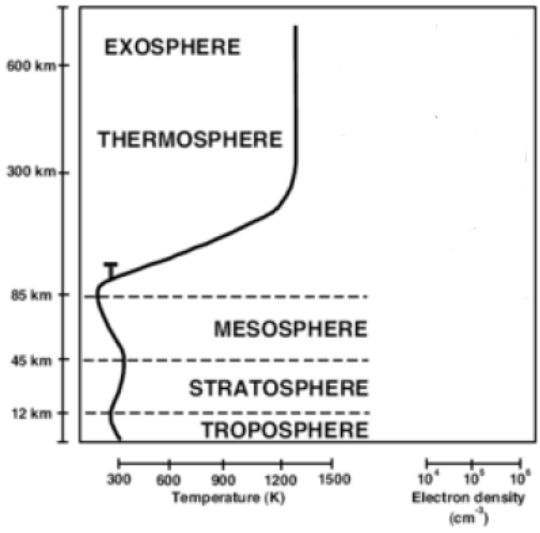

Figure 1

f) Draw a diagram showing electron profile density in the ionosphere as a function of height (altitude) for both day and night showing the D, E , F_1 and F_2 (2 marks)

QUESTION FOUR (20 MARKS)

a) An electron e moving with a velocity *v* in the earth's magnetic field B experience deflecting force F. What is the magnitude of this force on each electron in terms B, e and *v*. (2 marks)

b) The numerical value of gyrofrequency f_g is of great importance in radio wave propagation . Derive a mathematical expression for the gyrofrequency

$f_g = \left(\frac{1}{2\pi}\right)\left(\frac{\mu_o eH}{m}\right)$ (6 marks)

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

d) Derive the Chapman's formula (6 marks)

QUESTION FIVE (20 MARKS)

a) Show that equation of motion of an ion in an electric field is is

i. $\ddot{x}_2 + \frac{Ne^2}{\varepsilon_o m} x_2 = 0$ (8 marks)

ii. Hence define angular plasma frequency ω_N (2 marks)

b) The motion of an ion in a the earth's magnetic field is a helix where centrifugal force is equal to centripetal force, or $mr_h\omega_H^2 = er_H\omega_H B$. Show that

i. $f_H = \frac{1}{2\pi}\omega_H$ where f_H is called the gyro (or gyromagnetic) frequency and ω_H the angular velocity (3 marks)

ii. $f_H = 2.84\ x\ 10^{10}\ B$ (2 marks)

iii. $f_H = 3.57\ x\ 10^4\ H$ (3 marks)

iv. $f_H = 1.42\text{X}10^6\ \text{c}/m^{-1}$ (2 marks)

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