MACHAKOS UNIVERSITY

University Examinations 2022/2023

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (TELECOMUNICATION AND INFORMATION TECHNOLOGY)

SPH 311: IONOSPHERIC PHYSICS

DATE: **TIME:**

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks)

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 (COMPULSORY) (30 MARKS)

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

b) Explain how density of air in the atmosphere changes with decrease in altitude. (3 marks)

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

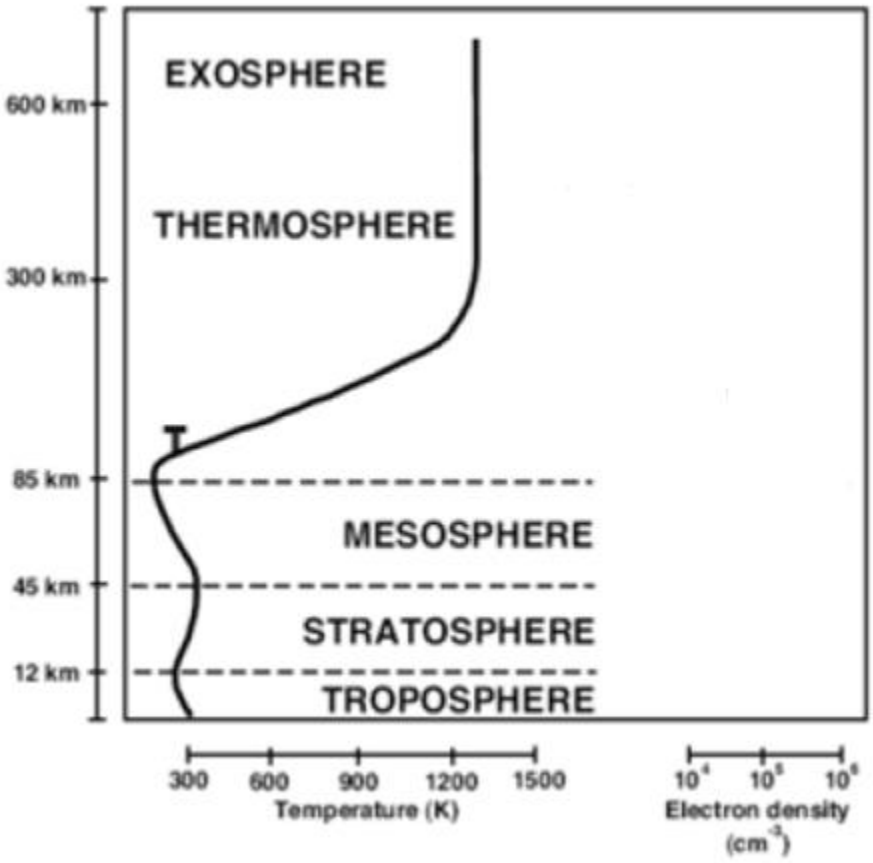
e) Write down the continuity equation in terms of electron effective rates of production and disappearance. (2 marks)

f) Explain the following:

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

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

g) 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)



h) Draw the electromagnetic spectrum showing: (2 marks)

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

ii. position of radio waves (1 mark)

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

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

QUESTION TWO

a) Using a diagram, show how temperature of the atmosphere varies with increasing altitude. (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) 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 layers. (3 marks)

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

c) Define the following

i. Skip distance (2 marks

ii. MUF (maximum usable frequency) (2 marks)

iii. Duct propagation (2 marks)

iv. Magneto-Ionic Theory (2 marks)

d) Radio fm stations do not make use of the ionosphere in their signal transmission. Explain their mode of operation. (3 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 (6 marks)

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

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

QUESTION FIVE (20 MARKS)

a) In thermosphere, the diatomic gases exist as monoatomic, give a reason. (2 marks)

b) In kilometres, state the altitude range where the ionsphere is domicile. (2 marks)

c) In stratosphere, temperature increases with altitude. Give a reason. (2 marks)

d) The motion of an ion in 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 (4 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)

e) Draw electromagnetic spectrum and show position of radio waves. (3 marks)

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