KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2011/2012

SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE (TELECOMMUNICATION AND INFORMATION TECHNOLOGY)

SPH 311: IONOSPHERIC PHYSICS

DATE: WEDNESDAY, 28TH MARCH 2012 **TIME: 11.00 A.M. – 1.00 P.M.**

INSTRUCTIONS

1. **Read carefully the instructions on your answer booklet and adhere to them.**
2. **Answer question 1 and any other two questions. Question 1 carries 30 marks while the other question carry 20 marks each.**
3. **You may find the following information and constants useful.**

a). Air density at an altitude h: $\rho = \rho_o \exp(-h / H)$

Where ρ, represents density at ground level and H is the scale height.

b). Earth's radius $R_e = 6370$ km.

c). Q_e is the electronic charge and $= 1.602 \times 10^{-19}$C

d). ϵ_o is the permittivity of free space and $= 8.854 \times 10^{-12}$ Fm^{-1}

e). m_e is the electron's mass and $= 9.1066 \times 10^{-31}$ kg.

QUESTION ONE.

a. How is the ionosphere layer formed? 3 marks

b. Describe an accurate method used for measuring the electron concentration levels in the ionosphere region. 6 marks

c. Why do we study the ionospheric layer? 3 marks

d. On page two are two graphs showing the overall rate of ion formation within the ionosphere, as a function of altitude (in km) and the zenith angle for the equinox period, at various levels of the solar activity.

Each of the curves in the two graphs have **three** distinct regions, described roughly by their gradients as (positive, constant and negative).

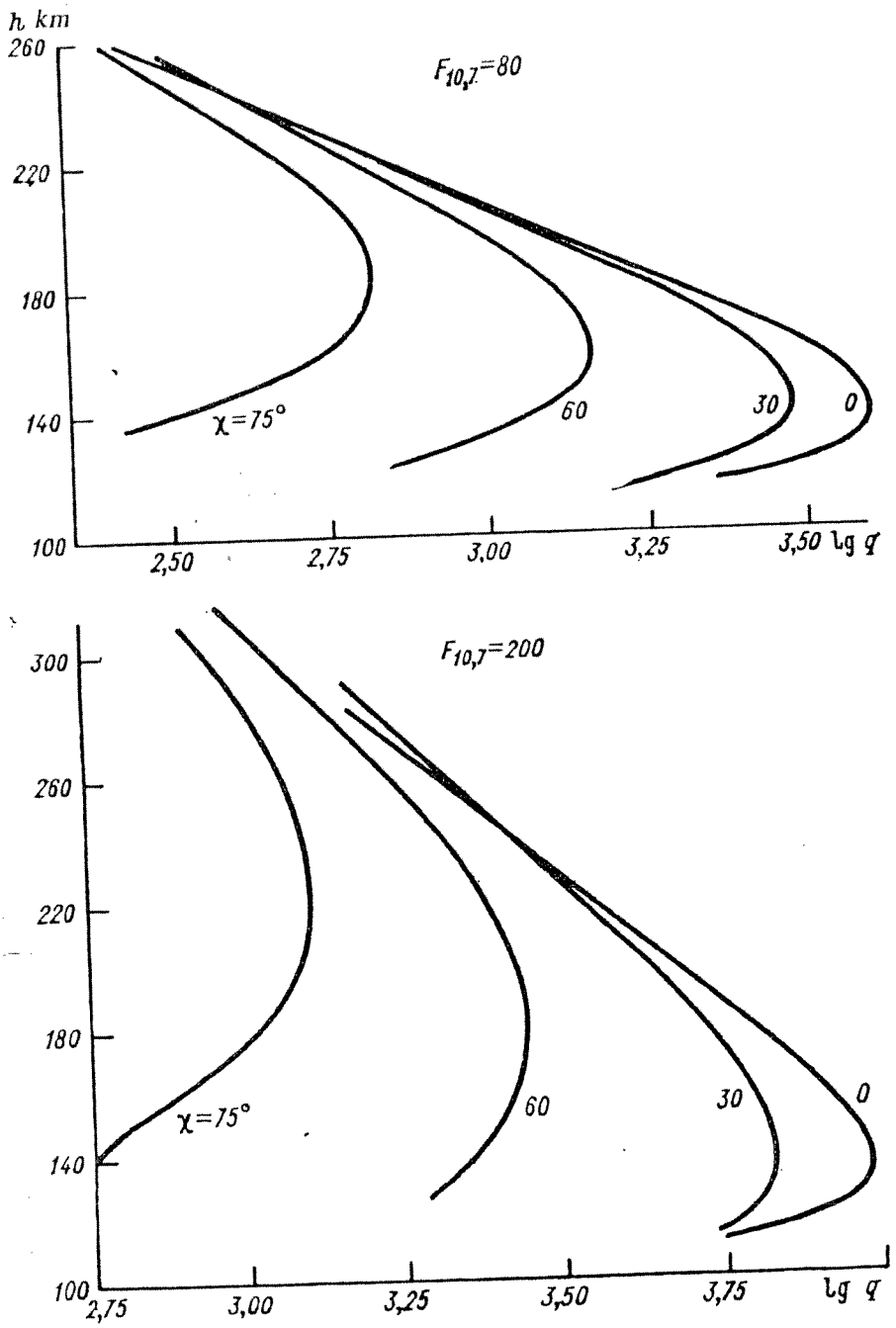
Identify the regions represented by these slopes and explain the processes taking place and their consequences in detail. 9 marks

e. i. A radio wave propagating through space describes a curvature of radius 3185 km.

Calculate the K-factor of the concerned space and elaborate on the physical significances of the K-factor? 3 marks

ii. Determine the velocity of propagation of radio waves in a medium of refractive index 1.65. Can velocity of radio waves in a medium exceed the velocity of light? Explain your answer. 3 marks

iii. When dealing with radio wave propagation, why is there a demarcation line at a frequency of around 10 GHz.? 3 marks



QUESTION TWO.

a. Discuss any two significant phenomena of radio waves propagation in the ionosphere in the presence of earth's magnetic field. 6 marks

b. i. How is the magneto-plasma medium formed? 2 marks

g Differentiate between magneto-plasma properties and wave properties of a higher space (exosphere) medium. 4marks

c. Calculate the free-space loss for a LOS radio link 45 statute kilometers long. Given that the operating frequency = 6.135 GHz.
Double the frequency and calculate the free-space loss. Halve the frequency and calculate the free-space loss. What is the lesson learned from the last two steps? 5 marks

d. What is the significance of the Appleton-Hartree equation below?

$$n^2 = 1 - [\, X / (\, 1 - z_i \,) - (Y^2_T \,/\, \{2(1 - X - z_i)\} \pm (Y^4_T / (4(1 - Y - z_i)^2 + Y^2_L \,)^{1/2}$$

Where the symbols represent their usual values. 3 marks

QUESTION THREE.

a. Using actual chemical reaction equations, describe the interaction occurring between in-coming ionizing solar radiation and the elemental components of the underlying ionospheric region. 10 marks

b. From the reactions above and considering the E- layer, show that the electron concentration N_e is given by the formula $\mathbf{N_e = [\, q/\alpha \,]^{1/2}}$.
Where q represents the electron's production rate and α is the loss coefficient. 4 marks

c. What are the significances of establishing the extent of electron concentration in the ionosphere? 4 marks

d. Calculate the power (kW) of a radio transmitter situated 1000m from a detector/receiver if the amplitude of the signal detected is 300 mV per meter. 2 marks

QUESTION FOUR.

a. i. When is the frequency critical in radio wave propagation? 3 marks

ii. An ionosphere layer has a maximum electron density of 5.0×10^{11} electrons m^{-3}. The virtual height of the layer is 90 km. Assuming a flat earth, calculate the maximum usable frequency for communicating with a receiver situated 100 km away. 4 marks

b. i. Derive the expression below, for the refractive index (n) of the ionospheric layer.

$$n = [\,1 - (\,81N/f^2\,)]^{1/2}\,.$$

Where, N is the electron density and f the frequency of the radio wave propagating through the ionosphere. 6 marks

ii. Briefly analyze a situation where $81N < f^2$. 3 marks

c. Explain what you understand by "Path Analysis Worksheet" in an analog radio link. 4 marks.

QUESTION FIVE.

a. Explain the following ionosphere phenomena:

i. Multipath Fading 4 marks

ii. Dellinger Effect 4 marks

b. With the aid of a diagram, describe the characteristics of space waves. 4 marks

c. What are the significances of Chapman's theory of layer formation? 4 marks

d. List four unique properties of the ionosphere. 4 marks