TECHNICAL UNIVERSITY OF MOMBASA

Paper 1

EXAMINATION RUBRIC

FACULTY   ENGINEERING AND TECHNOLOGY

DEPARTMENT   ELECTRICAL & ELECTRONIC

Common ☐   **Not common**

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COURSE/CLASS   **Bachelor of Science in Electrical and Electronic Engineering**

UNIT CODE   **EEE 2419**

PAPER   **Microwave**

SERIES   **May 2016**

NO. OF STUDENTS   ☐

INSTRUCTION TO CANDIDATES

Answer Question One (Compulsory) and any other Two Questions

Name of setter: Stephen Sande

Name of moderator: Prof. Heywood Ouma

Date submitted to examination centre _____

TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

UNIVERSITY EXAMINATION FOR :

THE DEGREE OF BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

EEE 2419   MICROWAVE

END OF SEMESTER EXAMINATION

SERIES: MAY 2016   **TIME : 2 HOURS**

DATE:

Instructions to Candidates

You should have the following for this examination:

- *Answer Booklet, examination pass and student ID*

This paper consists of five questions;

Question ONE is compulsory. In addition attempt any other TWO questions

$$\varepsilon_0 = \frac{1}{36\pi} \times 10^{-9} \, F/m \, ; \, \mu_0 = 4\pi \times 10^{-7} \, H/m$$

Do not write on the question paper

Question ONE (Compulsory 30 marks)

(a)   Highlight any FOUR application areas of microwave engineering.
(4 marks)

(b)   Using appropriate sketches describe the following types of EM waves

　　　　(i)　　TEM　　　　(ii)　　TE　　　　(iii)　　TM

(6 marks)

(c)   Explain how the following parameters are used to characterize microwave networks:

　　　　(i)　　Z　　　　(ii)　　Y　　　　(iii)　　S

(6 marks)

(d)   A plane electromagnetic wave having a frequency of 100 MHz has an average Poynting vector of 1 W/m^2. If the medium is lossless with ε_r = 2.7 and μ_r = 1, determine the:

　　　　(i)　　Velocity of propagation　　(ii)　　Wavelength (iii)　　Impedance of

　　　　　　the medium

　　　　(iv)　　rms value of the electric field　　　　　　　　　　(4 marks)

(e)   With the aid of a schematic diagram, describe the operation of a four-port microwave circulator.　　　　　　　　　　　　　　　　　　(6 marks)

(f)   Highlight FOUR major parameters that are used to measure frequency in the mirowave spectrum.　　　　　　　　　　　　　　　　　　(4 marks)

Question TWO

(a)   A plane wave propagating in a lossless dielectric has an electric field given as

$$E = E_0 cos(2.2 \times 10^{10}t - \frac{8\pi}{3}z).$$

　　　　Determine　　(i)　　Phase velocity　　(ii)　　Wave impedance　　(4 marks)

(b)   Starting from the three dimensional Helmholtz equation, derive expressions for transverse and longitudinal fields for TM modes in a rectangular waveguide.

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　(13 marks)

(c)   (i)　　Highlight any simple detection technique used for the measurement of power.

(ii)   Explain why such a technique may not be used to measure a microwave signal at frequencies above 1 GHz.   (3 marks)

Question THREE

(a)   Highlight FOUR factors that impair the performance of conventional tubes at microwave frequencies.   (4 marks)

(b)   (i)   Describe using appropriate sketches the principle of operation of a reflex Klystron amplifier.

(ii)   Describe FOUR major applications of a reflex Klystron

(7 marks)

(c)   A reflex Klystron is to be operated at a frequency of 10 GHz with a DC beam voltage 300V, repeller space 0.1 cm for $1\frac{3}{4}$ mode. Determine:

(i)   The maximum RF power output

(ii)   Repeller voltage for a beam current of $20\ mA$ (4 marks)

(d)   Describe THREE major differences between a Klystron and a travelling wave tube.   (3 marks)

(e)   Explain briefly the concept of resonant modes in magnetrons.   (2 marks)

Question FOUR

(a)   For a dielectric material show that Maxwell's equation for **H** is given by

$$\nabla \times H = j\omega \left(\epsilon - j\epsilon - j\frac{\delta}{\omega}\right)\bar{E}$$ (4 marks)

(b)   Highlight any FOUR operational characteristics of waveguides   (4 marks)

(c)   A rectangular waveguide has the following characteristics:

$$b = 1.5\ cm \qquad a = 3.0\ cm \qquad \mu_r = 1 \qquad \varepsilon_r = 2.6$$

(i)   Calculate the cut-off frequency for $TE_{10},\ TE_{20}\ and\ TM_{11}$

(ii)   Calculate the guide wave length at 4.0 GHz for TE_{10} mode

(iii)   Determine the attenuation at 3 GHz for a guide length of $12.0\ cm$ for TE_{10} mode

(iv)   Determine the attenuation α for $f \ll f_c$ (12 marks)

Question FIVE

(a)   With the aid of suitable sketches explain the principle of operation of transferable electron device (GUNN diode)   (5 marks)

(b)   Explain the main electrical features of the following microwave devices:

   (i)   IMPATT diode   (ii)   TRAPATT diode   (iii)   BARITT diode

                                                                           (6 marks)

(c)   Define the terms coupling factor and directivity for a four port directional coupler.

                                                                           (3 marks)

(d)   Show that for a rectangular waveguide

$$\lambda_g = \frac{\lambda_o}{\sqrt{1 - \left(\frac{\lambda_o}{\lambda_c}\right)^2}}$$

Take:

$$\beta = \pm\sqrt{k^2 - k^2 c}$$

                                                                           (6 marks)