The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Electrical and Computer Engineering

Study Programme	:	Bachelor of Science Honours in Engineering
Name of the Examination	:	Final Examination
Course Code and Title	:	**EEX7333 Microwave Devices and Antennas**
Academic Year	:	2024/25
Date	:	23rd February 2026
Time	:	13:30-16:30h
Duration	:	3 hours

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Five (05)** questions in **Three (03)** pages.
3. Answer **all** questions.
4. All questions carry equal marks.
5. Answer for each question should commence from a new page.
6. This is a Closed Book Test (CBT).

Question 01 **(20 marks)**

a. Starting from Maxwell's equations, derive the wave equation for the electric field in free space. (06 marks)

b. Explain the physical significance of the displacement current and its importance in time-varying electromagnetic fields. (04 marks)

c. Define the time-averaged Poynting vector and explain how it represents the power flow in an electromagnetic wave. (04 marks)

d. A uniform plane wave propagating in free space has an electric field given by (06 marks)

$$\mathbf{E} = 50\cos(\omega t - \beta x)\,\hat{\mathbf{a}}_x \text{ V/m}$$

Determine the following.

i) Intrinsic impedance of free space
ii) Magnetic field intensity **H**
iii) Average power density of the wave

Hint: For free space, $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m and $\mu_0 = 4\pi \times 10^{-7}$ H/m

Question 02 **(20 marks)**

a. Impedance matching is critical in microwave transmission lines. Explain why. (04 marks)

b. Define the propagation constant of a transmission line and explain the significance of its real and imaginary components. (04 marks)

c. Derive an expression for the characteristic impedance of a lossless transmission line. (04 marks)

d. A coaxial transmission line operates at 1 GHz and has the following per-unit-length parameters. (08 marks)
L = 250 nH/m, C = 100 pF/m.
Assuming the line is lossless, determine the following.
i) Characteristic impedance
ii) Phase velocity
iii) Wavelength on the line

Question 03 **(20 marks)**

a. Explain why a rectangular waveguide without an inner conductor does not support TEM waves. (04 marks)

b. Describe the field configuration of the dominant mode in a rectangular waveguide. (02 marks)

c. A rectangular waveguide with dimensions a = 5 cm and b = 3 cm operates in the TE11 mode at 10 GHz. (10 marks)

i) Cut-off frequency
ii) Guided wavelength
iii) Phase velocity
iv) Group velocity

Hint: $\lambda_g = \frac{\lambda_0}{\sqrt{1-\frac{f_c^2}{f^2}}}$, $v_p = \frac{c}{\sqrt{1-\frac{f_c^2}{f^2}}}$, $v_g = c\sqrt{1-\frac{f_c^2}{f^2}}$

d. Briefly explain waveguide dispersion and its effect on signal propagation. (04 marks)

Question 04 **(20 marks)**

a. Define antenna directivity and explain its relationship with the radiation pattern. (04 marks)

b. Compare linear polarization and circular polarization and give one application for each. (04 marks)

c. A parabolic reflector antenna has a diameter of 2.4 m and an aperture efficiency of 65%. Determine its gain at an operating frequency of 6 GHz. (06 marks)

Hint: $G = \eta \left[\frac{\pi D}{\lambda}\right]^2$

d. An antenna radiation pattern is given by (06 marks)

$$U(\theta) = U_0 \cos^2\theta,\ 0 \leq \theta \leq \pi/2$$

Determine the directivity of the antenna.

Question 05 **(20 marks)**

a. State the principle of operation of a microwave isolator. (02 marks)

b. State the role of ferrite material and DC magnetic bias in achieving isolation. (04 marks)

c. State two physical properties of ferrite materials that cause non-reciprocity under a DC magnetic field. (02 marks)

d. A Gunn diode V-I characteristic shows a peak current at 8.2 V and a valley current at 9.6 V. (08 marks)
   i) Identify the negative resistance region on the curve.
   ii) State one physical reason for current decrease after the peak point.
   iii) State one use of this negative resistance property in microwave circuits.

e. Give the phase relationship between the outputs at ports 1 and 2 of a magic-tee when the power is fed into (04 marks)
   i) H-arm.
   ii) E-arm.

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