UNIVERSITY OF SWAZILAND
FACULTY OF SCIENCE

DEPARTMENT OF ELECTRONIC ENGINEERING

SUPPLEMENTARY EXAMINATION 2005/2006

TITLE OF PAPER : ANTENNAS AND WAVE PROPAGATION

COURSE NUMBER : ECO510

TIME ALLOWED : THREE HOURS

INSTRUCTIONS : READ EACH QUESTION CAREFULLY
ANSWER ANY **FOUR** OUT OF **FIVE** QUESTIONS.
EACH QUESTION CARRIES **25 MARKS**.
MARKS FOR EACH SECTION ARE SHOWN IN THE RIGHT-HAND MARGIN.

THIS PAPER HAS 4 PAGES INCLUDING THIS PAGE.

THIS PAPER IS NOT TO BE OPENED UNTIL PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR.

USEFUL INFORMATION

Electronic charge	$e = 1.6 \times 10^{-19}$ C
Permittivity of space	$\varepsilon_0 = 8.85 \times 10^{-12}$ F/m
Electronic mass	$m = 9 \times 10^{-31}$ kg.
Effective radius of the earth plus the mean terrain level	$R_e = 8500$ km
Antenna efficiency factor	$k = 0.55$
Gain for $\lambda/2$	1.64
General expression for gain	$(4\pi k)$ (effective area) / λ^2
The radar equation	$P_r = P_t G_t G_r \lambda^2 \sigma / (4\pi)^3 r^4$
Figure of merit for a $\lambda/2$ dipole antenna	222

QUESTION 1

a) Explain the following terms as applied to antennas:
(i) Beamwidth angle (2 marks)
(ii) Radiation resistance and (2 marks)
(iii) Reciprocity (2 marks)

b) Assuming a uniformly illuminated dish antenna of diameter 3.05 m and operating frequency of 12.6 Ghz, find the gain for the dish antenna. (3 marks)

c) (i) Is the optical horizon the same as the radio horizon? Explain your answer. (3 marks)

(ii) How far above ground would the receiving antenna need to be elevated when the transmitting antenna is 88.6 m away and on top of a 283 m, high building? (7 marks)

d) Beyond-the-horizon transmission is possible using scatter mode propagation at very high frequencies (VHF) and ultrahigh frequencies (UHF). Distinguish between the three possible types of scatter propagation. (6 marks)

QUESTION 2

a) You are to set up a 5-GHz microwave communication link using two dish antennae. The minimum detectable receiver power P_r, should be $2.5 \times 10^{-6} W$, the transmitted power P_t maintained at $50dBm$ and the antenna diameter $d = 2.0m$.

(i) How far apart should the transmitter and receiver be placed to operate satisfactorily under the above conditions.

(11 marks)

(ii) What minimum antenna height will part (i) require?

(4 marks)

b) A new link is now to be established over a range of 100 km using the same transmitter and receiver characteristics as in section (a). What antenna diameter can be used for this application? (5 marks)

c) If G is the power gain of the transmitting antenna in the direction of maximum radiation, I_o, its excitation current, while R_{rad} is its radiation resistance, how will you express the electric field intensity at distance r away from the transmitter?

(5 marks)

QUESTION 3

The commercial FM broadcast radio operates over the frequency band 88 MHz to 108 MHz. A variety of Educational programmes are broadcast over this band.

(i) Design a simple but effective antenna, ensuring good coverage at the band edges, which will enable the reception of any of the programmes . Include a well labeled geometrical structure. Let the spacing and scale factors be $\sigma = 0.18$ and $\tau = 0.92$, respectively.

(24 marks)

(ii) How many programmes can be received using your antenna design?

(1 mark)

QUESTION 4

a) (i) The distance at which a receiving antenna can have an unobstructed view of the transmitting antenna is limited by the curvature of the earth. Derive an approximate expression for the maximum line-of-sight range for a radio system, in terms of the heights of both antennas, given that the radius of the earth is approximately equal to 6350 km. (6 marks)

(ii) Determine the maximum distance at which an aircraft, flying at an altitude of 3000 m, will be able to receive signals from a transmitting antenna located at the top of a 200 m high tower. Assume line-of-sight propagation only. (4 marks)

(iii) If the transmitting antenna has a power gain of 13 dB in the direction of the receiving antenna on the aircraft and the power radiated is 400 W, calculate the electric field strength of the signal at the receiving end. (5 marks)

b) What is the signal attenuation from a 25 W satellite at 22,000 km altitude, transmitting at 3.2 GHz from an antenna with 27 dB gain into a receiving antenna with 60 dB gain? (4 marks)

c) (i) Name two types of diversity receptions. (2 marks)
(ii) Describe their differences and similarities. (4 marks)

QUESTION 5

a) Signals from a small boat in the sea are received at a fire station 80 km from the seashore.
(i) How will the terrain between the boat 50 km from the seashore affect the magnitude of the electric field along the propagation path? (3 marks)

(ii) Given that the frequency of propagation is f, $\sigma_2 = 10mS/m$, $\varepsilon_{rl} = 4$, $\sigma_s = 4000mS/m$ and $\varepsilon_{rs} = 80$, show how you will analyse and compute the magnitude of the electric field strength at the receiver. Include well labelled diagrams and equations which can be used. (16 marks)

b) A 3 - m high $\lambda/2$ - dipole antenna with a radiation resistance of 3.6 Ω is fed with current I_{rms} = 50 mA. Compute the unatennuated field at 1 km from the antenna. (6 marks)
