Name: _____ Index No. _____/_____

2207/303
COMMUNICATION AND
NAVIGATION SYSTEMS
Oct./Nov. 2015
Time: 3 hours

Candidate's Signature: _____

Date: _____

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN AERONAUTICAL ENGINEERING AVIONICS (COMMUNICATION AND NAVIGATION OPTION)

COMMUNICATION AND NAVIGATION SYSTEMS

3 hours

INSTRUCTIONS TO CANDIDATES

Write your name and index number in the spaces provided above.
Sign and write the date of the examination in the spaces provided above.
You should have the following for this examination:
Mathematical tables/Non-programmable scientific calculator;
*Answer any **FIVE** of the **EIGHT** questions in the spaces provided in this question paper.*
ALL questions carry equal marks.
Maximum mark for each part of a question are as shown.
Do not remove any pages from this question paper.
Candidates should answer the questions in English.

Take: Impedance of free space, £ = 377Ω
Free space wave velocity, C = 3×10^8 m/s

For Examiner's Use Only

Question	1	2	3	4	5	6	7	8	TOTAL SCORE
Candidate's Score									

This paper consists of 24 printed pages.

Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.

1. (a) (i) List any **two** factors that determine the sensitivity of a radio receiver.

(ii) With the aid of a circuit diagram explain ganging as applied to radio receiver tuning. (7 marks)

(b) (i) Draw a labelled block diagram of a Frequency Modulation (FM) radio receiver and describe its operation.

(ii) An Amplitude Modulation radio receiver, tuned to 1000 kHz, has an intermediate frequency of 455 kHz. Determine its:

(I) image frequency;

(II) local oscillator frequency.

(13 marks)

2. (a) (i) List any **two** advantages of the single sideband (SSB) - over the double sideband amplitude modulation (AM) systems.

(ii) With the aid of a labelled block diagram, describe the operation of a low level modulation AM radio transmitter.

(9 marks)

(b) (i) A double sideband AM system modulates a carrier signal of 3 MHz using an audio signal varying from 1 kHz to 3 kHz.

(I) Determine the frequencies of the upper sideband and the lower sideband signals.

(II) Sketch the transmission spectrum for the system.

(ii) An FM transmitter has modulation index of 7. The highest modulating signal frequency is 15 kHz. Determine the:

(I) frequency deviation;

(II) required bandwidth.

(11 marks)

3. (a) (i) Define each of the following with respect to antennas:

(I) polar diagram;
(II) front-to-back ratio.

(ii) Table 1 shows a comparison of two antennas, A and B in terms of their 3 dB beamwidths and output powers. State any **two** areas of application of each antenna.

Table 1

Antenna	θ 3dB	Output power (kW)
A	0.5°	5
B	90°	200

(iii) Describe mutual impedance as applied to antenna arrays.

(9 marks)

(b) A transmitting antenna, operating at 600 MHz, radiates 5 W to a receiving antenna located 800 km away. If the receiving antenna has an effective aperture of 2 m^2, determine the:

(i) power flux density at the receiving point;

(ii) received power.

(4 marks)

(c) With the aid of a labelled diagram, describe the operation of a 4-element broadside antenna array. (7 marks)

4 (a) (i) With the aid of a labelled diagram, describe packet switching as applied to data communications.

(ii) With the aid of a block diagram, describe the operation of a 6-to-3 line data concentrator.

(11 marks)

(b) A 2.1 kHz audio signal is sampled and transmitted using 8-bit pulse code modulation. Determine the:

(i) signal-to-quantisation noise ratio in dB;
(ii) number of coding levels;
(iii) Nyquist sampling rate.

(6 marks)

(c) Describe full-duplex data communication. (3 marks)

5. (a) (i) List any two application of radar buoys.

(ii) With the aid of a labelled block diagram, describe the operation of a distance measuring equipment (DME) radar. (9 marks)

(b) A radar system, operating at 750 MHz over a 10 km range, produces a minimum receivable power of 600 pW. If the antenna capture area is 6 m^2 and the target cross-sectional area is 12 m^2, determine the:

(i) peak pulsed power radiated;

(ii) range over which the minimum receivable power would increase to 1 nW for the same radiated power. (6 marks)

(c) With the aid of a directional signal pattern, describe the operation of a very high frequency omnidirectional range (VOR) equipment. (5 marks)

6. (a) Define each of the following with respect to satellite communication:

(i) major axis;
(ii) latency;
(iii) station-keeping. (3 marks)

(b) Describe the functions of the following satellite organisations:

(i) Intelsat;
(ii) Inmarsat. (6 marks)

(c) (i) A satellite earth station uses an antenna of 58 dB gain radiating 3 kW at 9 GHz towards a space station located 36,000 km away. If the receiving antenna, with an efficiency of 64% receives 2.4 μW, determine the gain of the receiving antenna in dB.

(ii) Figure 1 shows a labelled block diagram of the telemetry, tracking and command (TTAC) sub-system of a satellite. Describe its operation. (11 marks)

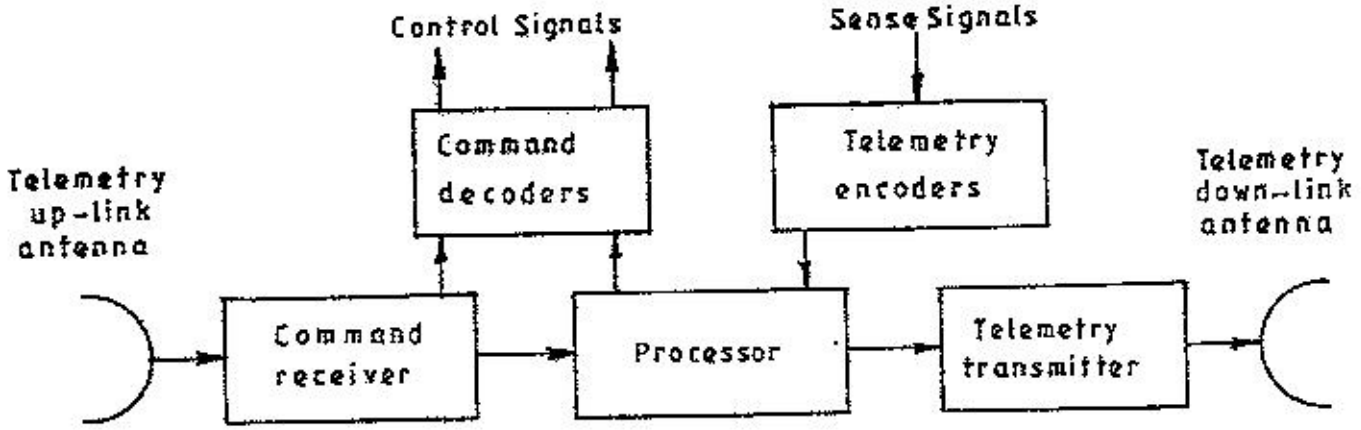

Fig. 1

7. (a) (i) With the aid of a raypath diagram and refractive index profile, explain light propagation through a graded index optical fiber.

(ii) Draw a labelled construction diagram of a photodiode and describe its operation. (11 marks)

(b) Table 2 shows data for an optical sensor.

(i) plot the response curve.

(ii) determine the:
(I) detector 3dB bandwidth;
(II) frequencies at which the output power is 11.5 mW;
(III) frequency at the highest sensitivity.

(9 marks)

Table 2

Frequency (THz)	400	390	380	370	360	350	340	330	320	310
Output power (mW)	5	12.8	17	20	19	16	13	11	7	2

8. (a) (i) List the **two** boundary conditions necessary for a signal to propagate in a waveguide.

(ii) With the aid of a labelled diagram, describe the operation of a klystron amplifier. (9 marks)

(b) (i) Figure 2 shows waveguide slot coupling method. Explain how maximum coupling is achieved.

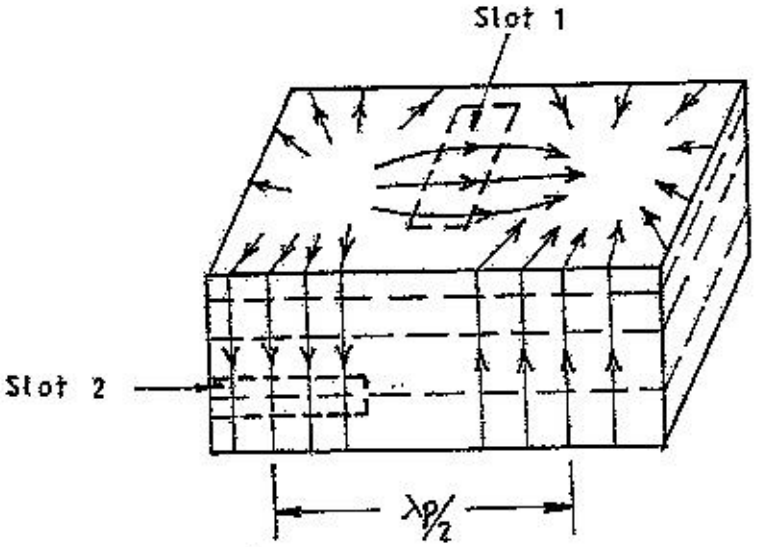

Fig. 2

(ii) A parallel-plane waveguide, with a plane separation of 4.5 cm, operates at 9 GHz when carrying the $TE_{1,0}$ mode. Determine the:

(I) cut-off wavelength;
(II) guide wavelength;
(III) group velocity.

(11 marks)