UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2010/2011

COURSE	:	SATELLITE COMMUNICATION SYSTEM
COURSE CODE	:	BEP 4243
PROGRAMME	:	BEE
EXAMINATION DATE	:	APRIL / MAY 2011
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FIVE (5)** QUESTIONS ONLY

THIS PAPER CONSISTS OF SEVEN (7) PAGES

Q1 (a) Explain the THREE laws that was derived by Johannes Kepler (1571 – 1630) that are able to show the rotation of satellite around the Earth. Use figures or mathematic models to enhance the definition.

(9 marks)

(b) With the aid of sketch or diagram, intepret the meaning of some of the Keplerian elements that are given below:-

(i) apogee and perigee,

(2 marks)

(ii) inclination,

(1 mark)

(iii) semi-major axis,

(1 mark)

(iv) right ascession of the ascending node, and

(2 marks)

(v) argument of perigee

(2 marks)

(c) The eccentricity, *e*, and the semi-major exis, *a*, are given as 0.0011501 and 7192.335 km, respectively. Calculate the apogee and perigee heights by assuming that the mean Earth radius is 6371 km .

(3 marks)

Q2 (a) Distinguish the position vector, ***r*** and the velocity vector, ***v*** which can specify the motion of a satellite in an orbital plane.

(4 marks)

(b) The 2-line elements for satellite NOAA 27 are as follows;

```
NOAA   27
1 28654U 05018A   05154.51654998  .00000093  00000-0  28161-4  0  189
2 28654  98.7443 101.8853 0013815 210.8695 149.1647 14.10848892 1982
```

By referring to Table 1, calculate:-

(i) epoch day in Julian Day,

(2 marks)

(ii) time in Julian century with JD_{ref} is reference time of January 0.5, 1900 = 2415020 Julian days and Julian Century (JC) = 36525 days,

(2 marks)

(iii) Greenwich Sidereal Time, GST, where it is given as,

$$GST = 99.6910 + 36{,}000.7689 \times T + 0.0004 \times T^2 + UT\,^{\circ}$$

(3 marks)

(iv) semi-major axis, a, and

(4 marks)

(v) true anomaly, v, where it is given as below.

$$v \cong M + 2e\sin M + \frac{5}{4}e^2 \sin 2M$$

(2 marks)

(c) Differentiate between high earth orbiting (HEO), medium earth orbiting (MEO) and low earth orbiting (LEO).

(3 marks)

Q3 (a) For a point rain rate of 11.3 mm/h, the rain attenuation exceeded 0.001% of the time in any year. The altitude of the Earth station and the antenna elevation angle at the Earth station is given as 243.4 m and 21.6 °, respectively. For a satellite communication with a carrier frequency of 15 GHz and the height of rain of 1.95 km, estimate:

(i) vertical polarization,

(4 marks)

(ii) horizontal polarization and

(3 marks)

(iii) circular polarization.

(5 marks)

(b) By using the rain attenuation for the circular polarization from Q3 (a)(iii) above, evaluate the cross-polar discrimination, XPD, in unit dB. Given;

$$V = \begin{cases} 20 & for\ 8 \le f \le 15GHz \\ 23 & for\ 15 < f \le 35GHz \end{cases}$$

$$U = 30\log f - 10\log(0.5 - 0.4697\cos 4\tau) - 40\log(\cos\theta)$$

(8 marks)

Q4 (a) Depolarization is an effect of orthogonal component that may be generated from the transmitted polarization. Differentiate in between Ionospheric, Rain and Ice depolarizations.

(6 marks)

(b) A geostationary satellite is stationed at 10° E and transmits a vertically polarized wave. Estimate the angle of polarization at an Earth station at latitude of 45° N and longitude 5° E. Given a_{GSO} = 42164 km and the mean radius of spherical Earth, R = 6371 km.

(14 marks)

Q5 (a) Create a satellite circuit which consists both the B_1 and B_2 modes of interference. Explain the meaning of -3dB contour and coordination, in terms of interference.

(5 marks)

(b) Design a satellite circuit block diagram, which can be used to define the transmission gain factor.

(5 marks)

(c) Given that L_U = 200 dB, L_D = 196 dB, $G_E = G'_E$ = 25 dB, $G_S = G'_S$ = 9dB, $G_{TE} = G_{RE}$ = 48 dB, $G_{RS} = G_{TS}$ = 19 dB, $U_S = U'_S$ = 1 μJ, and U'_E = 10 μJ. Given [k] = - 228.6 dB. Calculate:

(i) transmission gain, γ,

(4 marks)

(ii) the equivalent temperature rise overall.

(6 marks)

Q6 (a) Global Positioning Satellites (GPS) is a system that can be used for so many applications such as for Military, Navigation, Aviation, Asset Tracking, Surveying and Agriculture.

(i) Intepret the statement above by giving brief explanation on the usage of the GPS system in Military, Navigation and Aviation.

(9 marks)

(ii) In terms of accuracy, ionosphere does give positioning error in Navigation. Propose 3 methods that can be implemented in order to mitigate the ionospheric error and to improve the performance of the GPS system in Navigation.

(6 marks)

(b) During raining time at tropical countries such as Malaysia, the TV signals that are being broadcasted using the geostationary satellites will be distorted. They are few reasons for the occurance of this problem. Name and explain TWO (2) main reasons for this distortion to take place.

(5 marks)

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Table 1: Julian Dates at the beginning of each year (Jan 0.0 UT) for the years 1999 - 2010

Year	Julian date (days)
	2 450 000.+
1999	1 178.5
2000	1 543.5
2001	1 909.5
2002	2 274.5
2003	2 639.5
2004	3 004.5
2005	3 370.5
2006	3 735.5
2007	4 100.5
2008	4 465.5
2009	4 831.5
2010	5 196.5

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Table 2 : Reduction Factors

For p = 0.001%	$r_{0.001} = \frac{10}{10 + L_G}$
For p = 0.01%	$r_{0.01} = \frac{90}{90 + 4L_G}$
For p = 0.1%	$r_{0.1} = \frac{180}{180 + L_G}$
For p = 1%	$r_1 = 1$

Table 3 : Specific Attenuation Coeficients

Frequency, GHz	a_h	a_v	b_h	b_v
8	0.00454	0.00395	1.327	1.31
10	0.0101	0.00887	1.276	1.264
12	0.0188	0.0168	1.217	1.2
15	0.0367	0.0335	1.154	1.128
20	0.0751	0.0691	1.099	1.065
25	0.124	0.113	1.061	1.03
30	0.187	0.167	1.021	1

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Constant values and formulas:

$\mu = 3.986005 \times 10^{14}\ m^3\ sec^{-2}$ (Gravitational parameter)

R = 6371 km (mean Earth radius)

$K_1 = 66063.1704\ km^2$ (Earth's constant)

Boltzman's constant, k = 228.6 dB

$\mathbf{r} = (r \cos v)\,\mathbf{P} + (r \sin v)\,\mathbf{Q}$

$$\begin{bmatrix} r_I \\ r_J \\ r_K \end{bmatrix} = \vec{R} \begin{bmatrix} r_P \\ r_Q \end{bmatrix}$$

$$\vec{R} = \begin{bmatrix} (\cos\Omega\cos\omega - \sin\Omega\sin\omega\cos i) & (-\cos\Omega\sin\omega - \sin\Omega\cos\omega\cos i) \\ (\sin\Omega\cos\omega + \cos\Omega\sin\omega\cos i) & (-\sin\Omega\sin\omega + \cos\Omega\cos\omega\cos i) \\ (\sin\omega\sin i) & (\cos\omega\sin i) \end{bmatrix}$$