UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2009/2010

SUBJECT NAME	:	SATELLITE COMMUNICATION SYSTEM
SUBJECT CODE	:	BEP 4243
COURSE	:	4 BEP
EXAMINATION DATE	:	NOVEMBER 2009
DURATION	:	3 JAM
INSTRUCTION	:	ANSWER FIVE (5) QUESTIONS ONLY

Q1 (a) Johannes Kepler (1571 – 1630) was able to derive empirically THREE (3) laws describing planetary motion. Define those THREE (3) laws that are able to show the rotation of satellite around the Earth. Use figures or mathematic models to strengthen the definition.

(9 marks)

(b) For some particular case of Earth-orbitting satellites, certain terms are used to describe the position of the orbit with respect to the Earth. These terms sometimes termed as Keplerian elements. Using diagrams wherever necessary, describe the meaning of the terms 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) Calculate the apogee and perigee heights for the given eccentricity, e = 0.0011501 and semi-major axis, a = 7192.335 km. Assume a mean Earth radius of 6371 km .

(3 marks)

Q2 (a) With the aid of a suitable figure, 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 18 are as follows;

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NOAA   18
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
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By referring to Table 3, 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, using approximated equation as given below.

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

(2 marks)

(c) Differentiate between mean solar day and mean sidereal day.

(3 marks)

Q3 (a) For a satellite transmission path, the angle of elevation of the Earth station antenna is 35°. The Earth station is situated at mean sea level. The rain height is 1km and a rain rate of 10 mm/h is exceeded for 0.001% of the year. Under all those conditions and for a radio transmission with a frequency of 20GHz, estimate:-

(i) horizontal polarization,

(4 marks)

(ii) vertical polarization and

(4 marks)

(iii) circular polarization.

(5 marks)

(b) A transmission path between an Earth station and a satellite has an angle of elevation of 15° with reference to the Earth. The transmission is circularly polarized at a frequency of 15 GHz. When the rain attenuation on the path is 1 dB, calculate the cross-polarization discrimination. Given;

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

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

(7 marks)

Q4 (a) One of the effects of the ionosphere is to produce a rotation of the polarization of a signal, an effect known as Faraday rotation. Describe the Faraday rotation effect to a typical satellite signal.

(3 marks)

(b) The unit polarization vector p at the Earth station will be able to define the polarization of a respective satellite. Using the relevant vectors at the Earth station and the satellite and relevant diagrams, formulate the angle of polarization at an Earth station.

(7 marks)

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

(10 marks)

Q5 (a) Design satellite circuits block diagram which contain both wanted and unwanted network and explain the B_1 and B_2 modes of interference in those circuits.

(3 marks)

(b) (i) The desired Equivalent Isotrophic Radiated Power [EIRP] from a satellite S_1 is 34dBW, and the gain of the ground station receiving antenna, B is 44dB in the desired direction and 24.47 dB toward the interfering satellite S_2. The interfering satellite also radiates an [EIRP] of 34 dBW. The polarization discrimination is 4dB. Calculate the downlink Carrier-to-Interference ratio [C/I] at the ground receiving antenna.

(3 marks)

(ii) An Earth station A transmits 24 dBW power with an antenna gain of 54 dB, and station C transmits 30 dBW power. The off-axis gain in the S_1 direction is 24.47 dB, and the polarization discrimination is 4 dB. Calculate the [C/I] on the uplink.

(3 marks)

(iii) Using the uplink and downlink values from (b) (i) and (ii) above, calculate the overall [C/I].

(3 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. Estimate the transmission gain, γ, the interference levels, I_1 and I_2, and the equivalent temperature rise overall.

(8 marks)

Q6 (a) In Global Positioning Satellites (GPS) system, ionosphere becomes as a major source of error which effects the system's performance especially over the equatorial region.

(i) Analyse the statement above by referring to the formation of the ionosphere, the relathionship between the Total Electron Content (TEC) of the the ionosphere and GPS carrier frequencies and the presence of greater ionospheric horizontal gradient over the equatorial region.

(8 marks)

(ii) Construct and explain the Differential GPS (dGPS) method which is widely used in order to remove or mitigate the ionospheric error especially over the equatorial region.

(8 marks)

(b) As ionosphere, troposphere is another layer in the atmosphere. However, tropospheric effect to GPS system is just one tenth (~ 10%) of the total ionospheric effect. Analyse why there is huge different in the the amout of error from the tropospheric layer to GPS system though it is another atmospheric layer like ionosphere.

(4 marks)

Table 1 : Reduction Factors

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

Table 2 : Specific Attenuation Coeficients

Frequency, GHz	a_h	a_v	b_h	b_v
1	0.0000387	0.0000352	0.912	0.88
2	0.000154	0.000138	0.963	0.923
4	0.00065	0.000591	1.121	1.075
6	0.00175	0.00155	1.308	1.265
7	0.00301	0.00265	1.332	1.312
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

Table 3: 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