# KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
## COLLEGE OF COMPUTER SCIENCES & ENGINEERING
## *COMPUTER ENGINEERING DEPARTMENT*

**COE-241 – Data and Computer Communication**
**October 13th, 2012 – Major Exam #1**

**Student Name:**
**Student Number:** **ModelA**
**Exam Time: 90 mins**

- Do not open the exam book until instructed
- The use of programmable calculators and cell phone calculators is not allowed – only basic calculators are permitted
- Answer all questions
- All steps must be shown
- Any assumptions made must be clearly stated

| Question No. | Max Points | |
|---|---|---|
| 1 | 30 | |
| 2 | 30 | |
| 3 | 20 | |
| 4 | 30 | |
| 5 | 30 | |

Total: 140

**Q.1) (30 points) Mark the following statements with either TRUE (T) or FALSE (F)**

| | | |
|---|---|---|
| 1 | Interfacing is one communication task requiring the transport of signal from device to medium. | |
| 2 | Several peripherals connects to a common bus is an example of a multi-access link. | |
| 3 | Segmentation and re-assembly is one function that a protocol may have where transmitted data is augmented with overhead information for protection against errors. | |
| 4 | Half-duplex communications implies that communications occur in two directions but one at a time. | |
| 5 | Gateways are devices utilized by links to perform data link functions. | |
| 6 | Token bus network is typically an example of a local area network. | |
| 7 | All periodic signals have a DC component at zero frequency. | |
| 8 | Intermediate nodes in a wide area network are typically responsible for switching the traffic in the direction of the destination. | |
| 9 | Energy spectral density has the units of Watts per Hz. | |
| 10 | A band pass filter is a filter which allows high frequency components to pass while it suppresses low frequency components. | |
| 11 | Impulse noise has the same effect on digital and analog communication. | |
| 12 | Elastic traffic accepts variable range of QoS levels across the internet. | |
| 13 | For a circuit switching session across a network, a dedicated path between the source and destination is established. | |
| 14 | The service access point (SAP) for the TCP layer within the IP protocol stack is referred to as a port. | |
| 15 | Quality-of-service parameters for network applications include throughput, delay, delay variation, and packet loss. | |

**Q.2) (30 points) For each of the following questions select the *most* appropriate answer:**

1. A TV signal with 400 horizontal lines with 500 pixels per line and 50 μsec to scan these pixels has a bandwidth equal to
   a. 200 cycles per second
   b. 400 MHz
   c. 500 cycles per second
   d. 5 MHz

2. Attenuation distortion is caused by
   a. Different propagation speeds for various frequency components of the signal
   b. The signal has a narrow bandwidth compared to the system
   c. The system does not have a flat attenuation function versus frequency
   d. None of the above

3. Intermodulation noise refers to the following
   a. Undesired signals at the frequency that is multiples of sum or difference of the two original input frequencies
   b. Excessive attenuation of signal power due to attenuation distortion
   c. Induced electromotive force in one conductor when placed near another one
   d. Sudden and large discharge of electric charges that create unwanted signals in the conductor of interest

4. To achieve full connectivity between *N* nodes using direct point-to-point links, assuming full duplex links, the required number of links is equal to
   a. *N* links
   b. $N^2/2$ links
   c. $N\text{x}(N-1)/2$ links
   d. $N^3$ links

5. The public telephony switching network (PTSN) is a classical example of a networking deploying
   a. Message switching technology
   b. Circuit switching technology
   c. Packet switching technology
   d. ATM and frame-relay technology

6. If the attenuation for a given cable is measured to be 8.2 dB per 100 meters. Then if we start by 10 Watts of power, then after 200 meters we should get:
   a. 1.6 Watts
   b. 8.2 Watts
   c. 0.5 Watts
   d. None of the above

7. The dynamic range of a signal in dBs is a measure for
    a. Range of all frequencies contained in signal
    b. Range of all amplitudes contained in signal
    c. Range of speed for signal
    d. Range of quality for signal

8. For a 1 mW input signal, your audio/video amplifier whose gain is 30 dB will produce an output power equal to
    a. 30 dBmW
    b. 30 mW
    c. 30 dB
    d. 30 W

9. The presentation layer in the OSI protocol stack has the following responsibilities:
    a. The presentation layer is not part of the OSI protocol stack
    b. Defines format of data to be exchanged by applications
    c. Controlling dialog between applications at end systems
    d. Both (b) and (c)

10. The OSI model for computer communication nodes is:
    a. A software model and abstraction
    b. Defines set of layers and the services at these layers necessary to perform communication
    c. Logical partitioning of functions
    d. All the above

**<u>Q3) (20 points) On the subject of Z-transform and transmission impairments:</u>**

a) (5 points) Sketch the graph for the sampled signal $x(n)$ specified by $x(n) = 2 \times 0.5^n u(n-3)$, where $u(n)$ is the standard unit step function. Consider values of $n$ less or equal to 7.

b) (8 points) Compute the Z-transform for the sample signal $x(n) = 0.5^n u(n)$.

c) (7 points) Explain very briefly the difference between signal amplifiers and signal repeaters.

Use the definition of the Z-transform and show you computations when applicable.

Hint: the sum $\sum_{n=0}^{\infty} r^n$ is equal to $1/(1-r)$ if $|r| < 1$.

**Q4) (30 points) On the subject of thermal noise and channel capacity:**

Consider the classical telephone channel of bandwidth equal to 3000 Hz where the typical average signal power is equal to 1 milli watts. Let the effective noise temperature of the system be equal to 1000,000 degrees Kelvin.

a) (5 points) Compute the noise power of the system in Watts and in dBW?

b) (5 points) Compute the maximum possible capacity for this channel in bits per second.

c) (5 points) The capacity computed in part (b) is an upper limit and may be very hard to achieve. If this theoretical capacity is to be achieved, what is the maximum number of signal levels required?

d) (5 points) Compute the spectral efficiency for the telephone channel and specify the units for the computed quantity?

e) (5 points) If the above capacity is to be achieved what would be the *energy-per bit to noise power spectral density* (Eb/N0) figure for this channel. Specify the answer on the linear scale and in dBs.

f) (5 points) What is the maximum signaling or baud rate (i.e. number of symbols per second) that can be made theoretically on this channel without accounting for the noise impairment?

*Hint: Boltzman constant is equal to* $1.3803 \times 10^{-23}$ *J/degree Kelvin*

**Q.5) (30 points)** Consider the periodic half-wave cosine signal whose Fourier Series Expansion (FSE) is given by

$$s(t) = \frac{A}{\pi} + \frac{A}{2}\cos(2\pi f_0 t) + \frac{2A}{\pi}\sum_{n=2,4,6,\ldots}^{\infty} \frac{(-1)^{1+\frac{n}{2}}}{n^2-1}\cos(2\pi n f_0 t)$$

Let $T = 0.5$ seconds and $A = 2$ volts.

a) (5 points) Compute the DC component for $s(t)$ and specify the fundamental frequency.

b) (5 points) If $s(t)$ is passed through an ideal low pass filter whose cut-off frequency is equal to 6 Hz, specify the output signal $s_o(t)$.

c) (5 points) Compute the total power for the output signal $s_o(t)$.

d) (10 points) Specify and plot the power spectral density for the output signal $s_o(t)$.

e) (5 points) Compute the power dynamic range for the signal $s_o(t)$ and produce a power ratio in dB versus frequency.

# Appendix: Relations you MAY need

$\cos(a) = \cos(-a)$ $\sin(a) = -\sin(a)$

$\cos(a +/- b) = \cos(a)\cos(b) -/+ \sin(a)\sin(b)$

$\sin(a +/- b) = \sin(a)\cos(b) +/- \cos(a)\sin(b)$

$\sin(2a) = 2\sin(a)\cos(b)$

$\cos(2a) = \cos^2(a) - \sin^2(b) = 2\cos^2(a) - 1 = 1 - 2\sin^2(a)$

$$\cos(ax)^2 = \frac{1}{2} + \frac{1}{2}\cos(2ax)$$

$$\sin(ax)^2 = \frac{1}{2} - \frac{1}{2}\cos(2ax)$$

$$\int \cos(ax)dx = \frac{1}{a}\sin(ax) + C$$

$$\int \sin(ax)dx = \frac{-1}{a}\cos(ax) + C$$

$$\int \cos(ax)^2 dx = \frac{x}{2} + \frac{1}{4a}\sin(2ax) + C$$

$$\int \sin(ax)^2 dx = \frac{x}{2} - \frac{1}{4a}\sin(2ax) + C$$

$$\int x\cos(ax)dx = \frac{\cos(ax)}{a^2} + \frac{x\sin(ax)}{a}C$$

$$\int x\sin(ax)dx = \frac{\sin(ax)}{a^2} - \frac{x\cos(ax)}{a}C$$