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

COE 540 –Computer Networks
April 23rd, 2011 – Midterm Exam

Student Name:
Student Number:
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	
5	40	
Total:	120	

Q.1) (30 points) On the subject of channel models and modems

Suppose that a linear time-invariant (LTI) channel has the ideal low-pass frequency response $H(f) = 1$ for $-f_0 \leq f \leq f_0$ and $H(f) = 0$ elsewhere.

a) **(8 points)** Compute the impulse response for the channel $h(t)$.

b) **(5 points)** Sketch a plot for $h(t)$ for $t \in \left[-\frac{3}{f_0}, \frac{3}{f_0}\right]$.

c) **(10 points)** Compute the channel response if the channel is excited by a train of impulses spaced by $2/f_0$. In other words, compute $r(t)$, for an input equal to $s(t) = \sum_{n=-\infty}^{\infty} \delta(t - \frac{2n}{f_0})$, where $\delta(t)$ is the unit impulse signal.

d) **(7 points)** Sketch the response $r(t)$ computed in part (c).

Hint: The Fourier Transform pair: $H(f) = \int_{-\infty}^{\infty} e^{-2\pi jft} h(t)dt$ and $h(t) = \int_{-\infty}^{\infty} e^{2\pi jft} H(f)df$. Euler identities are as follows: $\sin(\theta) = \left(e^{j\theta} - e^{-j\theta}\right)/(2j)$, and $\cos(\theta) = \left(e^{j\theta} + e^{-j\theta}\right)/2$. For parts (b) and (d) only a sketch is required, not a detailed graphical plot.

Q.2) (30 points) On the subject of flow control protocols:

Consider the link between an earth station in Riyadh and a geostationary communications satellite. Assume the link is using the *stop-and-wait* protocol to transfer frames of length equal to 1500 bytes from the earth station to the satellite. In this context, answer the following questions:

a) **(10 points)** Assume the link bit rate is equal to 500 kb/s. Compute the utilization and net (useful) throughput (in bits/sec and frames/sec) for the link.

b) (**10 points**) If it is desired to improve the link utilization computed in part (a), suggest mechanism*s* and explain how to improve the utilization for the satellite link.

c) **(10 points)** What is meant by the correctness of the stop-and-wait protocol. Outline the proof for the correctness of stop-and-wait discussed in class.

Hints: Assume that Tack and Tproc are negligable. Assume also that the geostationary satellite orbits earth at the height of 36,000 *km and the speed of light c is equal to* 3×10^8 *m/s. The net throughput is defined as number of data bits sent per second.*

Q.3) **(20 points)** On the subject of error control and framing

Consider the CRC procedure explained in class and illustrated in the textbook. Let $s(D)$ be the polynomial of degree K-1 representing the data string while $g(D)$ be the generator polynomial of degree L. The transmitted frame, denoted by $x(D)$, is constructed as $s(D)D^L + c(D)$, where $c(D)$ is a polynomial of degree L-1 at most.

(a) **(8 points)** How is the polynomial $c(D)$ calculated?

(b) **(12 points)** Show that if $g(D)$ has at least two non-zero terms (i.e. D^L and 1), then all single bit errors are be detected.

Q.4) (**40 points**) On the subject of frame length and probability theory:
Assume that for a data link the frame length (in bytes), K, is a random variable that follows the Binomial probability distribution with parameters N equal to 3 and p equal to 0.4.

a) **(5 points)** Specify the probability mass function for the frame length K.
b) **(5 points)** Compute the probability generating function (PGF) $G_K(z)$ defined as $E[z^K]$.
c) **(5 points)** Use the result in (b) to compute the average of frame length $E[K]$.
d) **(8 points)** If it is required to encode the frame length information, what would be the minimum number of bits required? Show your calculations.
e) **(10 points)** Use Huffman coding to derive a coding scheme for the frame length information.
f) **(7 points)** For the length information codes derived in part (e), compute the average code length. Compare that to result computed in part (d).

Hint: The binomial identity is given by $\sum_{m=0}^{M} \binom{M}{m} q^m p^{M-m} = (q+p)^M \; \forall q, p \in \mathbb{R}$.