ASSIGNMENT NO 1 SOLUTION

Problem 1

There is no single right answer to this question. Many protocols would do the trick. Here's a simple answer below:

Messages from ATM machine to Server

```
Msg name              purpose
--------              -------
HELO <userid>         Let server know that there is a card in the ATM machine
                      ATM card transmits user ID to Server
PASSWD <passwd>       User enters PIN, which is sent to server
BALANCE               User requests balance
WITHDRAWL <amount>    User asks to withdraw money
BYE                   user all done
```

Messages from Server to ATM machine (display)

```
Msg name              purpose
--------              -------
PASSWD                Ask user for PIN (password)
OK                    last requested operation (PASSWD, WITHDRAWL) OK
ERR                   last requested operation (PASSWD, WITHDRAWL) in ERROR
AMOUNT <amt>          sent in response to BALANCE request
BYE                   user done, display welcome screen at ATM
```

Correct operation:

```
client                             server

HELO (userid)    ---------------> (check if valid userid)
                 <--------------   PASSWD
PASSWD <passwd>  ---------------> (check password)
                 <--------------   OK (password is OK)
BALANCE          --------------->
                 <--------------   AMOUNT <amt>
WITHDRAWL <amt>  ---------------> check if enough $ to cover
                 withdrawl
                 <--------------   OK
ATM dispenses $
BYE              --------------->
                 <--------------   BYE
```

In situation when there's not enough money:

```
HELO (userid)    ---------------> (check if valid userid)
                 <--------------   PASSWD
PASSWD <passwd>  ---------------> (check password)
                 <--------------   OK (password is OK)
BALANCE          --------------->
                 <--------------   AMOUNT <amt>
WITHDRAWL <amt>  ---------------> check if enough $ to cover withdrawl
                 <--------------   ERR (not enough funds)
error msg displayed
no $ given out
BYE              --------------->
                 <--------------   BYE
```

Problem 5

Tollbooths are 75 km apart, and the cars propagate at 100km/hr. A tollbooth services a car at a rate of one car every 12 seconds.

a) There are ten cars. It takes 120 seconds, or 2 minutes, for the first tollbooth to service the 10 cars. Each of these cars has a propagation delay of 45 minutes (travel 75 km) before arriving at the second tollbooth. Thus, all the cars are lined up before the second tollbooth after 47 minutes. The whole process repeats itself for traveling between the second and third tollbooths. It also takes 2 minutes for the third tollbooth to service the 10 cars. Thus the total delay is 96 minutes.

b) Delay between tollbooths is 8*12 seconds plus 45 minutes, i.e., 46 minutes and 36 seconds. The total delay is twice this amount plus 8*12 seconds, i.e., 94 minutes and 48 seconds.

Problem 6

a) $d_{prop} = m / s$ seconds.

b) $d_{trans} = L / R$ seconds.

c) $d_{end-to-end} = (m / s + L / R)$ seconds.

d) The bit is just leaving Host A.

e) The first bit is in the link and has not reached Host B.

f) The first bit has reached Host B.

g) Want

$$m = \frac{L}{R}s = \frac{120}{56 \times 10^3}\left(2.5 \times 10^8\right) = 536\,\text{km}.$$

Problem 9

a) 10,000

b) $\sum_{n=N+1}^{M} \binom{M}{n} p^n (1-p)^{M-n}$

Problem 13

a) The queuing delay is 0 for the first transmitted packet, *L/R* for the second transmitted packet, and generally, *(n-1)L/R* for the n^{th} transmitted packet. Thus, the average delay for the *N* packets is:

(L/R + 2L/R + ... + (N-1)L/R)/N
*= L/(RN) * (1 + 2 + ... + (N-1))*
*= L/(RN) * N(N-1)/2*
= LN(N-1)/(2RN)
= (N-1)L/(2R)

Note that here we used the well-known fact:

1 + 2 + ... + N = N(N+1)/2

b) It takes LN / R seconds to transmit the N packets. Thus, the buffer is empty when a each batch of N packets arrive. Thus, the average delay of a packet across all batches is the average delay within one batch, i.e., (*N*-1)*L/2R*.