1. A satellite serving 100 stations can receive a maximum of 10,000 packets per second. If the channel is being utilized optimally
   I. What is the average number of packets sent by every station? (for plain and slotted ALOHA)
   II. How many packets (per second) suffer collisions? (for plain and slotted ALOHA)

In slotted ALOHA all stations together will attempt to send 10,000 packets/sec on an average – or each station will send 100 packets / sec (on an average)

Out of the 10,000 packets a fraction 1/e (about 36%) will reach without collision; 64% (or 6400 packets/sec) will suffer collision.

In Plain ALOHA all stations together will attempt to send 5,000 packets/sec on an average – or each station will send 50 packets / sec (on an average).

Out of the 5,000 packets a fraction 1/e (about 36%) will reach without collision; 64% (or 3200 packets/sec) will suffer collision.

The best that we can possibly do (or 100% efficiency) is when 10,000 packets/ sec reach the satellite successfully. Slotted ALOHA (which can deliver 3600/sec has an efficiency of 1/e (or 36%). Plain ALOHA, which can deliver only 1800 packets/sec has an efficiency of 18% (1/(2e))

2. Assume that you are designing a CSMA-CD protocol which permits
   - maximum bit-rate of 1 Mbps
   - maximum distance of 1250 m between any two stations (no repeaters are used)
   - maximum packet size of 1000 bits

The velocity of propagation of electromagnetic waves in the medium is 250 million m/s. Specify other parameters of the system. What is the efficiency when the maximum allowed packet size is used for all packets? What is the efficiency if we use packet size of 500 bits?

Bit rate \( R = 10^6 \text{ bps} \)
Frame size \( F = 1000 \text{ bits} \)
Packet Duration \( P = F / R = 1 \text{ millisecond} \)
Max Propagation Delay \( \tau = 125 / 2.5 \times 10^8 = 5 \mu s \)
Minimum packet duration is \( 2 \tau = 10 \mu s \)
Minimum packet size is \( 10 \text{ bits} \)
Efficiency = \( P / (P + 2 \tau e) = 1000 / (1000 + 27.18) = 0.973 \)

If we choose half the max frame size
\( Efficiency = P / (P + 2 \tau e) = 500 / (500 + 27.18) = 0.948 \)
Minimal efficiency (if all packets have the minimum packet size)
\( Min \text{ Efficiency} = 10 / (10 + 27.18) = 1 / (1 + e) = 0.2689 \)

3. Explain the hidden station and the exposed station problems in CSMA-CA. Is exposed station problem handled in 802.11? Why?

MACA-W which is used by 802.11 does not handle exposed station problem

Hidden station problem occurs due to the fact that CSMA cannot prevent two stations which are out of each other's transmission range (and thus hidden from each other) from sending packets at the same time. Their transmissions however can collide for receivers which are in the range of both transmitters.

Exposed station problem occurs in scenarios where a station can actually transmit safely when the rules of CSMA says that
it cannot. Specifically, two stations A and B within each other range can transmit to two receiver A' and B' respectively, at
the same time, as long as A' is out of the range of transmitter B (and in the range of A) and B' is out of the range of A
(but in the range of B).

However, if we allow A and B to transmit at the same time, then B will not be able to receive the ACK from B' (as the
ACK from B will collide with the transmission from A). MACA which attempts to solve both exposed and hidden station
problems, ignores the need for ACKs. MACA-W takes the need for ACKs into account, and thus does not address the
exposed station problem.

4. Briefly explain the concept of backward learning in bridges.

Bridges learn the topology by inspecting from addresses in the MAC packets. A bridge with say 3 lines will come to know
in due course the MAC addresses of the machines that can be reached by sending a packet through each of the 3 lines.
Bridges create a hash table to store the MAC addresses associated with each line. This is used to make forwarding
decisions.

Assume that a bridge with 4 lines (say line 1,2,3, and 4) receives a MAC packet in line 2 with from address F and to
address T.

The bridge will check if the address F is in the hash table; if not it will add “F, line 2” to the table;

The bridge will search the table to see if it has an entry for the address T;

If an entry exists, say “T, line 3”, the incoming MAC packet will be sent out through line 3.

If an entry exists, say “T, line 2”, the incoming MAC packet (in line 2) is disregarded by the bridge.

If no entry for T exists the packet will be flooded (sent out through lines 1,3, and 4)

Periodically hash table entries are removed to permit the ability to move a machine connected to one line of a bridge to a
new location where it may be connected to another line of the bridge (or even another bridge)