1. (a) Sketch the signal on a wire if the bit sequence 10111010 is to be transmitted using Manchester Coding (Slide 24 in Topic 3). Note: It will be easier to make this sketch if you draw a reference clock signal.

   (b) One of the reasons why Manchester-coding is used, despite having a bitrate that is half the baud rate, is because the receiver can synchronize with the sender's clock using the data stream. Consider the situation the receiver starts listening to the signal at some arbitrary time after the signal has started arriving. Describe an algorithm for the receiver's synchronize with the sender (i.e., figure out which transitions corresponds to a data bit).

   (c) A quad-level code (same slide) has a bitrate that two times the baud rate. What is the bitrate in terms of a baud rate of an 8-level (oct-level?) code? Explain what physical limits exist that prevent an arbitrarily large amount of data to be sent using a very slow clock.

2. (a) Using the CRC-8 polynomial $x^8 + x^2 + x + 1$, compute the 8-bit CRC of the 16-bit message 0xBEEF.

   (b) Show the computation the receiver performs in order to detect that the above message is corrupted when several bits are flipped.

3. The *repetition code* is a very basic example of forward error correction. In this code, every input bit is encoded by repeating it three times. For example, encoding the bitstring 0110 would produce 000111111000, which is the data that is sent on the wire.

   (a) If we make the assumption that *at most* one bit might be flipped, explain how a receiver would be able to extract the original (i.e., unencoded) bitstring correctly.

   (b) If we make the assumption that up to two bits could be flipped, can the receiver still perform forward error correction using this code?

4. A standard Ethernet frame consists of a number of fields.

   (a) Explain why the source address field is important.

   (b) Give a reason why it makes sense for error detection to be implemented in the Ethernet link layer rather than in the network layers above.

5. How does a sender on a shared medium network know a collison has occured?

6. Define one 'bit-time' as the time it takes for a network interface to place a bit onto a link. Two hosts, A and B, are connected by a link over some distance. On this link, it takes 340 bit-times for data to propagate from one host to the other (but the hosts have no way of knowing this). Messages on the link have a size of 576 bits.

   Consider the case where at time 0, A sends a single message. At some later time t, B begins transmitting a message of its own.

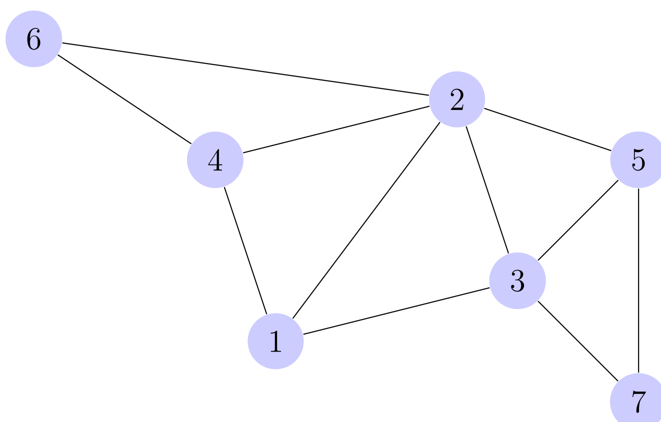
   (a) For what values of t will there be a collision?

   (b) For what values of t will there be a collision that A is not aware of?

   (c) For what values of t will there be a collision that neither A nor B is aware of?

   (d) How do your answers change if A and B are separated by 1000 bit-times?

7. Consider the following topology of devices within a LAN.



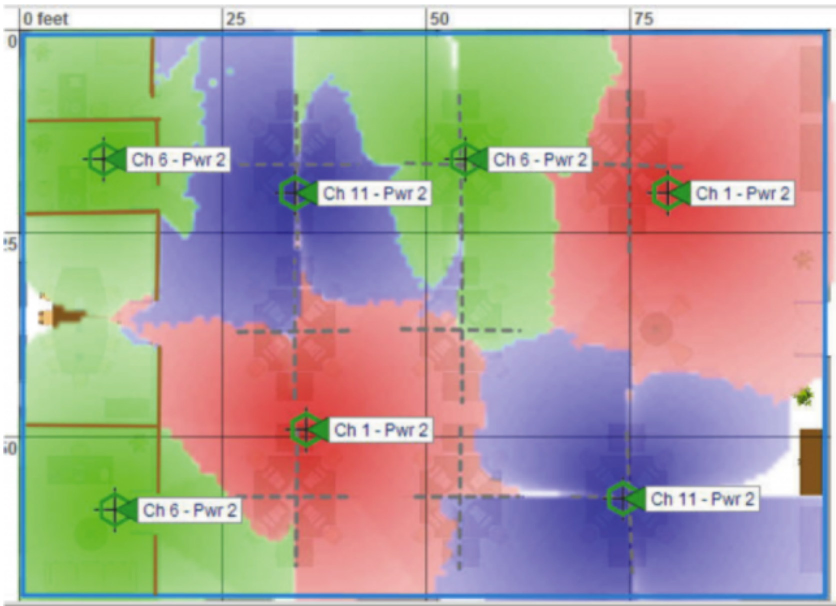
   (a) If the circles represent Ethernet hubs, what problem will arise?

   (b) If the circles represent Ethernet switches that implement the spanning tree protocol (the switch IDs are the numbers within the circles, assume all links have a distance of 1), what is the resulting spanning tree that is formed?

   (c) How does the tree change if switches 1 and 3 are removed?

8. A common recommendation for setting up Wi-Fi access points in a building is to give adjacent APs different channels as in the figure below. Another recommendation, which seems counter-intuitive at first, is to *reduce* the transmission

power of each AP for better performance. Explain why these recommendations make sense within the context of a building.



9. The operations a router perform are typically divided into a control plane and a data plane.

   (a) What is the difference betwen forwarding and routing? On which plane does each belong?

   (b) To which plane does the cross-bar (more generally called the interconnect) belong?

   (c) What is the purpose of a routing table? What plane does the routing table belong to?