1. What are the main problems of signal propagation? Why do radio waves not always follow a straight line? Why is reflection both useful and harmful?

Ans: Problems:

- Attenuation
- Scattering
- Diffraction
- Reflection
- Refraction.

As the radio signal always follows a straight line as light does but because of the presence of various structures it affects the path and can divert the waves from a straight line. Only in vacuum and without gravitational effects radio waves follow a straight line, Except for attenuation, all other types of problems in signal propagation affect the path of signal. Without the possibility of reflection radio reception in towns would be almost impossible. A line-of-sight almost never exists. However, reflection is the main reason for multipath propagation causing ISI. Without reflection radio reception in towns would be almost impossible. A line-of-sight almost never exists. However, reflection is the main reason for multipath propagation causing ISI

2. What are the means to mitigate narrowband interference? What is the complexity of the different solutions?

Ans: narrowband interference is characterized by relatively high interference power levels concentrated at specific frequencies, which usually originate from other mobile networks or from non-cellular sources. To mitigate narrowband interference following methods can be used:

- **Dynamic Frequency Selection:** Senders can sense the medium for interference and choose a frequency range with lower/no interference. HiperLAN2 and 802.11h use this scheme. Network operators may also this scheme to dynamically assign frequencies to cells in mobile systems. DFS includes a relatively low complexity.
- **Frequency hopping:** Slow frequency hopping (several symbols per frequency) may avoid frequencies with interference most of the time with a specific probability. This scheme is also employed in GSM. Furthermore, wireless systems can use this principle for multiplexing because it is completed in Bluetooth systems (still slow hopping as Bluetooth sends many symbols, indeed an entire packet, on the identical frequency). Fast hopping schemes transmit a logo over several frequencies, thus creating a selection spectrum. FH systems have medium complexity. Main topic is synchronisation of the devices.
- **Direct sequence spread spectrum:** Data is XORed with a chipping sequence leading to a variety signal. this can be exhausted all CDMA systems, but also in WLANs using, e.g., Barker sequences for spreading (e.g., 802.11b). The signal is covering an outsized spectrum and, thus, narrowband interference only destroys a tiny low fraction of the signal. This scheme is extremely powerful but requires more powerful receivers to extract the initial signal from the mixture of spread signals.

3. Name several methods for ISI mitigation. How does ISI depend on the carrier frequency, symbol rate, and movement of sender/receiver? What are the influences of ISI on TDM schemes?

Ans: ISI mitigation: large enough guard spaces between symbols/low symbol rate (used in OFDM), channel estimation/calculate the n strongest paths and adapt the receiver accordingly. Using higher frequencies reduces the results of multipath propagation and thus ISI waves more and more behave like light. the upper the symbol rate the stronger the ISI. If senders and/or receivers move fast the probabilities for ISI are higher because the placement of obstacles changes, hence the amount, magnitude, and timing of the secondary pulses – it's difficult to follow the signals and adjust the delays for recombination.
ISI lowers the bandwidth of a TDM scheme because the guard spaces require your time.

4. What are the main benefits of a spread spectrum system? How can spreading be achieved?

Ans: Spread spectrum techniques involve spreading the bandwidth needed to transmit data. Main benefits of a spread spectrum system is that they are very robust against interference, inherent security (if the spreading code is unknown, it is very difficult to tap the transmission), and can be used in the "background" of existing systems if the signal level is low enough.
Spreading can be achieved by XORing a bit with a chipping sequence or frequency hopping. Guard spaces are now the orthogonality of the chipping sequences or hopping patterns. The higher the orthogonality (well, that is not very mathematical, but intuitive), the lower the correlation of spread signals or the lower the collision probability of frequency hopping systems. DSSS systems typically use rake receivers that recombine signals travelling along different paths. Recombination results in a stronger signal compared to the strongest signal only.

5. What are the main reasons for using cellular systems? How is SDM typically realized and combined with FDM?

Ans: The main reason is the support of more users. Cellular systems reuse spectrum according to certain patterns. Each cell can support a maximum number of users. Using more cells thus results in a higher number of users per km². Additionally, using cells may support user localisation and location-based services. Smaller cells also allow for less transmission power, longer runtime for mobile systems, less delay between sender and receiver. Well, the downside is the tremendous amount of money needed to set-up an infrastructure with many cells.

Typically, each cell holds a certain number of frequency bands. Neighbouring cells are not allowed to use the same frequencies. According to certain patterns cellular systems reuse frequencies. If the system dynamically allocates frequencies depending on the current load, it can react upon sudden increase in traffic by borrowing capacity from other cells. However,

the “borrowed” frequency must then be blocked in neighbouring cells.

Open Ended Problem (Based on FHSS)

1. The school has a novel dress protocol. Each standard student can use colored dress on different days but should still be identifiable. How can the protocol follow hopping sequence for using the colors for the dress code: blue (B), Green (G), yellow (y) and orange (O).

Ans: BGYOBGY

	M	T	W	T	F
1	B	G	Y	O	B
2	G	Y	O	B	G
3	Y	O	B	G	Y
4	O	B	G	Y	O
5	B	G	Y	O	B
6	G	Y	O	B	G
7	Y	O	B	G	Y
8	O	B	G	Y	O
9	B	G	Y	O	B
10	G	Y	O	B	G
11	Y	O	B	G	Y
12	O	B	G	Y	O

For every day we will hop a colour in each standard and in each will also hop
So, on Monday 1st standard will wear B 2nd Y 3rd Y and so on
Also, on Tuesday 1st standard will wear G 2nd standard will wear Y 3rd O and so on.
The same goes for Wednesday to Friday.