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.

Except for attenuation all other effects can divert the waves from a straight line. Only in vacuum and without gravitational effects radio waves follow a straight line.

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: Several mechanisms exist to mitigate narrowband interference:

- **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 can also this scheme to dynamically assign frequencies to cells in mobile phone systems. DFS has a relatively low complexity.
- **Frequency hopping:** Slow frequency hopping (several symbols per frequency) may avoid frequencies with interference most of the time with a certain probability. This scheme may be used in GSM. Furthermore, wireless systems can use this principle for multiplexing as it is done in Bluetooth systems (still slow hopping as Bluetooth sends many symbols, indeed a whole packet, on the same frequency). Fast hopping schemes transmit a symbol over several frequencies, thus creating a spread spectrum. FH systems have medium complexity. Main topic is synchronisation of the devices.
- **Direct sequence spread spectrum:** Data is XORed with a chipping sequence resulting in a spread signal. This is done in all CDMA systems, but also in WLANs using, e.g., Barker sequences for spreading (e.g., 802.11b). The signal is spread over a large spectrum and, thus, narrowband interference only destroys a small fraction of the signal. This scheme is very powerful but requires more powerful receivers to extract the original 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 effects of multipath propagation and thus ISI waves more and more behave like light. The higher the symbol rate the stronger the ISI. If senders and/or receivers move fast the chances for ISI are higher because the location of obstacles

changes, hence the number, magnitude, and timing of the secondary pulses – it is difficult to follow the signals and adjust the delays for recombination.

ISI lowers the bandwidth of a TDM scheme as the guard spaces require some time.

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

Ans: Main benefits: very robust against interference, inherent security, basis for CDMA technologies, 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.

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.

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.