**Question 1:**
A LoRa device is currently achieving a data rate of 15.625 kbps within a 500 kHz channel. If this device were assigned a spreading factor of 7, what coding rate would be applied to this connection?
**Select one alternative:**

- 4/5
- 4/8
- 4/7 (Correct)
- 4/6
- None of these

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**Question 2:**
A FMCW radar operates with a frequency sweep from 25 GHz to 25.1 GHz over a period of 5 milliseconds. The radar signal is directed toward a stationary target located 150 meters away, which reflects the signal back to the radar receiver. What is the beat frequency, i.e., the frequency difference between the transmitted chirp and the received chirp, observed by the receiver? You can assume that the light travels at the speed of 3 × 10^8 m/s.
**Select one alternative:**

- 10 MHz
- 20 kHz
- 15 kHz
- 10 kHz (Correct)
- None of these

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**Question 3:**
For downlink, NOMA combines
**Select one alternative:**

- Superposition coding at the base station (BS) as well as at the user device.
- Successive interference cancellation (SIC) at the user device as well as at the base station (BS).

- Superposition coding at the base station (BS) and successive interference cancellation (SIC) decoding at the user device. (Correct)
- Superposition coding at the user device and successive interference cancellation (SIC) decoding at the base station (BS).
- None of these.

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**Question 4:**
BLE supports a simple frequency hopping algorithm, a.k.a. Algorithm #1, that hops a fixed number of channels instead of selecting a random hop as used in BT Classic. Given that data channels range from 0–36, BLE uses the following equation to derive the next channel:

fk+1=(fk+h)mod 37f_{k+1} = (f_k + h) \mod 37fk+1=(fk+h)mod37

where hhh (hop increment) is a fixed value negotiated during connection setup.

Now imagine a modified version of the Bluetooth hopping algorithm #1 that introduces two variables, h1h_1h1 and h2h_2h2, during the connection setup process. This algorithm begins with h1h_1h1 and alternates between h1h_1h1 and h2h_2h2 for channel selection. In other words, the first hop is determined using h=h1h = h_1h=h1, the second using h=h2h = h_2h=h2, the third using h=h1h = h_1h=h1, and so on. If the initial channel selected is 36 and the negotiated values are h1=5h_1 = 5h1=5 and h2=6h_2 = 6h2=6, how many hops will it take before the algorithm selects channel 26?
**Select one alternative:**

- 5 hops (Correct)
- 7 hops
- 4 hops
- 6 hops
- 2 hops

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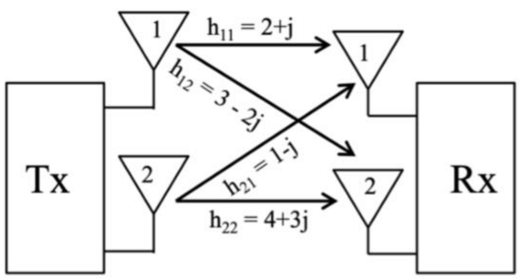
**Question 5:**
In a scenario where a Bluetooth (BT) device is operating in an area densely populated with WiFi networks, the BT device experiences interference in 65 out of its 79 available channels. If the device employs Adaptive Frequency Hopping (AFH), how many channels

will the BT device use for its frequency hopping sequence?
Enter a number between 2 and 79: **20**

**Question 6:**

The figure illustrates the channel CSI coefficients for the four wireless channels connecting the two transmitting antennas and two receiving antennas. When a signal is transmitted from the transmitter and received by the receiver, the phase change it experiences would be most pronounced when it is




**Select one alternative:**

- Transmitted by Antenna 1 and received by Antenna 2
- Transmitted by Antenna 2 and received by Antenna 2
- Transmitted by Antenna 2 and received by Antenna 1 (Correct)
- Transmitted by Antenna 1 and received by Antenna 1

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**Question 7:**

Imagine a chirp modulation system that employs the following frequency modulation formula: f(t)=f0·e^(kt), where f0 represents the initial frequency of the chirp, k is the rate of exponential change in transmission frequency, t is time in milliseconds, and e is the base of the natural logarithm.

Now, consider a scenario where you are using this chirp modulation with a 1 MHz channel centered at 20 MHz for communication. What value of k would ensure that the chirp sweeps the entire channel within a 1 ms timeframe? Show your calculations.

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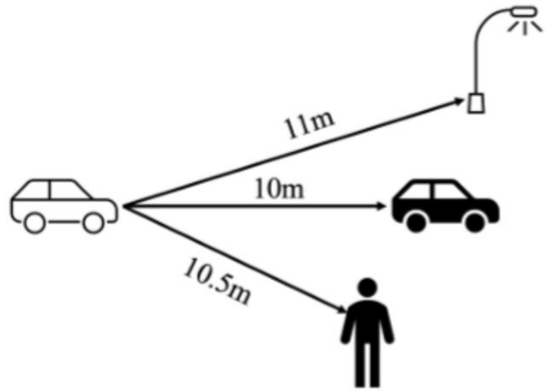
**Question 8:**




Autonomous vehicles must unequivocally detect all objects in their proximity to ensure safe operation. The diagram illustrates three distinct objects positioned in front of a car, which necessitates their detection using an FMCW radar. What minimum sweep bandwidth would be required for the radar to unambiguously detect all three objects? You can assume that light travels at the speed of 3×1083 \times 10^83×108 m/s.

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**Question 9:**

Consider a WiFi network that employs a CSMA/CA protocol, operating as follows: After experiencing the nnn-th consecutive collision, a host selects a random number, kkk, from the set {0,1,...,2n−1}\{0, 1, \dots, 2^n-1\}{0,1,...,2n−1} and refrains from transmitting for kkk slots. For instance, when the first collision occurs, k is chosen from {0,1}\{0, 1\}{0,1}, and after the second successive collision, kkk is selected from {0,1,2,3}\{0, 1, 2, 3\}{0,1,2,3}.

Now, let's assume that two devices, labelled as A and B, have already encountered three consecutive collisions. What is the probability that device A will successfully transmit a frame before device B in their next transmission attempt?

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**Question 10:**

An ambulance is moving towards an observer at a speed of 123.48 km/h while sounding a siren, which emits sound waves at a frequency of 1000 Hz. The speed of sound is 343 meters per second. Calculate the observed frequency of the siren when the ambulance is approaching the observer and when it is moving away from the observer.

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**Question 11:**

When a source emitting sound waves approaches an observer on the ground, a frequency shift of 200 Hz is observed. If the same source approaches an underwater observer at the same speed, what would be the observed frequency shift, considering that sound travels four times faster in water than in the air?

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**Question 12:**

Sound-based ranging, such as ultrasonic sensors, and radio wave-based radar are two distinct technologies used for measuring distances. Ultrasonic sensors emit sound waves, while radar relies on radio waves. Explain why sound-based ranging can provide high-precision distance measurements, compared to radar.

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**Question 13:**

The figure depicts a scenario with location coordinates on a square grid, where four mobile devices are being served by a 5G base station using Non-Orthogonal Multiple Access (NOMA). NOMA utilizes Successive Interference Cancellation (SIC) to concurrently serve two or more users by aggregating their individual signals into a unified signal. It's presumed that the wireless channel quality is primarily influenced by the distance between the base station and the mobile devices.

Is it more efficient to partition the four mobile devices into multiple groups and blend the signals within each group, as opposed to amalgamating all four signals into one? If so, how should the base station organise the mobile devices into groups to ensure that the combined signals in each group are effectively leveraged by the group members for signal decoding?

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**Question 14:**

| Path | Delay in μsec | Attenuation factor |
|---|---|---|
| Path 1 | 10 | 0.8 |
| Path 2 | 30 | 0.5 |
| Path 3 | 50 | 0.3 |

| Path | Delay in μsec | Attenuation factor |
|---|---|---|
| Path 4 | 60 | 0.2 |

In a wireless communication system, a transmitted signal traverses a multipath channel characterized by a significant delay spread. The transmitted signal takes the form of a pulse with a duration of 80 microseconds. Within this channel, four dominant paths exist, each distinguished by varying time delays and attenuation levels, as outlined in the table. In this context, the attenuation factor serves as a measure of the remaining signal power after attenuation, expressed as a fraction.

Calculate the following: a. The total delay spread in the channel. **[1 mark]**
b. The recommended minimum guard interval to avoid ISI. **[1 mark]**
c. What symbol rate, in terms of symbols per second, can be attained with the suggested guard interval in effect? **[2 marks]**
d. If a guard interval of 70 microseconds was chosen, what would be the extent of ISI, in microseconds, that could be encountered in each symbol? **[1 mark]**

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**Question 15:**

Bluetooth Classic primarily operates in a half-duplex mode where devices take turns transmitting and receiving data during time slots. However, achieving full-duplex communication, where both the master and slave can transmit and receive simultaneously, is a complex task. One approach to enable full-duplex communication in Bluetooth Classic is through Frequency Division Multiplexing (FDM).

a. Discuss how FDM could be implemented in Bluetooth Classic to enable simultaneous transmission and reception by both master and slave devices. **[1 mark]**
b. Explain any potential impact on the co-existence of Bluetooth and WiFi when FDM is used instead of TDM. Provide reasons for the anticipated impact and describe how it may occur. **[1 mark]**
c. Propose scenarios or use cases where the adoption of full-duplex communication in Bluetooth Classic through FDM would offer significant advantages. **[1 mark]**