

**First Name** :..... **Last Name:** ..... **G:**.....

We consider a digital transmission system intended to send a video image over a communication channel.

A source generates images of **400 × 600 pixels**, with **16 intensity levels**. The system transmits **25 images per second**.

The transmission channel has the following characteristics:

- Bandwidth: **3 MHz** , Signal-to-noise ratio: **30 dB** , Propagation speed: **2 × 10<sup>8</sup> m/s**

**1. How many bits are required to encode one pixel ?**

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**2. Calculate the bit rate generated by the source (in Mbps).**

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**3. Calculate the maximum channel capacity using Shannon's formula.**

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**4. Can the channel transmit this signal without loss? Justify your answer.**

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**5. Calculate the duration of one bit if the transmission rate is equal to the maximum capacity.**

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# Correction

Image size: 400 × 600 pixels

Intensity levels: 16

Frame rate: 25 images/s

Bandwidth: 3 MHz

SNR: 30 dB

Propagation speed:  $2 \times 10^8$  m/s

## 1. How many bits are required to encode one pixel? [1 pt]

Number of bits per pixel =  $\log_2(16) = 4$  bits

**Answer: 4 bits**

## 2. Calculate the bit rate generated by the source (in Mbps). [1.5 pts]

Pixels per image =  $400 \times 600 = 240,000$  pixels

Bits per image =  $240,000 \times 4 = 960,000$  bits

Bit rate =  $960,000 \times 25 = 24,000,000$  bps

**Answer: 24 Mbps**

## 3. Calculate the maximum channel capacity using Shannon's formula. [1.5 pts]

SNR (linear) =  $10^{(30/10)} = 1000$

$C = B \log_2(1 + \text{SNR})$

$C = 3 \times 10^6 \times \log_2(1001)$

$\log_2(1001) \approx 9.97$

$C \approx 3 \times 10^6 \times 9.97 \approx 29.9$  Mbps

**Answer:  $\approx 30$  Mbps**

## 4. Can the channel transmit this signal without loss? Justify. [1 pt]

Source rate = 24 Mbps

Channel capacity  $\approx 30$  Mbps

Since  $24 \text{ Mbps} < 30 \text{ Mbps}$ , the channel can transmit the signal without loss.

**Answer: Yes**

## 5. Calculate the duration of one bit if the transmission rate equals the maximum capacity. [1 pt]

Bit duration  $T = 1 / C$

$T = 1 / (30 \times 10^6)$

$T \approx 3.33 \times 10^{-8}$  s

**Answer:  $\approx 33$  ns**