Department of Electrical Engineering

Final-Assignment

Date: 22/06/2020

Course Details

Course Title:	Advance Computer Networks	**Module:**	3rd
Instructor:	Naeem Ahmad Jan	**Total Marks:**	50

Student Details

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Q1.	(a)	The Advanced Mobile Phone System (AMPS) uses two bands. The first band, 800 to 850 MHz, is used for sending; and 860 to 910 MHz is used for receiving. Each user has a bandwidth of 60 KHz in each direction. The 3-KHz voice is modulated using FM, creating 60 KHz of modulated signal. How many people can use their cellular phones simultaneously?	Marks 6
	(b)	Express a period of 1 ms in microseconds, and express the corresponding frequency in kilohertz and A sine wave is offset one-fourth of a cycle with respect to time zero. What is its phase in degrees and radians?	Marks 4
Q2.	(a)	Explain wave division multiplexing and it’s applications?	Marks 5
	(b)	Nine channels, each with a 99-KHz bandwidth, are to be multiplexed together. What is the minimum bandwidth of the link if there is a need for a guard band of 13 KHz between the channels to prevent interference?	Marks 5
Q3.	(a)	A constellation diagram consists of sixteen equally spaced points on a circle. If the bit rate is 4800 bps, what is the baud rate?	Marks 5
	(b)	Given a bandwidth of 7000 Hz for a 128-PSK signal, what are the baud rate and bit rate?	Marks 5
Q4.		Explain wireless propagation methods & wireless transmission waves? We need to send 265kbps over a noiseless channel with a bandwidth of 20KHz. How many signal levels do we need?	Marks 10
Q5.		What is the difference between Shannon & Nyquist Capacity? Consider a noiseless channel with a bandwidth of 3000 Hz transmitting a signal with 4 signal levels, the maximum bit rate can be ?	Marks 10

Q1
(a) Each band is 50 MHz

If we divide 50 MHz into 60 KHz,

Note: Mega = 10^6 , Kilo = 10^3

= 50*10^6 / 60*10^3

we get 833.33.

In reality, the band is divided into 832 channels.
42 of these are used for control which means only 790 channels are available for cellular phone users.

Q1
(b)
Express a period of 1 ms in microseconds, and express the corresponding frequency in kilohertz and A sine wave is offset one-fourth of a cycle with respect to time zero. What is its phase in degrees and radians?

Solution:

1 ms = 1 *10^{-3} s

We can also write

= 10^{-3} * 10^{3} * 10^{-3} s

= 10^{3} μs

1 ms = $\mathbf{10^{3}}$ μs

As 1 ms = 10^{-3} s

As f =1 / t

so

f = 1 / 10^{-3} Hz

f = 10^{3} Hz

f= 1000 Hz

f = 1 KHz

a sin wave is offset one forth of a cycle with respect to time zero its phase in degree is :

As Complete cycle is 360°

Therefore ¼ cycle is

¼ * 360 = 90°

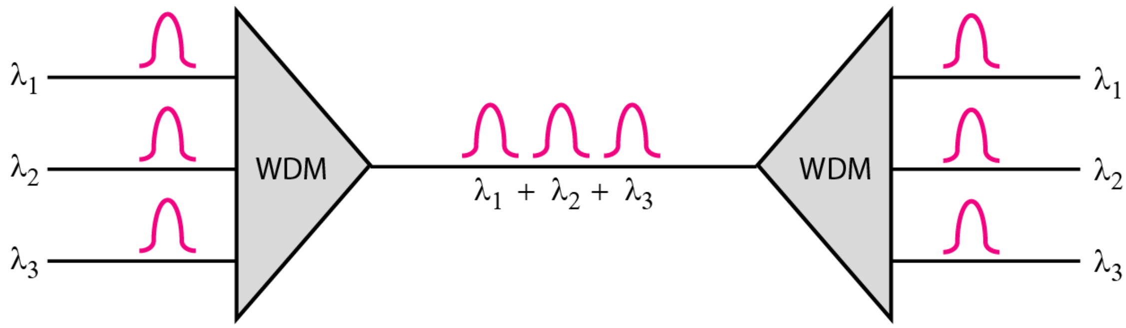
a sin wave is offset one forth of a cycle with respect to time zero its phase in radian is :

90° * $\frac{2\pi}{360}$ = $\frac{\pi}{2}$ = 1.5708 radian

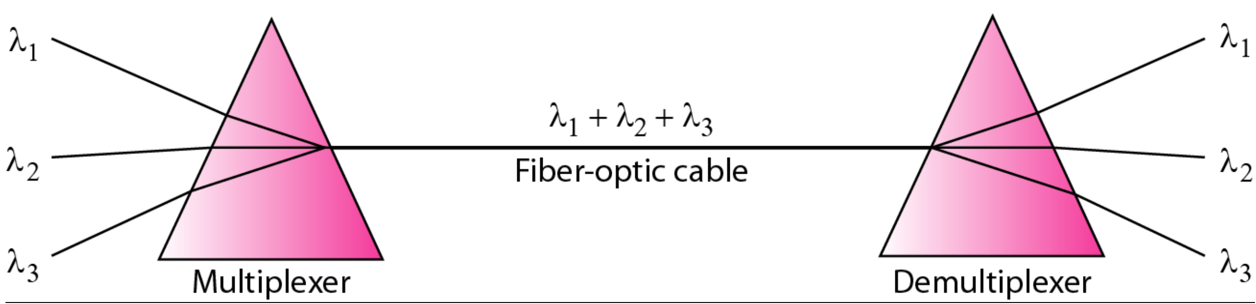
Q2. (a) Explain wave division multiplexing and it's applications? Marks 5

ANS: Wave-Division Multiplexing:

- Use light signals transmitted through fiber-optic channels.
- Very narrow bands of light are combined from several sources to make a wider band of light.
- A prism is used to bend the light beams based on the angle of incidence and frequency.
- Receiver's DEMUX separates signals.
- WDM is an analog multiplexing technique to combine optical signals.



Prisms in WDM multiplexing and demultiplexing :

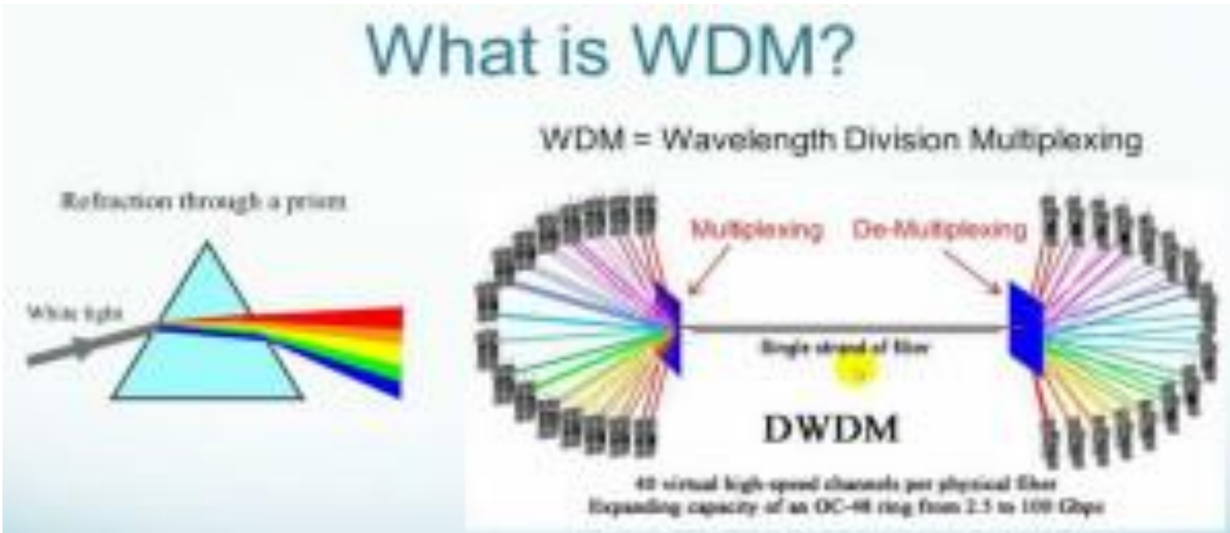


WDM Applications:

- Application: SONET network
  - ➡ Multiple optical fiber lines are muxed/demuxed
- DWDM (dense WDM) allows muxing of large numbers of channels by spacing channels closer to one another to achieve greater efficiency

EXPLINATIONS:

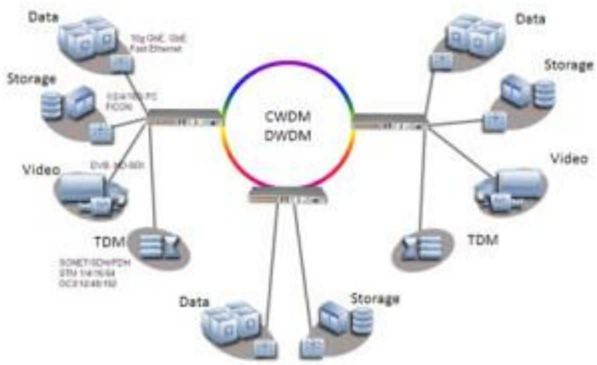
Wavelength division multiplexing (WDM) is a technique modulating various data streams, i.e. optical carrier signals of varying wavelengths in terms of colours of laser light onto a single optical fiber. Wavelength division multiplexing WDM is similar to frequency-division multiplexing (FDM) but referencing the wavelength of light to the frequency of light. WDM is done in the IR portion of the electromagnetic spectrum instead of taking place at radio frequencies (RF). Each IR channel carries several RF signals combined with frequency-division multiplexing (FDM) or time-division multiplexing (TDM). Each multiplexed infrared channel is separated or demultiplexed into the original signals at final point. Data in different formats and at different speeds can be transmitted simultaneously on a single fiber by using FDM or TDM in each IR channel in combination with WDM. It allows network capacity to be gradually and cost effectively increased.



Uses of Wavelength Division Multiplexing:

- WDM multiply the effective bandwidth of a fiber optic communications system
- A fiber optic repeater device called the erbium amplifier can make WDM a cost-effective and it is the long-term solution.
- This reduces the cost and increases the capacity of the cable to carry data.
- Wavelength Division Multiplexing (WDM) uses multiple wavelengths (colors of light) to transport signals over a single fiber.
- It uses light of different colours to create a number of signal paths.
- It uses Optical prisms to separate the different colours at the receiving end and optical prisms does not require power source.
- These systems used temperature stabilized lasers to provide the needed channels count.

WDM systems are divided according to wavelengths – WDM (CWDM) and dense WDM (DWDM). CWDM operates with 8 channels (i.e., 8 fiber optic cables) which is called as the “C-Band” or “erbium window” with wavelengths about 1550 nm (nanometers or billionths of a meter, i.e. 1550 x 10-9 meters). DWDM also operates in the C-Band but with 40 channels at 100 GHz spacing or 80 channels at 50 GHz spacing. Mostly WDM systems are operated on single-mode fiber optical cableshaving a core diameter of 9 µm. Wavelength division multiplexing is a technique where optical signals with different wavelengths are combined, transmitted and separated.



CWDM and DWDM

Each colour obtained from the prism is capable of carrying 10Gbps to 40Gbps. A 16 colour solution, based on 10Gbps per colour, yields a total network capacity of 160Gbps. Each colour can come off the network at multiple nodes and all these nodes are terminated in one or more data centres by allowing for resilient routing between circuits and also for 'on ramp' services.

Q2(b)

Nine channels, each with a 99-KHz bandwidth, are to be multiplexed together. What is the minimum bandwidth of the link if there is a need for a guard band of 13 KHz between the channels to prevent interference? Marks 5

Solution:

9 Number of Channels we have,
For each we have 99Khz Bandwith
As for 9 Channels we require 8 Guard Band & Guard band =13Khz

So,

For Nine channels, we need at Eight guard bands. This means that the required bandwidth is at least

$$9 \times 99 + 8 \times 13 = 995kHz..$$

Q3. (a) A constellation diagram consists of sixteen equally spaced points on a circle. If the bit rate is 4800 bps, what is the baud rate? Marks 5

Solution:

4 bits are transmitted with each signal i-e 16 = 2^4 and bit rate is 4800 bps given in question
As Baud rate = bit rate/bits per signal
Therefore,
Baud rate = 4800/4 = 1200 Baud.

(b) Given a bandwidth of 7000 Hz for a 128-PSK signal, what are the baud rate and bit rate? Marks 5

Solution:

For PSK the baud rate is the same as the bandwidth, which means the baud rate is 7000, but in 128 – PSK the bit rate is 7 times the baud rate

Bit rate = 7 x 7000
=49000 bps

Q4. (a) Explain wireless propagation methods & wireless transmission waves? We need to send 265kbps over a noiseless channel with a bandwidth of 20KHz. How many signal levels do we need? Marks 10

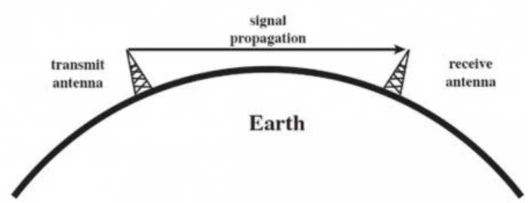
ANS: Wireless Propagation Methods:

- Ground – radio waves travel through lowest portion of atmosphere, hugging the Earth
- Sky – higher-frequency radio waves radiate upward into ionosphere and then reflect back to Earth
- Line-of-sight – high-frequency signals transmitted in straight lines directly from antenna to antenna

In ELF (Extremely low frequency) and VLF (Very low frequency) frequency bands, the Earth, and the ionosphere act as a wave-guide for electromagnetic wave propagation. In these frequency ranges, communication signals practically propagate around the world. The channel bandwidths are small. Therefore, the information is transmitted through these channels has slow speed and confined to digital transmission.

The line of Sight (LOS) Propagation:

- Among the modes of propagation, this line-of-sight propagation is the one, which we would have commonly noticed. In the line-of-sight communication, as the name implies, the wave travels a minimum distance of sight. Which means it travels to the distance up to which a naked eye can see. Then we need to employ an amplifier cum transmitter here to amplify the signal and transmit again.



Line-of-sight (LOS) propagation (above 30 MHz)

- The line-of-sight propagation will not be smooth if there occurs any obstacle in its transmission path. As the signal can travel only to lesser distances in this mode, this transmission is used for infrared or microwave transmissions.

Ground Wave Propagation:

- Ground wave propagation of the wave follows the contour of the earth. Such a wave is called a direct wave. The wave sometimes bends due to the Earth's magnetic field and gets reflected the receiver. Such a wave can be termed as a reflected wave. The following figure depicts ground wave propagation.

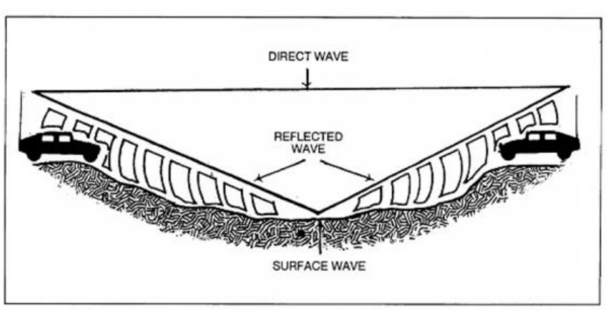
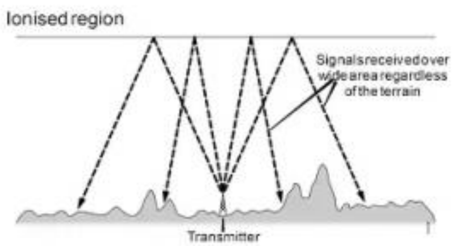


Figure Components of ground wave.

- The wave then propagates through the Earth's atmosphere is known as a ground wave. The direct wave and reflected wave together contribute the signal at the receiver station. When the wave finally reaches the receiver, the lags are cancelled out. In addition, the signal is filtered to avoid distortion and amplified for clear output.

SkyWave Propagation:

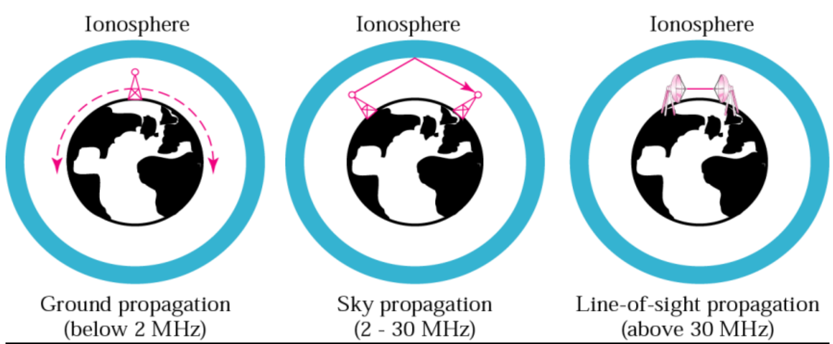
- Skywave propagation is preferred when the wave has to travel a longer distance. Here the wave is projected onto the sky and it is again reflected back to the earth.



- The sky wave propagation is well depicted in the above picture. Here the waves are shown to be transmitted from one place and where it is received by many receivers. Hence, it is an example of broadcasting.

- The waves, which are transmitted from the transmitter antenna, are reflected from the ionosphere. It consists of several layers of charged particles ranging in altitude from 30-250 miles above the surface of the earth. Such travel of the wave from the transmitter to the ionosphere and from there to the receiver on Earth is known as Sky Wave Propagation. The ionosphere is the ionized layer around the Earth's atmosphere, which is suitable for skywave propagation.

Propagation Methods:

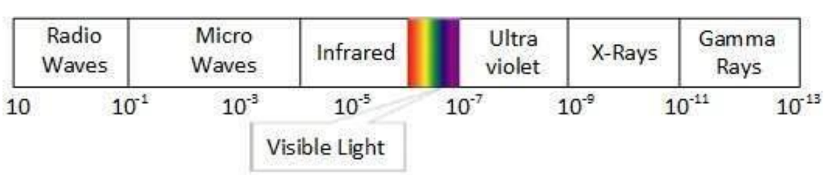


Wireless transmission waves:

Wireless transmission is a form of unguided media. Wireless communication involves no physical link established between two or more devices, communicating wirelessly. Wireless signals are spread over in the air and are received and interpreted by appropriate antennas.

When an antenna is attached to electrical circuit of a computer or wireless device, it converts the digital data into wireless signals and spread all over within its frequency range. The receptor on the other end receives these signals and converts them back to digital data.

A little part of electromagnetic spectrum can be used for wireless transmission.



Radio Wave Transmission:

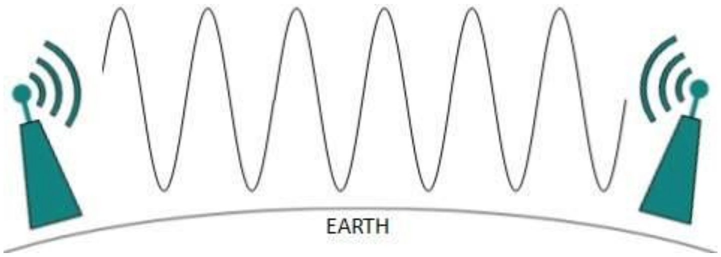
- Frequency ranges: 3 KHz to 1 GHz
- Omnidirectional
- Susceptible to interference by other antennas using same frequency or band

- Ideal for long-distance broadcasting
- May penetrate walls
- Apps: AM and FM radio, TV, maritime radio, cordless phones, paging

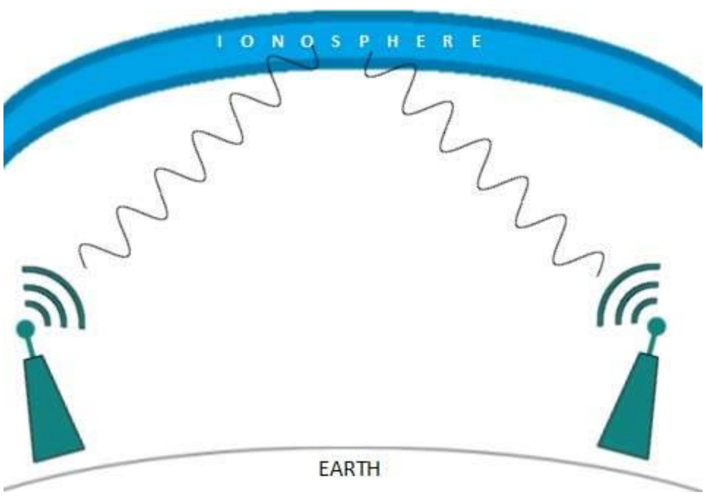
Radio frequency is easier to generate and because of its large wavelength it can penetrate through walls and structures alike.Radio waves can have wavelength from 1 mm – 100,000 km and have frequency ranging from 3 Hz (Extremely Low Frequency) to 300 GHz (Extremely High Frequency). Radio frequencies are sub-divided into six bands.

Radio waves at lower frequencies can travel through walls whereas higher RF can travel in straight line and bounce back.The power of low frequency waves decreases sharply as they cover long distance. High frequency radio waves have more power.

Lower frequencies such as VLF, LF, MF bands can travel on the ground up to 1000 kilometers, over the earth's surface.



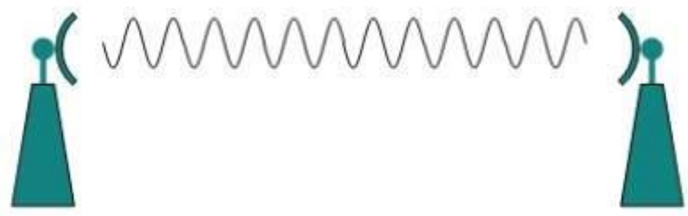
Radio waves of high frequencies are prone to be absorbed by rain and other obstacles. They use Ionosphere of earth atmosphere. High frequency radio waves such as HF and VHF bands are spread upwards. When they reach Ionosphere, they are refracted back to the earth.



Microwave Transmission:

Electromagnetic waves above 100 MHz tend to travel in a straight line and signals over them can be sent by beaming those waves towards one particular station. Because Microwaves travels in straight lines, both sender and receiver must be aligned to be strictly in line-of-sight.

Microwaves can have wavelength ranging from 1 mm – 1 meter and frequency ranging from 300 MHz to 300 GHz.



Microwave antennas concentrate the waves making a beam of it. As shown in picture above, multiple antennas can be aligned to reach farther. Microwaves have higher frequencies and do not penetrate wall like obstacles.

Microwave transmission depends highly upon the weather conditions and the frequency it is using.

- Frequencies between 1 and 300 GHz
- Unidirectional
- Narrow focus requires sending and receiving antennas to be aligned
- Issues:
    - Line-of-sight (curvature of the Earth; obstacles)
    - Cannot penetrate walls

Applications:

- Unicasting – one-to-one communication between sender and receiver
    - Cellular phones
    - Satellite networks
    - Wireless LANs

Infrared Transmission:

Infrared wave lies in between visible light spectrum and microwaves. It has wavelength of 700-nm to 1-mm and frequency ranges from 300-GHz to 430-THz.

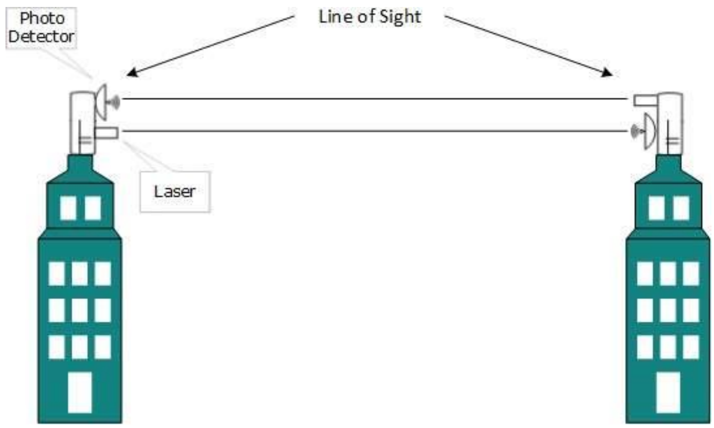
Infrared wave is used for very short range communication purposes such as television and it's remote. Infrared travels in a straight line hence it is directional by nature. Because of high frequency range, Infrared cannot cross wall-like obstacles.

- Frequencies between 300 GHz and 400 THz
- Short-range communication
- High frequencies cannot penetrate walls
- Requires line-of-sight propagation
- Adv: prevents interference between systems in adjacent rooms
- Disadv: cannot use for long-range communication or outside a building due to sun's rays.

Light Transmission:

Highest most electromagnetic spectrum which can be used for data transmission is light or optical signaling. This is achieved by means of LASER.

Because of frequency light uses, it tends to travel strictly in straight line.Hence the sender and receiver must be in the line-of-sight. Because laser transmission is unidirectional, at both ends of communication the laser and the photo-detector needs to be installed. Laser beam is generally 1mm wide hence it is a work of precision to align two far receptors each pointing to lasers source.



Laser works as Tx (transmitter) and photo-detectors works as Rx (receiver).

Lasers cannot penetrate obstacles such as walls, rain, and thick fog. Additionally, laser beam is distorted by wind, atmosphere temperature, or variation in temperature in the path.

Laser is safe for data transmission as it is very difficult to tap 1mm wide laser without interrupting the communication channel.

<u>Q4 Problem part:</u>

We can use nyquist formula

Nmax = 2 * B * Log2L

265000 = 2 * 20000 * Log2L

Log2L = 6.625 L = 26.625 = 98.7 levels

Q5.	What is the difference between Shannon & Nyquist Capacity? Consider a noiseless channel with a bandwidth of 3000 Hz transmitting a signal with 4 signal levels, the maximum bit rate can be ?	Marks 10

<u>Ans:</u>

Nyquist rate tells you in order to reconstruct a baseband signal with bandwidth W from sampling, you need to sample the signal at 2W rate. A good intuition is to think about a sine wave. This theory is applying to a signal without noise.

On the contrary, Shannon's Capacity theorem needs to specify noise distribution, Under Gaussian noise,

C=1/2log2(1+P/N) bits per sample,
where P and N are power of signal and noise respectively.
Combine with Nyquist rate and calculate the noise power properly, you get channel capacity of bandwidth W to be,
C=Wlog2(1+P/N0W) bits per second,
where N0 is 2 times of Gaussian noise spectral density.

Noiseless Channel: Nyquist Bit Rate :

For a noiseless channel, the Nyquist bit rate formula defines the theoretical maximum bit rate

$r = 2 * B * \log2 L$

In this formula, B is the bandwidth of the channel, L is the number of signal levels used to represent data, and r is the bit rate in bits per second.

According to the formula, we might think that, given a specific bandwidth, we can have any bit rate we want by increasing the number of signal levels.

Although the idea is theoretically correct, practically there is a limit. When we increase the number of signal levels, we impose a burden on the receiver. If the number of levels in a signal is just 2, the receiver can easily distinguish between a 0 and a 1. If the level of a signal is 64, the receiver must be very sophisticated to distinguish between 64 different levels. In other words, increasing the levels of a signal reduces the reliability of the system.

Noisy Channel : Shannon Capacity:

In reality, we cannot have a noiseless channel; the channel is always noisy. In 1944, Cloude-shannon introduced a formula called the shannon capacity, to determine the theoretical

highest data rate for a noisy Channel.

$C = B \times \log2(1 + SNR)$

In this formula B is the bandwidth of the channel, SNR is the signal-to noise ratio, and C is the capacity of the channel in bits per second. Note that the Shannon formula there is no indication of the signal level, which means that no matter how many levels we have. We cannot achieve a data rate higher than the capacity of the channel. in other words, the formula defines a characteristic of the channel, not the method of transmission.

In conclusion, we can say for channel capacity that the Shannon capacity gives us the' upper limit while the Nyquist formula tells us how many signal levels we need.

Q5 Problem part:

As Bit Rate = 2 * Bandwidth * log2 L

Bit rate = 2 3000 log2 4

Bit rate = 12000 bps

END