1. (10 points) What are the five layers in Internet Protocol (IP)? Describe the major functions including the objective of each layer in details.

**Answer:**

**Application layer:** Supports network applications.
- FTP, SMTP, HTTP DASH...

**Transport layer:** Processes data transfer.
- TCP, UDP

**Network layer:** Routing of datagram from source to destination.
- IP, routing protocols.

**Link layer** Data is transferred between neighboring network elements.
- PPP, Ethernet.

**Physical layer:** Bits "on the wire" during transmission.

**Grading:**
2 points for each layer and it’s functions and protocol.
-1 if a layer is missing.
-1 if a major functions is missing or not correct.

2. (10 points) Describe the process of closing a TCP connection using a time-space graph. Assume the server “Finish” request is lost. Describe what is going to happen.

**Answer:**

![TCP Connection Diagram](image)

If the server "Finish" request is lost, the server goes into LAST_ACK mode waiting for the ACK from...
the client. After some time, the server sends another "Finish" request but does not receive an ACK from the client.

Grading:
6 points for the time-space graph
-2 if a diagram is not provided.
-1 if any request and/or response is missing.
-2 if no description and/or diagram if not provided of what will happen if the server "Finish" request is lost or incorrect.

3. (10 points) There are 120 computers to be connected to each other. How many connections required if they are connected to each other with a direct link? Given a set of 5X5 switches (5 inputs and 5 outputs), what is the minimum number of switches needed to provide connectivity between any two computers? Please show how these switches are connected. Please note that we typically put one input port together with one output port such that we can send and receive on the same port. A 5X5 switch is a switch with 5 ports.

Answer:
1) \( \binom{120}{2} = \frac{120 \times 119}{2!} = 7,140 \)
2) For a 5x5 switch, we mean that the switch has 5 ports that can both be inputs and outputs. Thus we can connect them in series.

Assume there are \( x \) intermediate switches, thus we have: \( 4 \times 2 + 3x \geq 120 \)
Then we have \( x \geq 37.3 \)
Hence we need at least \( 2 + 38 = 40 \) switches
(This is not the only structure; some other structure can also be build but the least switches needed is
4. (10 points) What are twisted pair, coaxial cable and fiber optic cable? Please also describe the advantages and dis-advantages of each to be used as communication media. What are the types of networks that each one of them used the most?

Answer:

- **Twisted pair** Two conductors of a single circuit, often insulated copper wires.
  - **Advantage** Cheaper and easier to install than fiber optics.
  - **Disadvantage** Lower bandwidth and covers shorter distances than Fiber optics.

- **Coaxial cable** It’s made up of a round copper wire and three layer of insulations.
  - Bidirectional
  - **Advantage** Cheapest easiest to install.
  - **Disadvantage** Lowest bandwidth and can only cover short distances.

- **Fiber optics** It’s a glass fiber carrying light pulses with high speeds and frequencies.
  - Used to support long distance transmission between cities and countries.
  - Also widely used in data centers due to it’s high speed and bandwidth.
  - **Advantage** Very high frequencies, speeds and bandwidth and covers long distances.
  - **Disadvantage** Very expensive and difficult to install since it’s fragile, thinner and can easily break.

Grading:
3 points for twisted pairs and 3 points for coaxial cables.
4 Points for fiber optics.
-3 if any part of the question is missing.
-1 if network use is not given for each physical media.
-1 if advantage or disadvantage for each is not given.
-1 if description of the physical medias is wrong for each.