Networking

Networking Fundamentals

1.3.1 - Copper Cables

What are the different types of copper cables and their standards?

Overview
The student will be able to summarize the types of cables and connectors and explain which is the appropriate type for a solution

Grade Level(s)
10, 11, 12

Cyber Connections
- **Threats & Vulnerabilities**
- **Networks & Internet**
- **Hardware & Software**

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CompTIA N10-008 Network+ Objectives

Objective 1.3

- Summarize the types of cables and connectors and explain which is the appropriate type for a solution
  - Copper
    - Twisted pair
      - Cat 5
      - Cat 5e
      - Cat 6
      - Cat 6a
      - Cat 7
      - Cat 8
    - Coaxial/RG-6
    - Twinaxial
    - Termination standards
      - TIA/EIA-568A
      - TIA/EIA-568B
  - Ethernet Standards
    - Copper
      - 10BASE-T
      - 100BASE-TX
      - 1000BASE-T
   - 10GBASE-T
      - 40GBASE-T

Fiber-Optic Cables

Twisted Pairs

One of the most common copper cables is the *twisted pair* cable, also known as ethernet cable. There are 8 colored copper cables inside that are twisted to help reject outside electromagnetic interference. The 8 cables consist of four-color pairs, each having a solid color wire and a striped wire (with white). The four colors are green, blue, brown, and orange. When used with networking, these twisted pair cables commonly use the RJ45 connectors.

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RJ45 Connector
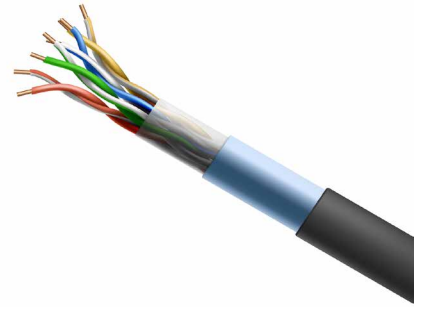
Inside of twisted pair cable

A typical twisted pair cable is either going to have a shield or not. A twisted pair with a shield is known as a STP (shielded twisted pair) while an unshielded is a UTP (unshielded twisted pair). The shields in the STP wires are there to also help against electromagnetic interference, they are often a thin piece of foil or a wire that is braided.

There are many different ethernet cables categories with different standards. Below is a chart that compares the different cables and some of their specs.

Cable Category	Shielding	Frequency	Maximum Length	Transmission Speed
Cat 5	No	100 MHz	100 Meters	0.1 Gbps
Cat 5e	No	100 MHz	100 Meters	1 Gbps
Cat 6	Sometimes	250 MHz	100 Meters	1 Gbps
Cat 6a	Sometimes	500 MHz	100 Meters	10 Gbps
Cat 7	Yes	600 MHz	100 Meters	10 Gbps
Cat 8	Yes	2 GHz	30 Meters	40 Gbps

Twisted Pair Termination Standards

Remember that all the Cat 5 – Cat 8 cables above have 8 wires inside of them. There are different wiring standards for how the 8 wires align in the RJ45 connector. The two most popular are the *T568A* and *T568B* wired standards, or TIA/EIA-568A and TIA/EIA-568B.

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Teacher Notes:
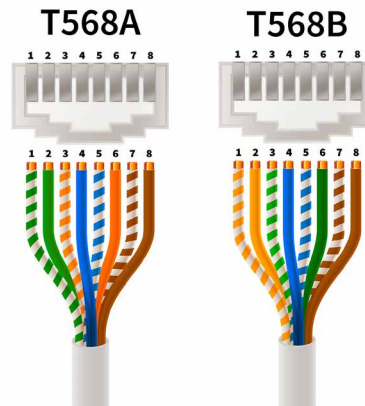
T568A   **T568B**

Wiring standards for T568A and T568B

From the image above, you should be able to notice that the color orders are the following:

Pins	T568A	T568A (abbreviated)	T568B	T568B (abbreviated)
Pin 1	Striped Green	g	Striped Orange	o
Pin 2	Solid Green	G	Solid Orange	O
Pin 3	Striped Orange	o	Striped Green	g
Pin 4	Solid Blue	B	Solid Blue	B
Pin 5	Striped Blue	b	Striped Blue	b
Pin 6	Solid Orange	O	Solid Green	G
Pin 7	Striped Brown	b	Striped Brown	b
Pin 8	Solid Brown	B	Solid Brown	B

Notice: A capital abbreviation represents a solid color while a lowercase represents a striped color

An interesting (and important) note about the wires is that only 4 pins are used for data transmission. In an RJ45 connectors, and the layouts above, only pins 1, 2, 3, and 6 are used for data transmission. Pins 4, 5, 7, and 8 are not used.

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Straight-Through and Crossover Cables

The two most common cables are the straight-through cable and the crossover cable. The straight-through is the most common ethernet cable, this connects two different devices. These are commonly found in houses when systems, like a game system or a computer, are connected directly to a router with an ethernet cable. These allow these systems to gain access to the network through the router. The crossover cable is used when the two devices are the same, or they want to share their own network. For example, if two computers are connected with a crossover cable, then these two computers are connected directly.

If you use a cable with a T568A connector on both ends of an ethernet cable, this forms a straight-through cable. That's because each pin will go directly to the same pin (or straight through) on the other side. Looking at the four pins used, pins 1, 2, 3, and 6, this means the following:

Pin Number (T568A)	Wire Color	Pin Number (T568A)
Pin 1	Striped Green (g)	Pin 1
Pin 2	Solid Green (G)	Pin 2
Pin 3	Striped Orange (o)	Pin 3
Pin 6	Solid Orange (O)	Pin 6

Similarly, if you use a cable with a T568B connector on both sides, you will still get a straight-through since the input pin will go to the same output pin, as shown below:

Pin Number (T568A)	Wire Color	Pin Number (T568A)
Pin 1	Striped Orange (o)	Pin 1
Pin 2	Solid Orange (O)	Pin 2
Pin 3	Striped Green (g)	Pin 3
Pin 6	Solid Green (G)	Pin 6

Lastly, if you were to use a cable with a T568A connector on one end and a T568B connector on the other, this would result in a crossover cable. Notice with the crossover cable, pin 1 goes to pin 3, pin 2 goes to pin 6, pin 3 goes to pin 1, and pin 6 goes to pin 2. This is shown in the chart below:

5

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Pin Number (T568A)	Wire Color	Pin Number (T568B)
Pin 1	Striped Green (g)	Pin 3
Pin 2	Solid Green (G)	Pin 6
Pin 3	Striped Orange (o)	Pin 1
Pin 6	Solid Orange (O)	Pin 2

Copper Ethernet Standards

Not all ethernet cables are made the same. While they all use twisted pair cable wiring with RJ45 connectors, they do not all transmit data at the same speeds. The Institute of Electronical and Electronics Engineers (IEEE) have their standards and IEEE 802.3 controls the standards for wired ethernet. Here are the five standards covered by CompTIA's Network+ exam.

10BASE-T - Standard set in 1990, the 10 here signifies that the data can move at 10 Mbps and uses a CAT 3 cable. The max distance of this standard is 100 m.

100BASE-TX – Standard set in 1995, the 100 signifies speeds up to 100 Mbps and can use a CAT 5, 5e, or 6 cable. The max distance of this standard is 100 m.

1000BASE-T – Standard set in 1999, the 1000 signifies up to 1000 Mbps (or 1 Gbps). This standard can reach up to 100 m and uses CAT 5 cabling.

10GBASE-T – Standard set in 2006, the 10G signifies that data can travel up to 10 Gbps and can reach up to 100 m. This uses CAT 5e, 6, 6A, or 7 cables.

40GBASE-T - Standard set in 2016, this 40G signifies that the data can travel up to 40 Gbps but it can only reach up to 30 m. CAT 8 cabling is the only cable able to work with this standard.

Coaxial and Twinaxial Cables

A *coaxial cable* is used in households to deliver cable internet and television. These cables commonly have one copper core wire that is surrounded by insulators and other shields.

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Example of a coaxial cable

RG-59 and RG-6 are the two most common ratings of coaxial cables. RG-59 is used for shorter distances and is cheaper since the core is slightly smaller while the RG-6 has a bigger core and is used for longer distances.

Twinaxial Cables are like coaxial cables, but they have two cores for faster data transmission. These can be commonly found in data centers to help transmit the data more quickly in and out of the center. While they are still not as fast as fiber optics, they are still significantly cheaper and can be used for quick, short distance transmissions.

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