Put this in tech blog?

**Computer has 3 major components:**

* Hardware
* Operating System
* Applications (software)

**The computing process:**

* Input
* Processing
* Output

People who pass the A+ have the ability to:

“Install, configure, optimize, troubleshoot, repair, upgrade and perform preventative maintenance on PCs, digital devices and operating systems.”  
Install and configure PC system unit components and peripheral devices

Install, configure and troubleshoot display and multimedia devices, storage devices and internal system components

Maintain and troubleshoot Microsoft Windows

Configure and troubleshoot network connections

Manage users, workstations, and shared resources

Implement client virtualization

Implement physical security

Secure workstations and data

Troubleshoot workstation security issues

Support and troubleshoot laptops, mobile devices and print devices

You use a class B fire extinguisher to put out electrical fires

What are the different classes of fire extinguishers?

Wearing leather soled shoes will help transfer electricity. Some rubber soled trues protect against ESD if the soles are made up of conductive rubber that scatters static electricity

MSDS, OSHA and EPA guidelines

**Electrostatic discharge (ESD):** ESD wrist strap and mat

Put electrical components in anti-static bag

Always disconnect power before repairing a computing device

Follow disposal requirements for environmentally harmful objects

Check for hot components before working on them

**Hardware:**

What is OEM software?

If the screen on a CRT monitor is broken, you cannot reclaim any materials from it. If the CRT is intact, you can reclaim lead, mercury and phosphorus from it. You can reclaim metal from circuit boards and computer cases, you can also reclaim data from a hard drive, even if the data has been erased.

The factors that generate and promote the transmission of ESD are moving machines, moving people, improper grounding and humidity below 40%

# CPU:

**External Data Bus** provides a channel for the flow of data and commands between the CPU and RAM. The CPU uses registers for temporary storage of internal commands and data

**Registers:** EAX, EBX, ECX, EDX for 32 bit and RAX, RBX, RCX, RDX for 64 bit

EDB went from 32 to 64 bits (the basis for 32 and 64 bit processing)

x86 processors are 32 bit, x64 bit processors are 64 bit

x86-64 are still 64 bit because 64 bit processors can run 32 bit software

Arithmetic Logic Unit (ALU)

Clock wire (CLK), a single charge is a clock cycle. Clock speed is the max number of cycles for the CPU**.** Hz: 1 cycle, MHz: 1 million cycles, GHz, 1 billion cycles (per second)

**System Crystal** determines the speed. A quartz oscillator similar to the one in a wristwatch

Real processor speed is the CPU clock but the actual speed is determined by a variety of factors including, clock speed, CPU architecture, bus speed, bus width, L1/L2 cache sizes, operating system capabilities

bit, byte (8 bits), word (16 bits), double word (32 bits), paragraph/quad word (64 bits)

**MCC (Memory Controller Chip)** sends bits from RAM to CPU

**The Address Bus** connects the CPU to the MCC. The number of wires determines the maximum amount of RAM a CPU can handle. These wires are set exponentially…

1 kilobyte: 1024

1 megabyte: 1,048,576

1 gigabyte: 1,073,741,824

1 terabyte: 1,099,511,627,776

Thermal Design Power: the amount of heat a CPU generates

**Static ram (SRAM) is very fast temporary memory storage on a CPU (faster than DRAM)**

level 1 cache: smallest and fastest, first check

level 2 cache: midpoint between speed and size, secondary data

level 3 cache: slowest and largest, shared among cores

32 bit vs 64 bit CPUs: 2 to the power of 32 or 64

**64 bit CPUs enable you to use more than 4 GB of ram**

All modern CPUs can run both 32 bit and 64 bit

**RISC:** reduced instruction set computer. A CPU design based on an instruction set that tries to improve speed by utilizing relatively few simple instructions

**CPU Extensions:** Virtualization support & **Integrated GPU,** allows certain CPU models to take over tasks normally executed by a dedicated graphics controller

Virtualization allows you to run other OSs within a single hardware platform

Modern CPUs have integrated graphics but a dedicated graphics card increases performance

**GPUs: graphics processing unit**

Modern video cards contain their own BIOS

**VRAM** is a special-purpose memory type used by graphics controllers

Most processors can use a process called **multithreading** or **hyper-threading (HTT)** to split a core into numerous virtual cores, which are called threads. Hyperthreading was developed by Intel for x86 CPUs. It does not double speed, increases only by 15% to 30%

**Multicore** is a type of CPU architecture in which a single physical CPU contains more than one execution core on a single die or chip. Each core has its own cache and the entire core might have a shared cache

**Overclocking** is a way to increase the performance of a device (e.g. a CPU, GPU, RAM, or motherboard) by running it at a higher speed than the rate tested and approved by the device manufacturer

modern CPU sockets are ZIF (zero insertion force) to prevent damage to fragile chips

If you snap off a pin you’ve pretty much wiped out the CPU

Intel and AMD products are not compatible. AMD tends to be a bit less expensive and Intel tends to be top of the line

**Intel:** LGA: land grid array. Pins are on the motherboard

**AMD:** PGA: pin grade array. Pins are on the CPU

**How to install a CPU:**

1. place the CPU on the motherboard
2. add thermal paste
3. place the heat sink
4. place the fan
5. plug in the fan to the motherboard

**passive cooling:** a heat sink with no fan

**active cooling (active heat sink):** a heat sink with a fan

**liquid cooling:** coolant is circulated through a computer, used on high-end systems for gaming and graphics-heavy machines

If the system shuts down after a few seconds or doesn’t turn on at all and you’ve checked that the computer has power, it’s probably a heating issue. Too much or not enough thermal paste, or the fan is not connected to the motherboard

Fan specifications: standard sizes are 80mm, 120mm, 200mm, variable speeds and noise levels. A heat sink dissipates heat through thermal conduction

**Physical Address Extension (PAE)** enables 32 bit OS to utilize more than 4GB of memory

PAE only allows you to use up to 64gb of memory, not the 16 exabytes in 64 bit architecture

**SSE2** (**Streaming SIMD Extensions 2**) is one of the Intel SIMD (Single Instruction, Multiple Data) processor supplementary instruction sets first introduced by Intel with the initial version of the Pentium 4 in 2000. It extends the earlier SSE instruction set, and is intended to fully replace MMX.

**Windows 8 and later requires CPUs to be capable of PAE**

The processor must be running in Physical Address Extension (PAE) mode to use the **NX bit** processor feature. The NX bit is a form of memory protection that provides additional security.

Intel: **XD bit (*execute disable*)**, AMD: **Enhanced Virus Protection** (**EVP**)

**SSE2** refers to a solution (a complimentary instruction set) that extends the capabilities of a CPU. All processors that support NX also support SSE2

SSE data transfers use XMM register

x86 is 32bit architecture

# Memory:

Ram is volatile storage. The data is lost when the computer is turned off

The capacitors on the memory need constant electricity to run

In order for a program to run, it needs to be loaded to RAM first

DRAM: slower and less expensive than SRAM (asynchronous)

SRAM: synchronized to the system clock, used for CPU cache memory

SIMM: single inline memory module (discontinued). Transfers 32 bits per clock cycle

DIMM: dual inline memory module. Transfers 64 bits per clock cycle. 2 notches, 184 pins

**SDRAM types:** DDR input/output speed and latency increases with each generation

**SODIMM** and **micro-DIMM** for laptops

**DDR**: 1 notch, 184 pins

**DDR2**: 1 notch, 240 pins (200 pin SODIMM), 4 words per clock cycle,

**DDR3**: 1 notch, 240 pins (204 pin SODIMM), 8 words per clock cycle,

**DDR4**: 1 notch, 288 pins (260 pin SODIMM), 8 words per clock cycle

**maximum data transfer rate is 8x the frontside bus speed**

**clock speed is half the frontside bus speed**

* The number in front of DDRX refers to the frontside bus speed
* The number in front of PCX refers to the maximum data transfer rate

DDR2-400, 400Mhz FSB == PC2-3200, 3200 MB/s == 200MHz clock speed

Which of the following is the industry name used for DDR2-1066 modules?: (\*8) PC2-8500

What is the peak transfer rate of a DDR2-533 module?: (\*8) 4266 MB/s

The different DDR types are not compatible

Make sure your motherboard can handle the amount of ram you want to install

Avoid mixing ram sizes and speeds, it can cause stability issues

Single sided and double sided ram, must have a motherboard that supports it

ECC and parity ram: these types of ram can only be used on particular motherboards

This type of ram is on big server systems, it checks for and corrects errors automatically

A motherboard with color-coded memory slots provides support for **multi-channel memory architecture… Dual channel mode, triple channel** and **quad channel**

In order to take advantage of the performance benefits offered by the multi-channel memory architecture, RAM has to be of the same type, speed and capacity.

Windows Memory Diagnostic Tool and Memtest86+ (open source software) used to check bad memory

NMIs (non maskable interrupts) can sometimes be RAM problems, but not necessarily

* Blue screen of death
* Spinning pinwheel of death on MacOS

**Which type of memory allows for permanent data storage?: DVD-RAM**

# BIOS:

**BIOS** (basic input/output system) is programming stored on a physical chip that is used to talk to the different pieces of hardware. Stored on the motherboard in the form of nonvolatile memory called **ROM** (read-only memory). Software used to start your computer.

Modern systems use **UEFI** (Unified Extendable Firmware Interface). Features include:

* mouse support
* GUI
* DRM support
* secure boot
* network access

UEFI also allows you to boot from large (>2.2 TB drives) GUID partition table (GPT) disks. Also supports FAT and removable media. Includes a pre-boot environment: This is not an operating system, it has its own shell, drivers and applications. Browse the internet, backup a storage drive, remote diagnostics, even without an OS

**Windows stores device drivers in the registry**

When you need to update BIOS/UEFI, you have to **flash the ROM (aka firmware updates)**

**firmware upgrades:** ROMs on older systems, flash memory on newer systems

Upgrades are rare and unnecessary unless you need to improve performance or fix bugs

Identify BIOS version through msinfo32. Interrupting the process during installation might brick your device.

**BIOS options:** press a “secret” button. Windows 8 and Windows 10 have a fast boot option that require disabling in order to access BIOS

* Set boot order, drive settings
* RAM - view and configure memory settings
* enable or disable optical drive
* monitor computer hardware, temperature, voltage information
* enable secure boot: digitally signs known-good software. Software won’t run without the proper signature
* BIOS password / User password needed to start the OS
* set an administrator/supervisor password that restricts BIOS changes
* chassis intrusion detection/notification
* Full disk encryption: Microsoft Bitlocker that BIOS integrates with Trusted Platform Module (TPM)
* LoJack (track a PC’s location if stolen, install a keylogger, remotely shut down). Remains on the system even if the OS is reinstalled
* activate virtualization support

Hardware and hardware cards sometimes come with **option ROM** that loads BIOS

**in modern PCs, BIOS contents are stored in flash memory and EEPROM**

**CMOS** (complementary metal-oxide semiconductor) is a small bit of nonvolatile memory (system ROM chip) that stores BIOS/UEFI settings, which can be adjusted using the system setup utility. It also handles the system’s RTC (real time clock). You can restore this to default settings by doing a **CMOS clear.** You have to tinker with the motherboard to do this, it’s a CLRTC jumper or a battery that you need to take out, on older systems.

If you lose CMOS settings, here are some common errors to troubleshoot:

* CMOS configuration mismatch
* CMOS date/time not set
* BIOS time and settings reset
* no boot device available
* CMOS battery state low

**POST** (power on self test): also stored on system ROM, performs preliminary hardware checks when the computer turns on and communicates results through **Beep Codes** and text messages

**POST card:** something to snap onto your computer to diagnose problems with a dead computer

When you turn on the computer it goes through a **boot sequence**:

1. power good
2. CPU
3. POST
4. **bootstrap loader (BIOS)/boot manager (UEFI)**
5. operating system

The **motherboard** is the main component of the computer (circuit board)

**Motherboard connectors:**

* CPU socket
* memory slots
* bus slots (various components that add capabilities)
* storage device cable connectors (SATA, PATA)
* front panel connectors (pwr button, reset button, LEDs, etc)
* USB connectors
* modern motherboards also contain an **M.2 SLOT** for an M.2 SSD

**Chipset** determines the processor and ram required. Chipsets were consolidated into these two types:

1. Older motherboards contain **Northbridge** and **Southbridge** chipsets.
   1. Northbridge managed communications between CPU, PCI express bus and memory
   2. Southbridge managed standard PCI slots, SATA connectors, USB hubs, etc.
2. Newer motherboards have a **PCH (Platform Controller Hub)** chip. Functions of the Northbridge chip have been integrated into the CPU.

**Form Factors:** Standard measurements for case, motherboard and power supply

AT was the old form factor and **ATX** form factor is the standard now

The main power connector used in modern ATX motherboards is a 24-pin connector

**Standard ATX** (12” / 9.6“), good for servers

**micro ATX (uATX)** (9.6” / 9.6“), good for desktops that don’t need extra expansion slots

**ITX** and **Mini-ITX** motherboards are low power and good for single purpose computing like streaming media. They are also screw compatible which allows them to fit in any traditional ATX or uATX case

A computer bus provides **Expansion Slots:** the expansion bus gets its own clock

PCI: shorter slots are 32 bit. Longer slots are 64 bit, Parallel communication speeds:

133 MB/s (32 bit @ 33MHz)

266 MB/s (32 bit @ 66MHz or 64-bit @ 33MHz)

533 MB/s (64 bit @ 66MHz)

PCIe (PCI express): Replaced PCI, PCI-x and AGP (accelerated graphics port). Serial communication. Slower devices don’t slow down everyone, unidirectional serial “lanes”. x1, x2, 4, x8, x16, x32 lanes of unidirectional (serial) communication

v1.x: 250 MB/s

v2.x: 500 MB/s

v3.x: ~ 1 GB/s

v4.x: 2 GB/s

v5.0: ~4 GB/s

mini-PCIe: laptop version of PCI, low power and lies flat

**Riser Card** adds more PCI slots and changes the directions of the slots

Expansion cards include: video cards (GPU) that usually come with fans, audio cards, network cards (NIC), multi-port Ethernet card, USB expansion card, storage cards (M.2), eSata card, check motherboard documentation before buying and installing cards.

**Installing expansion cards requires four steps:**

1. Knowledge that the card works with your motherboard/OS
2. Installation without damaging the card (make sure the card is properly seated and screwed in)
3. device drivers: install the device then insert installation media if not detected automatically
4. verification: verify the new card is working properly

**Troubleshooting expansion cards:** in Device Manager, a black ! On a triangle indicates a device is missing, Windows does not recognize the device, or there’s a device driver problem. The device may still work. A black downward-pointing arrow on a white field indicates a disabled device. Manually turned off or damaged. The ! Symbol is the most common error. Double-check device connections. Right click and select “update driver”.

**Computer Power Supply:** uses DC voltage. most power sources supply AC voltage

Power supplies convert 115V AC or 220V AC into DC power: 3.3V, 5.5V and 12V

Power supply tests are used to confirm voltage

Laptops have **external AC adapters** instead of power supplies. These may be auto-switching or fixed input of 110 volts or 220 volts. Converts AC to DC. Laptops have DC jacks

Laptops carry **lithium-ion batteries**

**amp and volt:**

ampere (amp, A) - the rate of electron flow past a point… the diameter of the hose

voltage (volt, V) - electrical “pressure” pushing the electrons… how open the faucet is

**Wattage** is the main difference between power supplies… measured in A \* V = W

**Sizing a power supply:** calculate the watts required for all components. online calculators

A good rule of thumb is to get a PSU that runs at 50% capacity

**Current:**

US/Canada - 110 to 120 volts of AC (VAC), 60 Hz

Europe - 220-240 VAC, 50 Hz

since voltage varies by country, power supplies switch between 110-115V / 220-230V

sometimes it is a switch you have to flip or the power supply might do it automatically

if the PSU doesn’t turn on, it could be a voltage problem

be careful not to provide too much voltage to a machine built for lower voltage, it could fry all your electronics!

**24-pin motherboard power:** provides +3.3V, +/-5V, +/-12V

20 pin connector was the original ATX standard, 24 pin was added for PCI Express power

you can connect a 24 pin connector to a 20 pin motherboard. Some PSUs are 20+4pin

**Power supply output:** positive and negative voltage, voltage is a difference in potential. the electrical ground is a common reference point

different voltages for different components:

+12V: PCIe adapters, hard drive motors, cooling fans, most modern components

+5V: some motherboard components, many components are now using +3.3V

+3.3V: M.2 slots, RAM slots, motherboard logic circuits

-12V: older machines use this for integrated LAN, older serial ports and some PCI cards

-5V: modern power supplies probably won’t have this, but used for ISA adapter cards

**Recommendations when you build computers:**

For audio/video editing workstation such as graphics workstations, computer aided design (CAD), computer aided manufacturing (CAM): They need an SSD drive, specialized audio card, high-end video card, and RAM maxed out

Virtualization workstations should have max ram and CPU cores since every OS needs its own memory

**Thick client:** apps run on the local PC, must meet hardware requirements

**Thin client:** apps run on a remote server, Virtualization Desktop Infrastructure (VDI). Minimal hardware requirements but big network requirements

**Emulation vs virtualization:**

virtualization is a native OS identical to a non-virtual system. Performing native OS process

emulation is one device running processes designed for a completely different architecture. one device is pretending to be another. original code is used. code is interpreted from running on the current hardware. This is commonly slower than running natively, emulation is not as easy to do as virtualization.

If you have BIOS, you need two NTFS partitions

If you have UEFI, you need one FAT32 and an NTFS partition

Is there a difference between flashing the bios and updating the EEPROM chip?

# Storage:

HDDs (hard disk drives) are ATA drives

Nonvolatile magnetic storage. Random access, can access any part of the drive

Lots of moving parts: spinning platters, moving actuator arm, mechanical components limit access speed but are easy to break. Spins at a rate measured in revolutions per minute

Rotational speed (RPM) Average rotational latency

15,000 2ms

10,000 3ms

7,200 4.16ms

5,400 5.55ms

USB flash drives use flash memory: EEPROM (electrically erasable programmable read-only memory). Non-volatile memory and no power required to retain data. Limited number of writes. Compact flash (CF), Secure Digital (SD), miniSD and micro SD, xD-Picture card

mSATA (micro sata), used for laptops and mounted directly on motherboards

Network attached storage device: NAS (access from everywhere). Used for media streaming and file sharing. Gigabit NIC and a RAID array

**Desktop HDD form factor size is 3.5”**

**SSD: solid state drives, non-volatile memory. Most common form factor is 2.5”**

Most common magnetic **hard drive form factor size for laptops** is 2.5”

**SSD form factor sizes for laptops** are 2.5” and 1.8”

SSD host interfaces include:

It’s more like RAM than magnetic storage, it uses flash memory

Sata/AHCI and PCIe/NVMe are the interfaces and protocols used by SSDs

When buying an M.2 drive, read the box to confirm if it needs SATA or NVMe

NVMe: logical device interface designed to access storage devices attached via PCIe

NVMe drive uses an M.2 interface. This is a smaller storage device that is as fast or faster than SATA with no SATA power cables. PCI express bus connection: 4 GB/s throughput or faster. Different connector types, need to be compatible with the slot key/spacer.

B key: PCIe x2, M key: PCIe x4, B & M key: some drives support both

An M.2 key is a notch on the pin contact surface of an M.2 expansion card which prevents insertion into an incompatible socket. The M.2 key IDs include 12 available letters from A to M. These letters correspond to the locations of notched pins on the card's contact surface and designate which interface the card is compatible with. M.2 expansion cards that are used for solid-state storage applications have key IDs of B and M. The B-keyed M.2 SSD cards use 2 PCIe lanes (lower read/write speed), while M-keyed M.2 SSDs use 4 PCIe lanes (higher read/write speed). M.2 SSDs with 2 notches on the card's pin contact surface (B + M) increase the card's compatibility as they can be installed in either of the two types of expansion slots on the motherboard.

**SSHDs** are a mixture of ATA and SSD that combine high capacity and performance with lower price. AKA hybrid drives. SSD caches the slower spinning hard drive data, increases speed without the cost of an SSD-only drive. Same form factor as a normal hard drive or SSD (3.5”)

A Disk Defragmenter is a software tool used to rearrange data on magnetic drives in order to improve system performance. Defragmentation results in faster read/write operations of a magnetic hard drive's read/write heads because defragmentation consolidates data into the smallest contiguous regions. This means that the heads can access data sequentially without seeking data fragments in different areas of a disk.

**AHCI: advanced host controller interface,** must be turned on so that it recognizes different drives. before installing an OS, make sure AHCI is turned on to use newer SATA feature

Logical Block addressing: LBA, takes discrete information stored in blocks on your hard drive and offers them up to RAM as necessary

**The file system sits between the storage device and the OS**

**RAID: Redundant Array of Independent Disks**

Raid 0: striping, files are split between two or more physical drives (high performance, no redundancy)

Raid 1: mirroring, files are duplicated. Uses double the disk space but provides redundancy

Raid 5: Striping with parity, 3+ drives, more efficient use of disk space with redundancy

Raid 1+0 AKA raid 10: Nested RAID, 4+ drives. Provides performance of RAID 0 with redundancy

Hot swappable drives: add and remove while the system is running

Examples include, SATA drives, eSATA drives and USB drives

Drive chassis of two or more drives. Easy to repair. Combine with RAID for 100% uptime

Software RAID: the OS takes care of RAID configurations

Hardware RAID: hard drive controller invisible to OS. designed for speed and more expensive

The new RAID array will appear as a single drive

LPs are legacy data storage, then we got optical discs

small bumps with a laser beam, microscopic binary storage

Burners don’t create bumps, they darken photosensitive dye to write to discs.

DVD-R, DVD+R, DVD-RW, DVD-R-DL

CDFS: compact disc file system

CD-ROM: 700 MB, 80 minutes of uncompressed audio

DVDs have region codes

DVD-ROM: 4.7 GB single layer, 8.5 GB dual layer

Blu-ray disc: 25 GB single layer, 50 GB dual layer

mini Blu-ray disc: 7.8gb single layer, 15.6gb dual-layer

Blurays require UDF format

Blu ray discs include HDCP, a content control system designed to prevent piracy

Blu-ray formats: bd-video, bd-rom, bd-r and bd-re

BD-R: blu-ray disc recordable. This storage media can be read, but not written to

BD-RE: blu-ray disc erasable

mini Blu-ray disc

**USB:**

usb 1.0: 1.5 mbps & 12 mbps

usb 2.0: 4.8 mbps

usb 3.0: 5 gbps

usb-a points to the pc (downstream), usb-b points away from the pc (upstream)

usb 3.0 b connector

Micro-USB and Mini-USB is used to plug in mobile devices

USB-C is a 24-pin double sided connector used for both hosts and devices

This connector acts as USB 3.1 and 2.0, and also includes analog audio option

USB-Micro B can be used on an Android device for mobile device synchronization

**flash media:** flash drives, compact media (CM), smart media card (SMC), secure digital (SD), miniSD, microSD

**File attributes:**

Read Only

Archive

System

Hidden

Windows extended file attributes

Index

Compression

Encryption

**CDFS (compact disk file system)** is a file system for read-only and write-once CD-ROMs.

**Universal Disk Format:** has been most widely used for DVDs and newer optical disc formats, supplanting ISO 9660/CDFS

**FAT32** has a 4hb max file size and a 32gb max hard drive size

**NTFS:** most popular windows file system. Insanely huge file size limits so in practice, no maximum file size. Also allows file permissions and encryption. Windows must be installed on an NTFS formatted partition. NTFS is read only in MacOS and older linux distros.

**exFAT:** designed as an upgrade from FAT, used mostly in memory cards (SD). has wider non-windows support

**ext2, ext3, ext4:** extended file system developer for linux

**HFS, HFS+, APFS:** apple file system

You use a different file system depending on your OS:

* NTFS for Windows
* HFS+/APFS for MacOS
* ext4 for linux

Use FAT32 on removable media below 32 gbs and exFAT on anything bigger

You can use as many disks as you want with a striped volume

A mirrored volume uses a maximum of 2 disks

**Partitioning schemes:**

MBR for PC BIOS-based systems

GPT for UEFI-based systems

MBR:

Four primary partitions, 3 primary and 1 extended

One marked active

2tb partition size limit

All primaries contain data

Boot sectors become populated on active partitions called system partitions

Boot partition is where the operating system resides

GPT:

Newer partitioning

Allows for 128 partitions

Backwards compatible with BIOS-based systems

Boot code redundancy

No 2TB partition size limit

The theoretical memory limits in 16, 32 and 64 bit machines are as follows:

16 bit = 65, 536 bytes (64 Kilobytes)

32 bit = 4, 294, 967, 295 bytes (4 Gigabytes)

64 bit = 18, 446, 744, 073, 709, 551, 616 (16 Exabytes)

NTFS allows windows to use Access Control Lists (ACL)

# Monitors:

**OLED** on laptops is thinner and lighter than LED but not quite ready for laptops. More costly and power-hungry than LCD?

**LCD** is the most common display technology. These are backlit. Some laptops have inverters that convert DC to AC. If the screen isn’t working, verify backlight. Look closely and use a flashlight. May need to replace the LCD inverter or display

**Digitizer** is used on laptops and touchpads as alternatives to keyboards, although some devices are hybrids of a touchscreen and a laptop

Older laptops use **CCFL** – Cold Cathode Fluorescent Lamp. Higher voltage and power needed and added thickness to display

# Mobile Devices:

Phones have baseband radio processors. Has its own firmware and memory

WWAN is a WAN technology that uses cell towers to provide wireless signal coverage for mobile devices

**Phone updates:**

Phones are radios. Baseband radio processor is a network interface for your radio, this isn’t Wi-Fi or Bluetooth. Has its own firmware and memory, proprietary. Real-time operating system. Firmware can be updated over the air (OTA), invisible to the end user.

PRL (preferred roaming list). CDMA networks (Verizon, sprint) allows your phone to connect to the right tower. Can be updated over the air (OTA). PRL is a database on a mobile device containing bands, sub-bands and service provider IDs allowing the device to establish a connection with the right cell phone tower

PRI (product release instructions): radio settings, ID numbers, network codes, country code, etc. Also updated OTA. PRI can be used as a reference during a mobile device update process

**IMEI.** International Mobile Station Equipment Identity. Identifies a physical mobile device. Every phone has a different IMEI and can be used to allow or disallow access.

**IMSI.** International Mobile Subscriber Identity. Identifies the user of a mobile network and is provisioned by the SIM card. Swap the SIM to move between phones.

**Proprietary mobile interfaces:** there were lots of different cables for early mobile phones but the EU changed things, adding common cables for all data-enabled mobile phones sold in the EU

**NFC (near field communication):** small amounts of data transferred between phones, such as payment data, transportation, in-person information exchange or even bootstrap for other wireless such as Bluetooth pairing. It also allows the phone to function as an access token or identity “card”. *Short range with encryption support.* Uses RFID.

**IR (infrared):** Your phone/wristwatch functions as a TV remote

**MDM** mobile device management is an industry term for the administration of mobile devices, such as smartphones, tablet computers and laptops. MDM is usually implemented with the use of a third-party product that has management features for particular vendors of mobile devices

# Printers:

You can share a printer from an OS. Common on Windows devices. Commonly uses udp/137, udp/138, tcp/139 and SMB/CIFS

Printer drivers are specific to a printer model, 32bit or 64bit

Bonjour discovers Apple devices on the LAN. part of macOS but can be added to Windows

AirPrint: print from iOS devices to compatible printers

**Printer data privacy:** user authentication, everyone can print, set rights and permissions to printing vs. managing the printer

**Print and scan caching**: click print, local system creates a file of the output, printing is done from a spoof file. Spoof file is deleted when done, but not always. Some printers can hack these spoof files to see what you’ve printed. Another security measure is regular clearing of printer’s cache memory

Printing speed is measured in PPM (pages per minute)

**remote printing network protocols:** LPD/LPR, IPP (SMB/CIFS also enables printing)

**Laser printer:** very high quality, fast printing speeds. requires on-printer memory

*Duplexing assembly*: printers usually print on one side, not two sides simultaneously, but some laser printers can turn the page around to print both sides.

**Steps to laser printing:**

1. Processing: build the entire page in memory
2. Charging: prepare the drum with a negative electrostatic charge. *Corona wire* on older printers and *primary charging roller* on newer printers
3. Exposing: laser writes the image, neutralizing negative charge on the print area
4. Developing: add negatively-charged toner to the *imaging drum*
5. Transferring: move the toner from the drum to the paper
6. Fusing: uses heat and pressure to melt the toner onto the paper
7. Cleaning: wipe off excess toner to prepare for the next print job

imaging drum holds a representation of output image drawn on its surface by laser

transfer belt (roller) picks up all the color layers of an image from imaging drums onto paper

fuser assembly applies heat and pressure to bond toner to paper

**Laser printer maintenance kit:** standard maintenance kits are a set of printer replacement parts. Replacement feed rollers, new fuser unit, etc. When to perform maintenance? check the printer page counter. power down and replace components, fuser units are HOT. reset the page counter when done

**laser printer calibration:** different toner cartridges print with different densities. Some dark, some light. Laser printer calibration adjusts the density. Can be automated or a manual process. Every printer is different, check the printer manual.

**laser printer cleaning:** check manufacturer recommendations. Water or IPA (alcohol). Outside, damp cloth. Inside, wipe dust away. Don’t use a normal vacuum cleaner or compressed air, clean rollers with IPA. Use toner vacuum, magnetic cleaning brush and isopropyl alcohol to clean laser printers

replacing the toner cartridge: low doesn’t mean empty, look for messages

The toner can also contain the Organic Photoconductor (OPC) Drum. This drum is sensitive to light, keep it in the bag. Don’t forget to remove packing strips from the new drum

**separation pad and pickup roller** prevent multiple sheets of paper from being fed at the same time

**Inkjet (ink-dispersion) printer:** relatively inexpensive technology. Quiet, high-resolution. printer ink eventually fades over time and cogs easily. Ink cartridges place drops of ink onto a page, pulled from a set of cartridges. CMYK cartridges. Print head: some consumer printers integrate the print head onto the ink cartridge. Change the cartridge, get a new print head. *Feed rollers* pick up and feed paper through the printer. Also supports duplex printing

Carriage and belt: ink cartridges are moved over the paper. Carriage may include its own print head. Belt moves the carriage back and forth.

Inkjet printer calibration: aligns the nozzles to the paper. Lines should be crisp, colors should align

ink cartridges are the most expensive part to replace in an inkjet printer (proprietary)

**Inkjet printer maintenance:** cleaning print heads. Small droplets of ink and small holes in a print head. Clogged heads is a big issue. Many printers automatically clean every day. Output has streaks or sections of missing color. Cleaning process can be started manually, only takes a few minutes. Clearing jams: remove tray paper and any loose paper. Use firm pressure to remove paper from the path, do not rip. Open the printer and check for any scraps of paper.

**Thermal printer:** uses thermal paper, turns black when heated. No ink! Very quiet. Paper is sensitive to light and heat. Usually used to print receipts. Feed assembly, pull paper through the printer, relatively small paper path. Full-length heating element, no moving print head. Different thermal printers are using different sizes. Used as a PoS terminal component

**Thermal printer maintenance:** paper replacement, relatively inexpensive. the replacement process is easy. Cleaning the heating element: Liquid cleaner, isopropyl alcohol (IPA). Get a cleaning pen, check the manufacturer's recommendations. Swab gently, usually small areas. use a cleaning card, which cleans the head and paper pathways. Removing debris: blow air out the printer and wipe it out with a damp cloth. Avoid using a vacuum unless it’s designed for computers… resists static buildup/discharge

**Impact / dot-matrix printers**: Tractor feed: paper pulled through with holes on the sides of the paper, instead of using friction. Continuous paper feed, perforation between pages. Impact printers do not need calibration. This is the only kind of printer that can print multipart forms. Uses an inked ribbon to print. Print head with a small matrix of pins. Presses against a ribbon to make a mark on paper. Low cost per page. Noisy. Niche uses, car rental, airports.

Dot-matrix print head: moves back and forth, pins hit ribbon and paper

**Virtual printers:** files are saved in a special file type, must use the command line to copy the file to the printer. file formats include: PDF, XPS, graphic image

**3D printers:** prints in 3 dimensions. additive manufacturing, melt plastic filament in layers to create the object. used for rapid prototyping…

# Connection types:

**Video connections:**

VGA (video graphics array), DB-15 connector (15 pins) AKA DE-15. Blue color and 2 screws

Analog signal: no digital. Image degrades after 5 – 10 meters

HDMI (high definition multimedia interface): video and audio stream. All digital, no analog. ~20 meter distance before losing too much signal. 19-pin (Type A) connector, proprietary connector. MiniHDMI, type C connector, designed for smaller devices

Display port: VESA standard (video electronics standards association). A royalty free standard. Data is sent in packetized form, like ethernet or PCI express. Compatible with HDMI and DVI (passive adapter).

DVI (digital visual interface): single and dual link. Single link: 3.7 Gbps (HDTV at 60 fps). Dual link: 7.4 Gbps (HDTV at 85 fps). DVI-A: analog signals, DVI-D: digital signals, DVI-I: integrated, digital and analog in the same connector

**Apple connections:**

Lightning cable: apple proprietary. 8-pin digital signals. Some advantages over Micro-USB. Higher power output for phones and tables, can be inserted either way, simpler design, more durable

All thunderbolt versions support the ability to daisy-chain up to 6 devices and has the capability to send PCIe/DisplayPort data and power over single cable

Thunderbolt. High-speed serial connector: data and power on the same cable, based on Mini DisplayPort (MDP) standard. DisplayPort can transmit both video and audio data

Thunderbolt v1: two channels, 10Gbit/s per channel for 20 Gbit/s total throughput. Thunderbolt v2: 20 Gbit/s aggregated channels

Thunderbolt v3: 40 Gbit/s aggregated throughput, USB-C connector, max 3 meters (copper) and 60 meters (optical)

**USB connections:**

USB (universal serial bus): simplifies connections. Printers, storage devices, keyboard, mouse, etc

USB 1.1/2.0 connectors: Standard-A plug: type A connectors can be attached to host devices and devices that supply power. Standard-B plug, Mini-B plug and micro-B plug. Type B connectors can be attached to devices that receive power and target devices

USB 1.1: low speed, 15 mbit/s, 3 meters. Full speed: 12 mbit/s, 5 meters

USB 2.0: high speed, 480 mbit/s, 5 meters

USB 3.0 connectors changed the standards a bit notice the difference between plugs

USB 3.0: SuperSpeed, 5 gbit/s, 3 meters. Standard does not specify a cable length

USB 3.1: released July 2013. SuperSpeed+, 10gbit/s – twice the rate of USB 3.0

USB 3.2: released September 2017, New SuperSpeed+ modes over USB-C. 10gbit/s and 20 gbit/s

USB 3.x Type-A provides full backward compatibility with earlier USB standards

USB-C: has a lot of different connectors. Replaces all other connectors. USB-C isn’t necessarily USB 3.1. The cable must support the function

**DB-9:** serial cable connector: D-subminiature or D-sub. Different sizes, A through E

Commonly used for RS-232: recommended standard 232, an industry standard since 1969

Serial communications standard: built for modern communication. printers, mice, networking

Commonly used as a configuration port: serial console interface. DE-9, DB-25

Also used for VGA cablesF

watch videos on hard drive connections

**Hard Drive connections:** SATA can only be used to connect one device. SATA (serial AT attachment): two cables, one plugs to motherboard the other plugs to power supply

SATA revision 1.0, SATA 1.5 gbit/s, 1 meter

SATA revision 2.0, SATA 3 gbit/s, 1 meter

SATA revision 3.0, SATA 6 gbit/s, 1 meter

SATA revision 3.2, SATA 16 gbit/s, 1 meter

The regular SATA connector is L shaped with one ear. ESATAis rectangular with two ears

The SATA interface specification defines data cable connector consisting of 7 pins

SATA and ESATA connectors. Molex connectors are 4 pin peripheral power, provides +12V a +5V

PATA drive cables (parallel AT attachment), Parallel ATA, ATA. Circa 1999 by Western Digital. Originally called integrated drive electronics (IDE). 2nd generation called EIDE Enhanced IDE). Promised faster speeds (from 16 Mb/s through 133 Mb/s). 39 PIN interface… cable consisting of 40 wires and a cable consisting of 80 wires. Molex connectors used to provide power. A PATA cable can connect a PC to two devices. Maximum cable length of 18 inches. PATA cabling uses 40-pin connectors

When installing two PATA drives on a single cable, each drive must be configured with a jumper to designate it as either a primary drive (a.k.a. "master") or a secondary drive (a.k.a. "slave"). The "cable select" jumper setting option automatically configures the drive as master or slave according to its position on a cable

SCSI standard (small computer systems interface): not really “small” any longer

Originally designed to string many peripherals together onto a single cable/controller. Up to 16 devices in a SCSI “chain”. Not just for hard drives… scanners, tape drives, CD-ROM drives. Many devices on a single bus. 8 on narrow bus, 16 on wide bus. Very intelligent interface functionality: much of the difficult configuration work is done between the SCSI devices. Industry longevity: well supported in the enterprise a standard drive for virtual systems.

SCSI ID and logical unit (LUN): Every SCSI device on a single bus is assigned a separate ID number. Logical units (LUNs) are defined within each SCSI ID. Separate drives in a storage array or virtual machine. The signal at the “end of a physical SCSI bus is terminated. LUN is a way to identify logical partitions on a SCSI hard drive.

1234567890+-

Serial attached SCSI (SAS) devices have no jumpers, terminators, or settings. Move from parallel to serial increases throughput similar to the move from PATA to SATA. Point to point connection (no daisy chains) and the control and management of SCSI but with the speed of a serial connection

**adapters and converters:**

DVI to HDMI: no loss of video quality and no signal conversion required

DVI to VGA: DVI-A includes analog signals. Only 640x480 resolution supported

USB to Ethernet: some laptops don’t have a wired Ethernet interface

**barcode/QR code reader:** serial, USB or wireless connector. on your phone with apps

**Peripherals:**

microphone: analog - TRS (tip/ring/sleeve), digital - usb

speakers: analog output devices, TRS or speaker output, audio adapter

headset: desktop and mobile use, USB, TRS, wireless/bluetooth

digital projectors: not always LCD. Metal-halide lamp, very bright and very hot. brightness is measured in lumens. Always let bulbs cool off

KVM: keyboard, video and mouse. Use many computers with a single set of peripherals

magnetic reader / chip reader: Point of sale (POS) terminal, USB connected

VR headset: virtual reality. Motion tracking on X,Y,Z axis

touch pad: may be a standalone advice as well

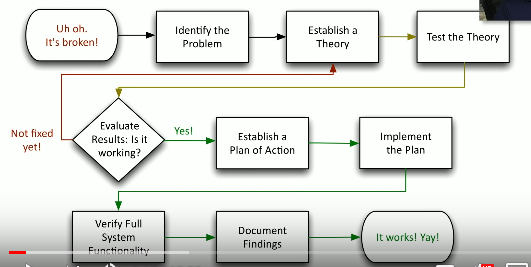
signature pad: small digitizer and stylus

gaming input: gamepad and joystick

webcam:

mouse: USB or adapter for PS/2

# Troubleshooting:



### The troubleshooting process: Change control is a formal process for managing change that avoids downtime, confusion and mistakes. Usually come in the form of corporate policy and procedures. Nothing changes without the process. You plan for a change, estimate risks associated, have a recovery plan, test before making a change and document everything to get approval

* **identify the problem:** Information gathering, get as many details as possible. Duplicate the issue, if possible. Identify symptoms: may be more than a single symptom. question users as much as possible. determine if anything has changed. approach multiple problems individually: break down problems into smaller pieces. backup everything: you’re going to make changes, always have a rollback plan. What else has changed? environmental / infrastructure changes? Clues: OS log files, application logsl
* **establish a theory:** the simplest explanation is the most likely but consider everything.. make a list of all possible causes ranked from easiest to most difficult. research the symptoms: internal knowledge base, google searches
* **Test the theory:** confirm the theory, determine next steps to solve the problem. theory didn’t work? re-establish a new theory or escalate, call an expert. If the theory doesn’t work, go back and establish a new theory. repeat as necessary
* **create a plan of action:** build the plan, correct the issue with minimum impact or do the work during non-production hours if they cause disruption. identify potential effects: every plan can go bad. Have a plan B and plan C
* **implement the solution:** fix the issue, implement during the change control window. Escalate as necessary, you may need 3rd party help
* **verify full system functionality:** Have the customer confirm the fix. Implement preventative measures to avoid issue in the future
* **document findings:** build a knowledge base of problems. What action did you take? What outcome did it have? consider a formal database, help desk case notes, searchable database

### Troubleshooting common hardware problems:

Safe mode in win 7 and 8 with F8

Safe mode in win 10 with shift+click restart, or Msconfig or settings

0

unexpected shutdowns: no warning, black screen, may have details in your event viewer: heat-related issue:

* high CPU or graphics, gaming
* check all fans and heat sinks
* bios may show fan status and temperatures

Failing hardware: has anything changed recently? check device manager, run diagnostics

overheating: heat generation, CPUs, video adapters, memory

cooling systems: fans and airflow, heat sinks, clean and clear

verify with monitoring software: built into the bios or use HWMonitor

lockups: system completely stops. Usually not much in the event log

check for any activity. Hard drive, status lights, ctrl-alt-del

update drivers and software patches. Has this been done recently?

low resources: ram, storage

hardware diagnostics may be helpful

POST (power on self test)

tests major system components before booting the OS

* main systems (cpu, cmos, etc)
* video
* memory

failures are usually noted with beeps and/or codes. BIOS versions differ, check documentation

POST and boot: blank screen on boot

* listen for beeps
* bad video
* BIOS configuration issue

BIOS time and setting. maintained with the motherboard battery, replace the battery

attempts to boot to incorrect device: check boot order in BIOS configuration

confirm startup device has a valid os

continuous reboots: causes include overheating, hardware failures, corrupted or misconfigured OS installation. How far does the boot go before rebooting? BIOS only? OS splash screen?

bad driver configuration. F8 to boot from last known working configuration… safe mode

if system starts, disable automatic restarts in system properties

bad hardware: try removing or replacing devices

check connections and reseat

no power: at the source or from power supply? UPS?

get out your multimeter

fans may spin but no power to other devices. Where is your fan power connected?

no POST, bad motherboard?

case fans have lower voltage requirements

check the power supply output

loud noises: computers should hum, not grind. rattling indicates loose components

scraping might be a hard drive issue (HDD not SSD)

Loud clicking noises in hard drives are not good.

clicking is a fan or hard drive problem, maybe a problem with the PSU

a pop followed by smoke it might be a blown capacitor

intermittent device failure: bad installs. check and reseat, use all the screws

bad hardware, poor connection, heat and vibration

indicator lights: POST codes on the motherboard

power, link light, speed, activity

smoke and burning smell: electrical problems. always disconnect power

locate and replace damaged components

crash screen (BSOD): windows stop error

contains important information, also written to event log

useful when tracking down problems: sometimes more useful for manufacturer support

the spinning ball of death (pinwheel of death) on MacOS: macOS X spinning wait cursor

many possible reasons: application bug, bad hardware, slow paging to disk

log entries: windows event viewer, boot logs in system configuration: C:\Windows\ntbtlog.txt

Linux: individual application logs, /var/log

macOS X: utilities / console.app

error messages: the details of an error message can make or break a troubleshooting session

write down everything, take pictures or video and train your users to do the same

the error might not make sense, write it down anyway, the internet will tell you what it means

this way you spend your time troubleshooting the right things

**Troubleshooting hard drives:**

read/write failure: “cannot read from the source disk”

slow performance, constant LED activity, loud clicking noise

get a backup. check for loose or damaged cables. Check power supply and overheating

run hard drive diagnostics from the manufacturer on a known good computer to check if it’s an OS issue, an issue with the computer itself, or maybe the hard drive is bad

boot failure symptoms: drive not recognized, lights (or no lights), beeps, error messages

“OS not found”. troubleshooting: check your cables (physical problem?)

check boot sequence in BIOS

check for disabled storage interfaces

for a new installation, check hardware configuration. Data and power cables, try different SATA interfaces.

RAID not found: missing or faulty RAID controller

each RAID is different, don’t start pulling drives until you check the console

How many drives can be lost in each RAID array before data loss occurs?

crash screen: windows stop error and apple spinning wait cursor could be a hard drive issue

diagnostics needed for drive and motherboard

**SMART (Self-Monitoring, Analysis and Reporting Technology)**: Use third party utilities

avoid hardware failure, look for warning signs. enables monitoring a system for anticipated HDD failures. schedule disk checks, built in to most drive arrays

there are usually warning signs to replace a drive before data loss or user downtime

**troubleshooting video and display issues**

no video image: is it connected? check both power and signal cables

input selection on monitor: hdmi, dvi, vga, etc

image is dim: check brightness controls

swap the monitor and try it on another computer to check if monitor or PC is the issue

no video after windows loads: usa VGA mode (F8)

image quality problems: flickering, color patterns incorrect: check the cable pins

distorted image and geometry: check the OS refresh rate and resolution settings

native resolution is important on LCD displays, check or replace cable

disable hardware acceleration, troubleshoot with software drivers

image quality problems: oversized images and icons. resolution set too low. lower = larger

burn-in or ghosting: discoloration on the screen, some displays will pixel shift

LCDs have image sticking. remove by displaying a white screen for an extended period

pixel problems: stuck pixels (constantly bright), dead pixels (always black)

artifacts: unusual graphics - check adapter.

image persistence - turn off display

motion trails - disable advanced video features

BSOD and overheating: video drivers, monitor the internal temp

**troubleshooting laptops:**

no display or dim video: verify the backlight. look closely, it may be barely visible

no backlight, replace the inverters

confirm video with an external display: video good but LCD bad, replace the LCD display

flickering video: connector problem, bad video cable, bad video hardware

input issues: sticking keys, difficult to clean. keycaps are very delicate!

ghost cursor / pointer drift: mouse pad causes cursor to bounce around

modify the configuration to check for palm press

update your drivers

letters typing numbers: num lock indicator lights

wireless troubleshooting: multiple antennas, WiFi main and aux, bluetooth, antenna wires wrap around the laptop screen. Easy to accidentally disconnect during maintenance.

check the connectors: loose cables can cause intermittent wireless access

power issues: battery not charging. batteries lose capacity over time. laptop charging hardware may be faulty. try charging battery in an identical laptop

no power: check the external power adapter “brick” with multimeter

master laptop reset: hold power for 10 seconds or a set of keystrokes that provides hardware reset

external monitor issues: fn key that toggles between LCD / external monitor / both

power off the laptop, connect to the external display then turn back on. Laptop default may be set to display to plugged in screen first

**troubleshooting mobile devices:**

touchscreen not responsive: black screen or touchscreen not responding, Erasing all content/settings and restoring the device to factory defaults (factory reset/hard reset)

try reseating device battery, removing screen protector and cleaning the screen

app issues: apps not loading or slow performance. Stop the app and restart

update the app

unable to decrypt email:

built-in to corporate email systems is a private key that is distinct per user

install individual private keys on every mobile device using a mobile device manager (MDM)

short battery life: bad reception, disable unnecessary features. Check application battery usage in settings. Replace aging battery, batteries have a certain number of recharges

phone overheating: things that create heat in a phone include, charging and discharging battery, CPU usage, display light. Check app usage to learn about battery usage. Avoid direct sunlight

Frozen system: nothing works, no screen or button response. Soft resets. ongoing problems may require a factory reset

No sound from speakers: no sound from a particular app? check volume settings, both app and phone settings. Bad software or hardware? use headphones. Sound starts but then stops: dueling apps / keep apps in foreground. no speaker sound from any app? load latest software / factory reset

GPS not functioning: check settings to enable GPS.

configure location mode and what apps are allowed to use location services

Swollen battery: buildup of gas. designed to self-contain. Do NOT open the battery packet/container. Significant fire risk. Faulty battery, stop using immediately and dispose of properly.

**device disassembly best practices:** Many different pieces, intricately engineered and tight quarters. Very easy to take apart but putting back together is a lot harder.

Use manufacturer documentation as a reference

Magnetic mat/separate containers used for holding disassembled parts

Document and label cable and screw locations

Use appropriate hand tools: A good screwdriver, tweezer, and some specialized tools

get a big anti-static cloth, something soft to protect screens, easy to break parts

Laptops disassemble in sections: outer shell, keyboard, video connector, etc.

Step by step process to duplicate in reverse to put back together.

Refer to manufacturer resources for step by step repair guides

the internet provides the rest: online written guides and YouTube videos.

specialized sites can help: ifixit.com

**Troubleshooting printers:** print or scan a test page built into Windows, not the app.

use diagnostic tools, web-based utilities built into the printer. A vendor app or generic app to manage printer

streaks and blurs: lean print heads

blank pages. Low toner or ink

final print: color prints in the wrong color. Low ink on one cartridge

**Laser printer troubleshooting:**

long vertical streaks on the page indicate damage to the imaging drum (NOT clogged print head nozzles)

ghost images on output pages indicates a problem with the cleaning stage

toner falling off a printed copy or output smudges indicate a problem with the fuser assembly

garbled characters means old printer drivers

**depleted toner:** causes faded printouts and blank pages

paper jam: careful when removing, don’t rip the paper or damage the internal components

paper not feeding: check the tray, pickup rollers, part of a laser printer maintenance kit

network issues: powered on? user intervention required. wired cabling / wireless settings

access denied: security tab, print, manage this printer, manage documents

bad output: garbled characters on paper. bad printer driver, wrong model

incorrect page description language: (PCL or PostScript)

bad application: check with a test page outside the app

OS issues: unable to install printer: drivers are important OS updates. user must have permission to install, check the printer driver (23 bit VS 64 bit)

backed up print queue: printer server not working, print spooler crash, restart the spooler, change recovery options

error messages: on the printer display, modern printers have large LCDs

lower memory error: laser printers build the entire page in memory. complex images and graphics consume more memory

no output: check the printer. getting power? check for display messages. run a test print from the printer. Check the connectivity. print a test page from a computer. check direct connections. try across the network. tests the OS, network, drivers and spooler

check other applications. print from a different program?

multiple failed jobs in logs: corrupted print jobs. Print spooler will crash. most spooler configurations will automatically restart. Problems are logged: windows event viewer, windows-printservice. one job may be causing the issues. monitor the queue for details