CompTIA A+

Complete Certification Cheatsheet

Core 1: 220-1101 · Core 2: 220-1102

25	50+	200+	100+
Pages	Diagrams	Exam Tips	Mnemonics

Hardware (Core 1) | **Networking (Core 1)** | **Cloud & Virtualization** | **Security & OS (Core 2)** | **Troubleshooting**

CORE 1 TOPICS (220-1101)

- Mobile Devices & Laptops
- Networking & TCP/IP
- PC Hardware & Components
- Printers & Imaging
- Cloud Computing
- Virtualization

CORE 2 TOPICS (220-1102)

- Windows / Linux / macOS
- Security & Encryption
- Malware & Removal
- Authentication & Access
- SW/HW Troubleshooting
- Operational Procedures

Pass Scores: Core 1 = 675/900 | Core 2 = 700/900 | Validity: 3 Years

Designed for Students · Entry-Level IT Professionals · Community College Programs

Content aligned with CompTIA A+ Exam Objectives for 220-1101 and 220-1102

PAGE 2 ■ PC Hardware Components

Core 1: 220-1101 Domain 3 – Hardware | Form Factors, Components, Common Issues

CompTIA A+ is the industry-standard entry-level IT certification. It covers hardware, networking, OS, security, and troubleshooting across **two exams**: Core 1 (220-1101) and Core 2 (220-1102). You need a score of **675/900 (Core 1)** and **700/900 (Core 2)** to pass.

■ Exam Details

Item	Core 1	Core 2
Questions	90 max	90 max
Duration	90 min	90 min
Passing	675/900	700/900
Question Types	MCQ + PBQ	MCQ + PBQ
Cost	$253 USD	$253 USD
Validity	3 years	3 years

■ Core 1 Domain Weights

Domain	Weight
Mobile Devices	15%
Networking	20%
Hardware	25%
Virtualization & Cloud	11%
Hardware & Network Troubleshooting	29%

■ Core 2 Domain Weights

Domain	Weight
Operating Systems	31%
Security	25%
Software Troubleshooting	22%
Operational Procedures	22%

■■ Recommended Study Plan

Week	Focus Area	Activities
1–2	Hardware + Mobile	Identify all components physically
3–4	Networking + TCP/IP	Memorize ports, subnetting basics
5–6	OS + Command Line	Practice in Windows and Linux VMs
7–8	Security + Threats	Study malware types, authentication
9–10	Troubleshooting	Work through CompTIA's 6-step method
11–12	Practice Exams	Aim for 80%+ before scheduling

■ EXAM TIPS

- PBQs (Performance-Based Questions) appear first — skip them, answer MCQs first, return later.
- There are NO trick questions — choose the BEST answer, not just a correct one.
- Eliminate obviously wrong answers; often 2 choices are clearly incorrect.
- For 'FIRST' questions, always think: Identify Problem → Theory → Test → Fix.
- Don't study outdated material — A+ retires questions over time; use latest objectives.

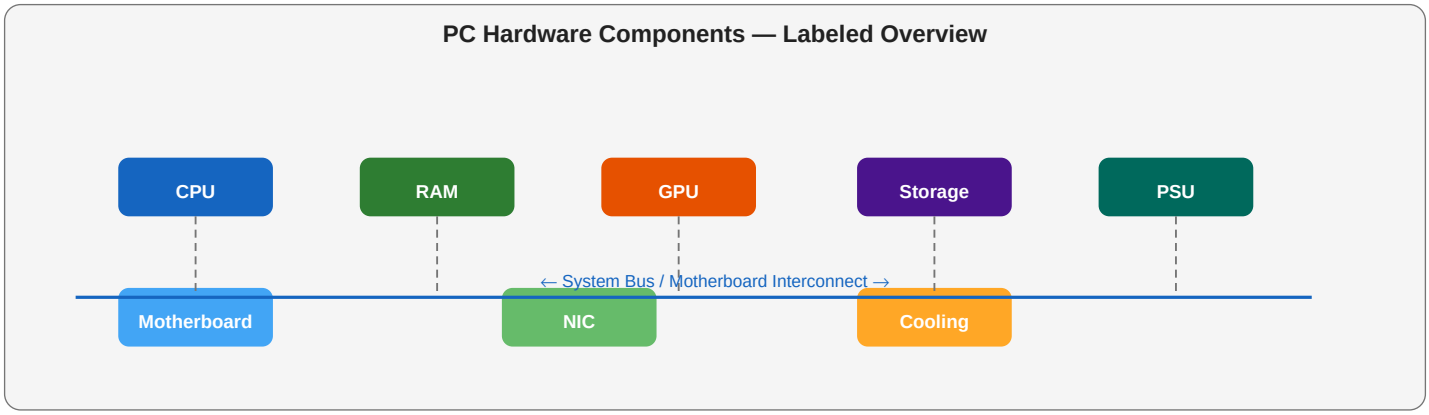
PAGE 3 ■ CPUs, RAM & Storage Types

Core 1: 220-1101 Domain 3 – Hardware | Processing, Memory, Storage Hierarchy

CompTIA A+

■ MEMORY ANCHOR

Core 1 = HARDWARE (what you can touch & connect)
Core 2 = SOFTWARE (what you install & configure)
675 / 700 = Pass scores. Think: '6 for Core 1, 7 for Core 2'
PBQ = 'Please Be Quick' — skip, come back!



■■ Internal Components

- **CPU (Processor)** – Brain of the PC; executes instructions
- **RAM** – Temporary workspace; volatile memory
- **Motherboard** – Connects all components via buses
- **GPU** – Handles graphics rendering; has VRAM
- **PSU** – Converts AC to DC power; ATX form factor
- **Storage (HDD/SSD)** – Permanent data storage
- **NIC** – Network Interface Card; RJ-45 / wireless
- **Sound Card** – Audio input/output processing
- **Expansion Cards** – PCIe slots; GPU, NIC, capture cards

■ Form Factors

Form Factor	Use Case
ATX	Full desktop; most expansion
Micro-ATX	Smaller; fewer PCIe slots
Mini-ITX	Compact; 1 PCIe slot
ITX	Embedded/industrial

■ Power Connectors

- 24-pin ATX – Motherboard main power
- 8-pin EPS – CPU power (4+4 pin)
- 6/8-pin PCIe – GPU power
- SATA power – Drives
- Molex – Older fans/devices

■■ Common Hardware Issues

Symptom	Likely Cause	Fix
No POST / No beep	Bad RAM or CPU	Reseat RAM; test each stick
Beep codes on boot	Hardware failure (BIOS)	Count beeps; check BIOS manual
Random reboots	Overheating / bad PSU	Check temps; replace PSU
Artifacts on screen	GPU overheating/failing	Clean GPU; check drivers
PC won't power on	PSU dead / switch off	Test PSU; check wall outlet
USB not detected	Driver issue / bad port	Try different port/device

PAGE 5 ■ Power Supplies & Cooling

Core 1: 220-1101 Domain 3 – Hardware | PSU Ratings, Connectors, Thermal Management

CompTIA A+

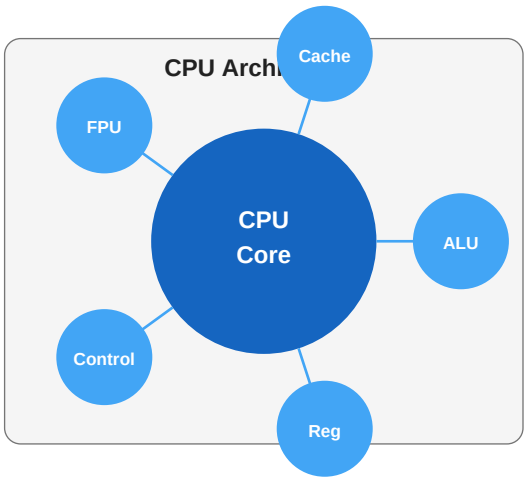
■ EXAM TIPS

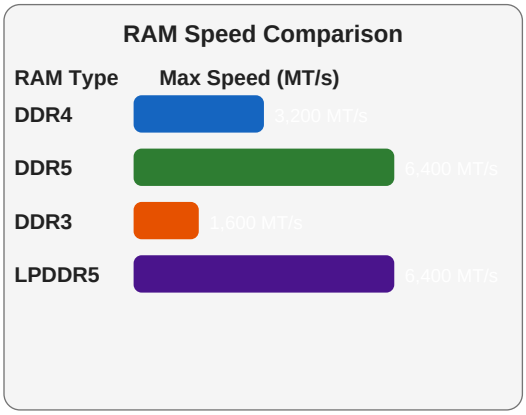
- POST = Power-On Self Test — runs before OS loads.
- Beep codes vary by BIOS manufacturer (AMI, Award, Phoenix) — know the difference.
- ESD (Electrostatic Discharge) can destroy components — always use anti-static wrist strap.
- Adding more RAM is the most cost-effective upgrade for slow computers.

■ MEMORY ANCHOR

CPU-RAM-MOBO-GPU-PSU-STORAGE = 'Can Robots Make Gears, Please Stay?'

Always ground yourself before touching components — ESD kills silently.





■ CPU Concepts

Term	Definition	Why It Matters
Cores	Independent processing units	More cores = better multitasking
Threads	Virtual cores (HyperThreading)	2 threads/core typical
Clock Speed	GHz = billion cycles/sec	Higher = faster (same gen)
Cache	L1/L2/L3 on-chip RAM	L1 fastest, L3 largest
TDP	Thermal Design Power (watts)	Affects cooling requirements
Socket	AM4/AM5 (AMD) LGA1700 (Intel)	Must match motherboard

■ RAM Types & Characteristics

Type	Speed	Pins	Notes
DDR3	800–2133 MT/s	240-pin	Legacy; EoL
DDR4	2133–4800 MT/s	288-pin	Current standard
DDR5	4800–8400 MT/s	288-pin	Latest; higher latency initially
LPDDR5	Up to 6400 MT/s	varies	Mobile/laptops
ECC RAM	Same as DDR4/5	288-pin	Error-correcting; servers
SO-DIMM	DDR3/4/5 speeds	200/260-pin	Laptop form factor

■ Storage Types Comparison

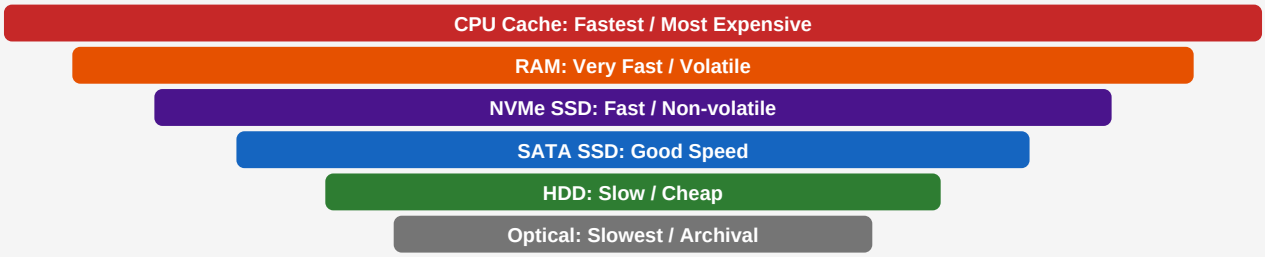
PAGE 7 ■ Ports, Connectors & Cables

Core 1: 220-1101 Domain 3 – Hardware | USB, Video, Network, Storage Cables

CompTIA A+

Storage Hierarchy — Speed vs Cost

← Faster / More Expensive Slower / Cheaper →



Storage Type	Interface	Speed	Best Use
NVMe SSD	PCIe M.2	3500 MB/s+	OS drive, fast workloads
SATA SSD	SATA III	550 MB/s	Budget SSD option
HDD	SATA III	100-150 MB/s	Bulk storage, NAS
Optane	PCIe/M.2	~2000 MB/s	Cache (discontinued)
eMMC	Built-in	~300 MB/s	Budget laptops/tablets

■ EXAM TIPS

- DDR4 and DDR5 are NOT backward compatible — check motherboard specs!
- M.2 slot can use SATA OR NVMe — M.2 is the form factor, not the protocol.
- Dual-channel RAM requires matched pairs in correct slots (A1+B1 or A2+B2).
- Virtual memory = page file on disk when RAM is full — causes slowdowns.

■ MEMORY ANCHOR

RAM slots: 'Match them like socks — same color slots go together'

NVMe > SATA SSD > HDD for speed. Cost is inverse.

Cache L1 < L2 < L3 in size but L1 > L2 > L3 in speed.

The Motherboard is the central PCB connecting all components. It houses the CPU socket, RAM slots, PCIe lanes, chipset, BIOS/UEFI, and I/O ports.

■ Key Motherboard Components

Component	Function	Notes
CPU Socket	Holds the processor	LGA (Intel) pins on board; AM5 (AMD) pins on CPU
Chipset	Controls data flow between CPU, RAM, peripherals	Northbridge + Southbridge (legacy) → unified
DIMM Slots	RAM slots	Usually 2 or 4; dual-channel needs pairs
PCIe Slots	Expansion cards (GPU, NIC, SSD)	x1, x4, x8, x16 — more lanes = more bandwidth
CMOS Battery	Keeps BIOS settings & clock	CR2032; replace if date resets
SATA Ports	Connect drives	Typically 4-6 ports
M.2 Slots	NVMe/SATA SSD	Key B (SATA) or Key M (NVMe/SATA)
VRM (Voltage Regulator)	Stable power to CPU	More VRM phases = better overclocking

■ PCIe Lanes

Slot	Bandwidth (Gen 3)	Common Use
x1	~1 GB/s	Sound/NIC cards
x4	~4 GB/s	NVMe SSDs
x8	~8 GB/s	Some GPUs
x16	~16 GB/s	Main GPU slot

■ BIOS vs UEFI

Feature	BIOS	UEFI
Boot drive size	2TB max	9.4 ZB max
Partition table	MBR	GPT
Interface	Text only	GUI + mouse
Boot speed	Slower	Faster
Secure Boot	No	Yes

■ Bus Types

- **Front Side Bus** – CPU to Northbridge (legacy)
- **PCIe Bus** – Primary expansion bus today
- **SATA Bus** – Storage interface
- **USB Bus** – Peripheral connection
- **LPC Bus** – Low-speed legacy (PS/2, serial)

■■ BIOS/UEFI Settings

- Boot Order – Set SSD first for fast boot
- XMP/DOCP – Enable RAM at rated speed
- Secure Boot – Protects against bootkit malware
- Virtualization (VT-x/AMD-V) – Required for VMs
- TPM 2.0 – Required for Windows 11
- Fan Curves – Control cooling vs. noise

■ EXAM TIPS

- Clearing CMOS (jumper or battery removal) resets ALL BIOS settings to default.
- UEFI requires GPT partition table; BIOS uses MBR. Windows 11 needs UEFI + TPM 2.0.
- A 'No POST' with all parts connected = suspect RAM first (remove and reseat).
- PCIe is backward compatible: x16 card works in x8 slot (at reduced bandwidth).

PAGE 9 ■ Networking Fundamentals

Core 1: 220-1101 Domain 2 – Networking | OSI Model, Devices, Topologies, TCP vs UDP

CompTIA A+

■ MEMORY ANCHOR

BIOS = Basic Input/Output System (old school, limited)

UEFI = 'U Even Interface Features' — modern, GPT, Secure Boot, GUI

MBR max = 2TB. GPT = nearly unlimited. 'GPT = Go Past Two-terabytes'

■ Power Supply Unit (PSU)

Rating	Meaning
80 PLUS	≥80% efficiency at 20/50/100% load
80 PLUS Bronze	≥82% efficiency
80 PLUS Silver	≥85% efficiency
80 PLUS Gold	≥87% efficiency
80 PLUS Platinum	≥90% efficiency
80 PLUS Titanium	≥94% efficiency

■ PSU Connectors

- 24-pin ATX – Motherboard main power
- 4+4 pin EPS – CPU/motherboard
- 6+2 pin PCIe – GPU power
- 15-pin SATA – Drive power
- 4-pin Molex – Legacy fans/optical
- 4-pin Berg – Floppy (legacy)

■ Sizing Your PSU

- Calculate total wattage of all components
- Add 20-30% headroom for safety
- GPU is typically biggest consumer (150-400W)
- Modular PSU = only plug in what you need

■■ Cooling Solutions

Type	Pros	Cons
Stock Fan	Free, easy	Loud, average
Aftermarket HSF	Better temps	Bulky
AIO Liquid	Great cooling	Cost, leaks
Custom Loop	Best cooling	Complex/cost
Thermal Paste	Improves contact	Must apply correctly

■ Thermal Management

- Ideal CPU temp: under 80°C under full load
- GPU safe: under 90°C; throttles above that
- Check temps with HWMonitor, Core Temp
- Positive air pressure: more intake than exhaust
- Clean dust filters every 3-6 months
- Replace thermal paste every 2-4 years

■■ Overheating Symptoms

- Random shutdowns or reboots
- Thermal throttling (sudden FPS drops)
- BSOD with thermal errors
- Loud fan noise at idle
- System won't boot (thermal protection)

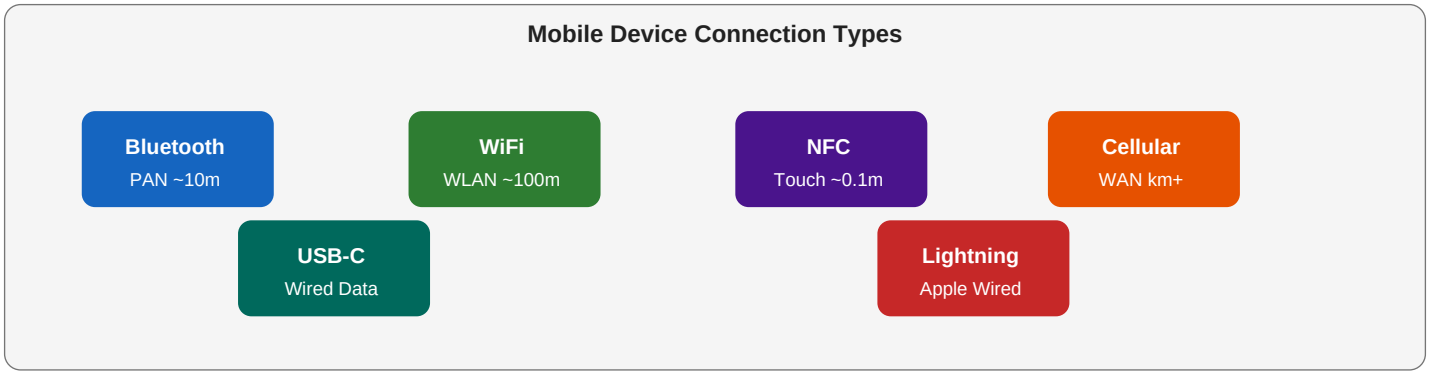
PSU Type	Description	Best For
Non-modular	All cables attached permanently	Budget builds
Semi-modular	Main cables fixed, others optional	Mid-range
Fully modular	All cables detachable	Clean builds, enthusiast
SFX	Small form factor	Mini-ITX builds

■ EXAM TIPS

- A failing PSU causes random reboots, instability, and can damage other components.
- Always turn off PSU and unplug before working inside the case.
- Thermal paste should be pea-sized in center — pressure spreads it evenly.
- ATX 3.0 standard introduces 12VHPWR connector for high-end GPUs (600W).

■ MEMORY ANCHOR

80 PLUS ratings: White → Bronze → Silver → Gold → Platinum → Titanium
Wattage formula: (CPU + GPU + RAM×2 + drives×5) × 1.25 = recommended PSU
Remember: 'Dead PSU = Dead PC' — buy quality brands (Corsair, Seasonic, EVGA)



■ Laptop Features

Component	Laptop Equivalent
RAM	SO-DIMM (soldered on many)
Storage	M.2 or eMMC (2.5" rare)
Display	LCD/IPS/OLED, 60-360Hz
Battery	Li-Ion/Li-Po; mWh rated
Cooling	Heat pipe + exhaust fan
Keyboard	Chiclet/low-profile
Webcam	720p-4K, IR for Win Hello

■ Smartphone/Tablet

- **iOS** – Apple; closed ecosystem; AirDrop, iMessage
- **Android** – Open; Google Play; sideloading possible
- **Biometrics** – Fingerprint, face unlock, iris
- **5G Bands** – Sub-6 GHz (range) + mmWave (speed)
- **eSIM** – Digital SIM; no physical card needed

■ Battery Technologies

Type	Characteristic
Li-Ion	Common; memory effect minimal
Li-Po	Thin/flexible; phones/tablets
NiMH	Older; has memory effect
NiCd	Legacy; toxic; memory effect

■ Mobile Connectivity

- **Bluetooth 5.x** – 40 Mbps, 400m range, BLE
- **NFC** – 13.56 MHz, ~10cm, payments/tags
- **WiFi 6E** – 6 GHz band, lower interference
- **GPS** – Location via satellite (passive)
- **A-GPS** – Assisted GPS; uses cell towers
- **IR Blaster** – Controls TV/devices; uncommon

■ Mobile Troubleshooting

- No signal → Check airplane mode, carrier outage
- Won't charge → Try different cable/adapter
- Overheating → Remove case, check battery
- Touchscreen issue → Clean screen, check digitizer
- Apps crashing → Clear cache/data, reinstall

Laptop Issue	Diagnosis	Solution
Screen dim/off	Backlight fail / display cable	Adjust brightness; check connection
Battery not charging	Charger, port, or battery	Test with different charger
Keyboard key stuck	Debris under key	Compressed air; keycap removal
Fan loud always	Thermal paste / clogged vents	Clean vents; repaste CPU
WiFi drops frequently	Driver or antenna issue	Update driver; check antenna cable

PAGE 12 ■ Cloud Computing Concepts

Core 1: 220-1101 Domain 4 – Virtualization & Cloud | IaaS, PaaS, SaaS, Deployment Models

CompTIA A+

■ EXAM TIPS

- MDM (Mobile Device Management) allows IT to remotely wipe lost/stolen devices.
- Screen rotation lock is in Control Center/Quick Settings — common ticket!
- iOS backup: iCloud or Finder (macOS)/iTunes (Windows).
- Android backup: Google One or manufacturer cloud services.
- Airplane mode disables ALL radios (cell, WiFi, BT) — then re-enable WiFi/BT individually.

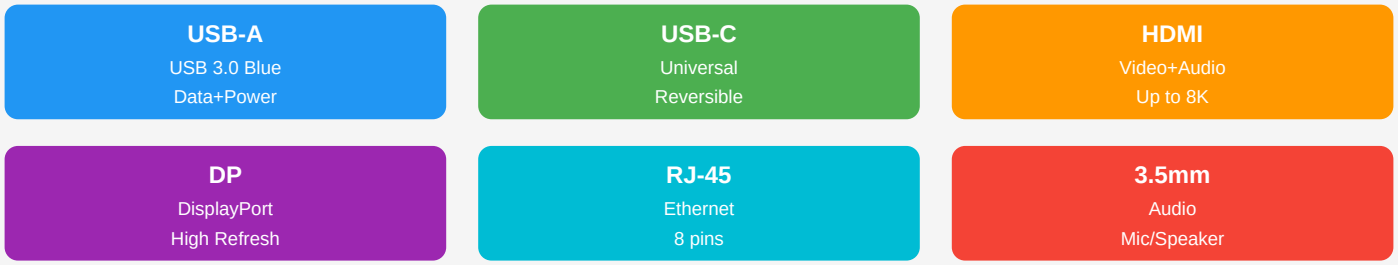
■ MEMORY ANCHOR

Mobile connections: 'BIG NFC' = Bluetooth, IR, GPS, NFC, Cellular (5G/4G)

Li-Ion vs Li-Po: Li-Po is flatter/flexible (like a pad vs bottle)

MDM = 'Mobile Devices Managed' — think corporate control of devices

Common Ports & Connectors Reference



■ USB Standards

Standard	Speed	Max Power	Connector
USB 1.1	12 Mbps	2.5W	Type-A/B
USB 2.0	480 Mbps	2.5W	Type-A/B/Mini
USB 3.2 Gen1	5 Gbps	4.5W	Type-A/C
USB 3.2 Gen2	10 Gbps	4.5W	Type-A/C
USB 3.2 Gen2x2	20 Gbps	100W	Type-C
USB4 Gen3x2	40 Gbps	240W	Type-C
Thunderbolt 4	40 Gbps	100W	Type-C

■ Video Connectors

Connector	Max Res	Audio?	Notes
VGA	2048x1536	No	Analog; legacy
DVI	2560x1600	No	Digital; legacy
HDMI 2.1	10K@120Hz	Yes	Most common
DisplayPort 2.1	16K	Yes	High refresh
Thunderbolt 4	8K	Yes	Dual 4K

■ Storage Connectors

- **SATA** – 7-pin data, 15-pin power; 6 Gbps
- **M.2 Key-M** – NVMe or SATA SSD
- **M.2 Key-B** – SATA only (or WWAN)
- **eSATA** – External SATA; older
- **SAS** – Enterprise; hot-swap capable

■ Network Cables

Cable Type	Speed	Max Distance	Use Case
Cat5e	1 Gbps	100m	Home/office LAN
Cat6	10 Gbps	55m (10G)	Modern office
Cat6a	10 Gbps	100m	Data centers
Cat7	10 Gbps	100m	Shielded; industrial
Cat8	25/40 Gbps	30m	Data centers
Fiber (SMF)	100+ Gbps	80 km	Long-distance WAN
Fiber (MMF)	10-100 Gbps	550m	Campus networks
Coax (RG-6)	~1 Gbps	300m	Cable TV/Internet

PAGE 14 ■ Operating Systems Overview

Core 2: 220-1102 Domain 1 – Operating Systems | Windows, Linux, macOS Comparison

CompTIA A+

■ EXAM TIPS

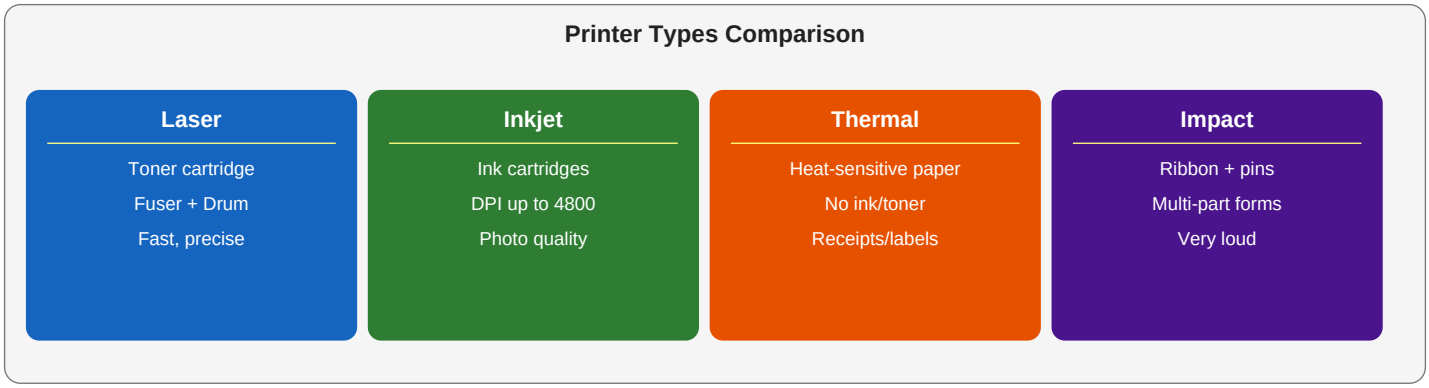
- USB-C is a connector SHAPE — it can carry USB, Thunderbolt, DisplayPort, or power.
- Blue USB port = USB 3.x | Black = USB 2.0 | Red = USB charging (always-on power).
- Straight-through cable = different devices (PC to switch); Crossover = same devices.
- 568A vs 568B: Use 568B for both ends (straight-through) = T568B standard.
- Fiber: Single-mode (yellow) = long distance; Multi-mode (orange/aqua) = short distance.

■ MEMORY ANCHOR

568B wiring order: 'White-Orange, Orange, White-Green, Blue, White-Blue, Green, White-Brown, Br

USB color guide: Black=2.0, Blue=3.0, Red=charging, Teal=3.1

SMF = Single-Mode Fiber = Slim beam, goes far. MMF = Multi-Mode = fatter, shorter.



■■ Laser Printer Process

Step	Phase	What Happens
1	Processing	RIP converts data to image
2	Charging	Drum charged to -600V
3	Exposing	Laser writes image (reduces charge)
4	Developing	Toner attracted to exposed areas
5	Transferring	Toner moves to paper
6	Fusing	Heat+pressure bonds toner
7	Cleaning	Excess toner removed from drum

■■ Inkjet Details

- **Thermal inkjet** – Heat bubble pushes ink (HP)
- **Piezoelectric** – Electric crystal squeezes ink (Epson)
- **DPI** – 300-4800 DPI typical
- **Nozzle clogs** – Run head cleaning utility
- **Calibration** – Align print head for accuracy

■ Printer Troubleshooting

Problem	Solution
Paper jam	Remove paper gently; check rollers
Faded prints	Low toner; replace cartridge
Ghosting	Fuser or drum issue
Vertical lines	Dirty drum or toner low
Won't print	Check queue, spooler, driver
Smearing	Fuser failure (laser)

■ Printer Types Quick Reference

Type	Technology	Cost/Page	Best For	Special Notes
Laser	Toner + heat fuser	Low	High-volume text	Warm-up time needed
Inkjet	Liquid ink	Medium	Photo printing	Heads can dry out
Thermal	Heat-sensitive paper	Very Low	Receipts, labels	No ink/toner needed
Impact/Dot Matrix	Ribbon + pins	Very Low	Multi-part forms	Extremely loud
3D Printer	Filament/resin	High	Prototyping	FDM/SLA types
Plotter	Vector + pens/ink	High	CAD/blueprints	Large format

PAGE 16 ■ System Configuration & Control Panel

Core 2: 220-1102 Domain 1 – Operating Systems | Admin Tools, Registry, Updates

CompTIA A+

■ EXAM TIPS

- Laser printer step order: DECFTC = 'Don't Expose Clients For Tax Compliance' (De/Ex/Dev/Trans
- Ghosting = faint repeat image = worn drum or fuser issue.
- Paper jam repeatedly = worn pickup rollers — replace them.
- Thermal printers use heat-sensitive paper — store away from sunlight/heat.
- Calibrate printer after replacing cartridge to ensure accurate color output.

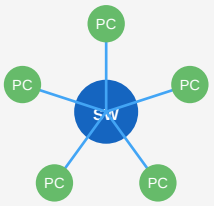
■ MEMORY ANCHOR

Laser steps: 'Processing, Charging, Exposing, Developing, Transferring, Fusing, Cleaning'

Mnemonic: 'Please Charge Every Developer To Fix Code'

Fuser = heat. Drum = image. Toner = powder. All three needed for laser printing.

Network Topologies — Star vs Bus



Star (Most Common)

Bus (Legacy)

Ring: Each node connects to 2 others | Mesh: Every node to every node

■ Network Types

Type	Scope	Example
PAN	~10m	Bluetooth headset
LAN	Building	Office network
MAN	City	City fiber ring
WAN	Country/World	Internet
WLAN	Wireless LAN	WiFi office
SAN	Storage net	Data center
CAN	Campus	University net

■ Network Devices

- **Hub** – Broadcasts to ALL ports; layer 1; obsolete
- **Switch** – MAC-based forwarding; layer 2
- **Router** – IP routing; layer 3; connects networks
- **AP** – Wireless Access Point; extends LAN wirelessly
- **Firewall** – Filters traffic by rules; layer 3-7
- **Modem** – Modulates/demodulates signal (ISP connection)
- **PoE Switch** – Powers devices via Ethernet cable
- **Load Balancer** – Distributes traffic across servers

■ OSI Model (All 7 Layers)

Layer	Name	Protocol/Device
7	Application	HTTP, FTP, DNS, SMTP
6	Presentation	SSL/TLS, JPEG, ASCII
5	Session	NetBIOS, RPC, SQL
4	Transport	TCP, UDP, ports
3	Network	IP, ICMP, Router
2	Data Link	MAC, Switch, Ethernet
1	Physical	Cables, Hubs, Bits

TCP vs UDP

Feature	TCP	UDP
Connection	Connection-oriented	Connectionless
Reliability	Guaranteed delivery	Best-effort
Speed	Slower	Faster
Order	In-order delivery	No guarantee
Use Case	HTTP, FTP, email	Video, VoIP, DNS

■ EXAM TIPS

- OSI Layer 7 = user-facing; Layer 1 = physical signals. Data flows DOWN sender, UP receiver.
- Switches use MAC addresses (Layer 2); Routers use IP addresses (Layer 3).
- Hub = dumb (broadcasts); Switch = smart (targeted); Router = routes between networks.
- PoE standard: IEEE 802.3af (15.4W), 802.3at (30W), 802.3bt (90W).

PAGE 18 ■ Malware Types & Removal

Core 2: 220-1102 Domain 2 – Security | Malware Categories, Lifecycle, Removal Steps

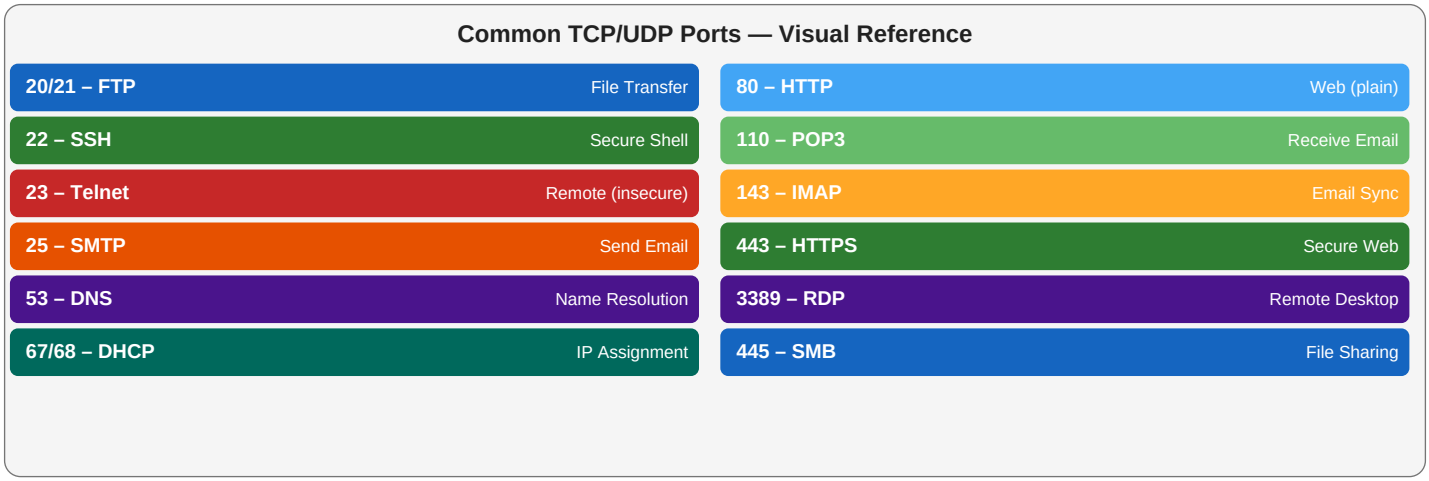
CompTIA A+

■ MEMORY ANCHOR

OSI 7→1: 'All People Seem To Need Data Processing'

Application, Presentation, Session, Transport, Network, Data Link, Physical

TCP = 'Totally Careful Protocol' | UDP = 'Unreliable Delivery Protocol'



■ Complete Protocol Reference

Port	Protocol	Layer	TCP/UDP	Description
20/21	FTP	App	TCP	File Transfer (21=control, 20=data)
22	SSH	App	TCP	Encrypted remote shell
23	Telnet	App	TCP	Unencrypted remote shell (insecure)
25	SMTP	App	TCP	Send email (server-to-server)
53	DNS	App	TCP/UDP	Domain name resolution
67/68	DHCP	App	UDP	Dynamic IP assignment
69	TFTP	App	UDP	Trivial FTP; no authentication
80	HTTP	App	TCP	Web traffic (unencrypted)
110	POP3	App	TCP	Download email (deletes from server)
119	NNTP	App	TCP	Usenet newsgroups
123	NTP	App	UDP	Time synchronization
137-139	NetBIOS	App	TCP/UDP	Windows name resolution
143	IMAP	App	TCP	Email sync (leaves on server)
161/162	SNMP	App	UDP	Network device monitoring
389	LDAP	App	TCP	Directory services
443	HTTPS	App	TCP	Secure web (SSL/TLS)
445	SMB	App	TCP	Windows file sharing
636	LDAPS	App	TCP	Secure LDAP
3389	RDP	App	TCP	Remote Desktop Protocol
5900	VNC	App	TCP	Virtual Network Computing

PAGE 20 ■ Software Troubleshooting

Core 2: 220-1102 Domain 3 – Software Troubleshooting | Windows, macOS, Linux

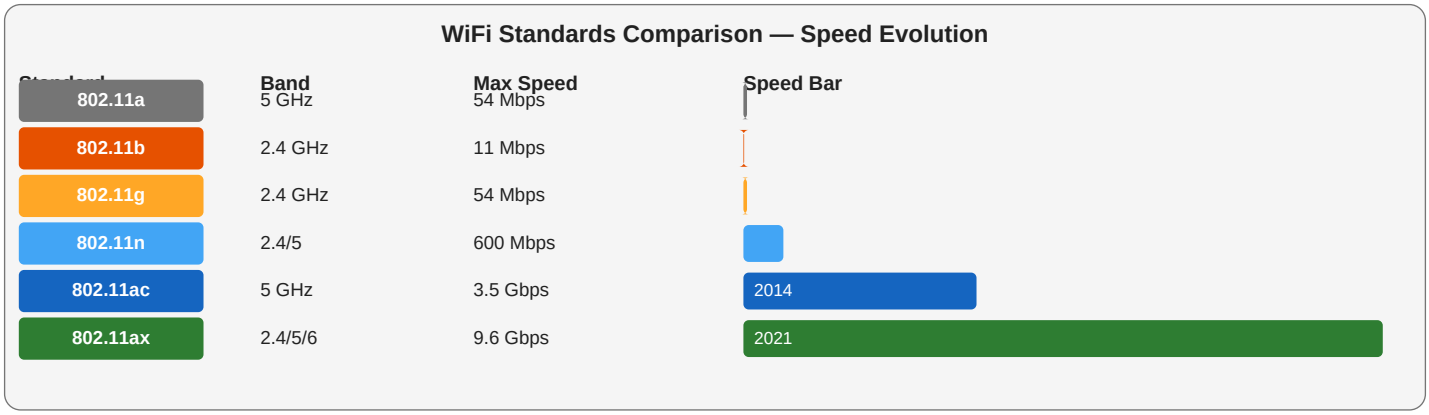
CompTIA A+

■ EXAM TIPS

- Know these cold: 22=SSH, 23=Telnet, 25=SMTP, 53=DNS, 80=HTTP, 443=HTTPS, 3389=RDP.
- DNS uses UDP (port 53) for queries but TCP (port 53) for zone transfers.
- POP3 (110) downloads and deletes; IMAP (143) syncs and leaves on server.
- TFTP (69) = no authentication — never use for sensitive transfers!
- DHCP is UDP: client broadcasts to 255.255.255.255 to find a server.

■ MEMORY ANCHOR

SSH=22, Telnet=23 (one above, more secure — think upgrade!)
FTP=21(control)/20(data), HTTP=80, HTTPS=443, RDP=3389
DHCP: 'DORA' = Discover, Offer, Request, Acknowledge
DNS=53: 'Five-Three makes names free' (resolves hostnames)



■ WiFi Frequency Bands

Band	Range	Speed	Interference
2.4 GHz	Longer	Lower	High (microwaves, BT)
5 GHz	Shorter	Higher	Lower
6 GHz	Shortest	Highest	Minimal

■ Wireless Security Protocols

Protocol	Encryption	Status
WEP	RC4 40/128-bit	BROKEN — Never use
WPA	TKIP	Weak — Legacy
WPA2	AES-CCMP	Current standard
WPA3	SAE (192-bit)	Most secure
Open	None	Public hotspots only

■ WiFi Channels

- 2.4 GHz: Channels 1-14 (1-11 in USA)
- Non-overlapping: 1, 6, 11
- 5 GHz: Channels 36-165; wider; less overlap
- DFS channels: Radar-shared; may cause drops

■ SOHO Network Setup

- **ISP Modem** → WAN port of router
- **Router** → DHCP server for local IPs
- **Switch** → Expands wired ports
- **Access Point** → Extends wireless coverage
- **DMZ** → Isolated zone for public servers

■■ Wireless Troubleshooting

Problem	Cause	Fix
Slow WiFi	Channel congestion	Change channel; use 5GHz
Drops frequently	Interference	Move AP; check band
Can't connect	Wrong password	Verify SSID/password
Poor range	Walls/distance	Add AP; use repeater
No internet	DNS/DHCP issue	ipconfig /renew

■ AP Placement Tips

- Central location; minimize walls between
- Avoid microwaves, cordless phones near AP
- Use multiple APs (mesh) for large areas
- Antenna: omni = all directions; directional = targeted

■ EXAM TIPS

- WEP is completely broken — if an exam asks for 'most secure,' it's WPA3, then WPA2-AES.
- SSID broadcast can be hidden but provides NO real security — use strong encryption instead.
- 802.11ax = WiFi 6; 802.11ac = WiFi 5; 802.11n = WiFi 4 (marketing names).
- MAC filtering is security through obscurity — easily bypassed with MAC spoofing.

PAGE 22 ■ Networking Troubleshooting

Core 1+2: 220-1101/1102 Troubleshooting | Diagnostic Tools, Layer-by-Layer Approach

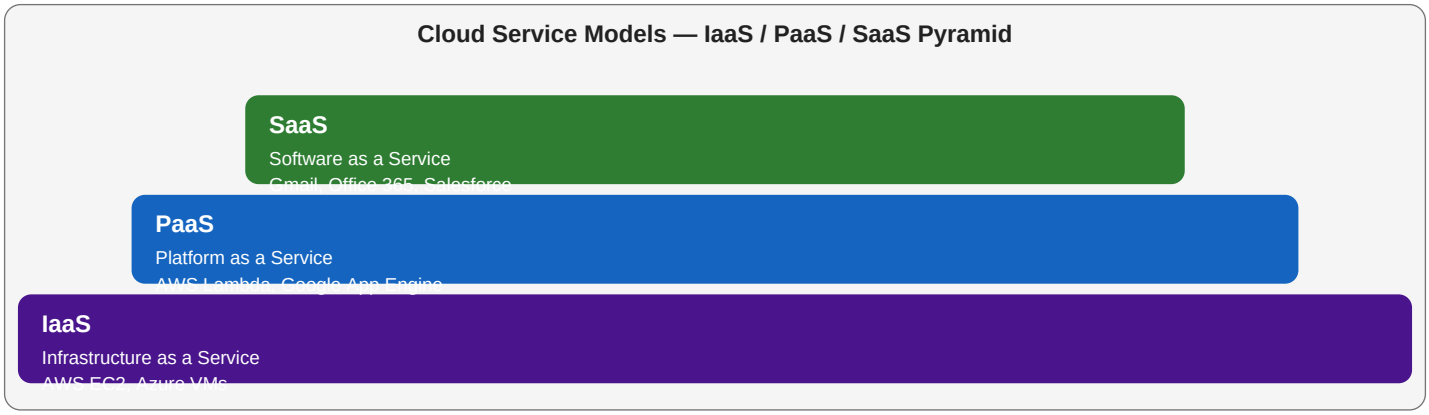
CompTIA A+

■ MEMORY ANCHOR

WEP=Weak, WPA=Weak-Plus, WPA2=Working, WPA3=Winner!

Non-overlapping 2.4GHz channels: 1, 6, 11 — 'Like a ruler: 1 foot, 6 inches, 11 inches'

WiFi generations: WiFi 4=N, WiFi 5=AC, WiFi 6=AX, WiFi 6E=AX+6GHz



■■ Cloud Service Models

Model	You Manage	Provider Manages	Example
IaaS	OS, Apps, Data	Hardware, network	AWS EC2, Azure VMs
PaaS	Apps, Data	OS, runtime, HW	Heroku, Google AppEngine
SaaS	Data only	Everything else	Gmail, Office 36■
DaaS	Desktop app	VDI infrastructure	Azure Virtual Desktop
SECaaS	Policy	Security services	Cloudflare, ZScaler

■ Cloud Deployment Models

Model	Access	Best For
Public	Via internet	Cost-effective; scalable
Private	Internal only	Sensitive data; compliance
Hybrid	Both	Flexibility; burst capacity
Community	Shared orgs	Government, healthcare
Multi-cloud	Multiple providers	Avoid vendor lock-in

■ Cloud Characteristics (NIST)

- **On-demand self-service** – Provision without human interaction
- **Broad network access** – Access from any device
- **Resource pooling** – Multi-tenant shared resources
- **Rapid elasticity** – Scale up/down instantly
- **Measured service** – Pay-per-use metering

■ Cloud Technologies

- **CDN** – Content Delivery Network; edge caching
- **Load Balancer** – Distributes traffic across servers
- **Auto-scaling** – Add/remove instances automatically
- **Containers** – Docker; lightweight VMs; portable
- **Kubernetes** – Container orchestration
- **Serverless** – AWS Lambda; no server management

■ Cloud Economics

- CapEx → OpEx shift (no hardware purchase)
- Pay-as-you-go pricing model
- Reserved instances = 30-60% savings
- Spot instances = up to 90% savings (interruptible)

Concept	Definition
Availability Zone	Isolated data center within a region
Region	Geographic cluster of data centers
Edge Location	CDN cache closer to users
VPC	Virtual Private Cloud — isolated network in public cloud

PAGE 24 ■ Documentation, Change Management & Safety

Core 2: 220-1102 Domain 4 – Operational Procedures | Ticketing, Compliance, Safety

CompTIA A+

Concept	Definition
S3/Blob Storage	Object storage for files, backups, media
Metered Utilization	Usage tracked and billed by consumption

■ EXAM TIPS

- IaaS = most control; SaaS = least control but least management overhead.
- Shared responsibility model: Provider secures the cloud; YOU secure data IN the cloud.
- High availability in cloud = multiple AZs; disaster recovery = different regions.
- Cloud bursting = using public cloud when private capacity is exceeded.

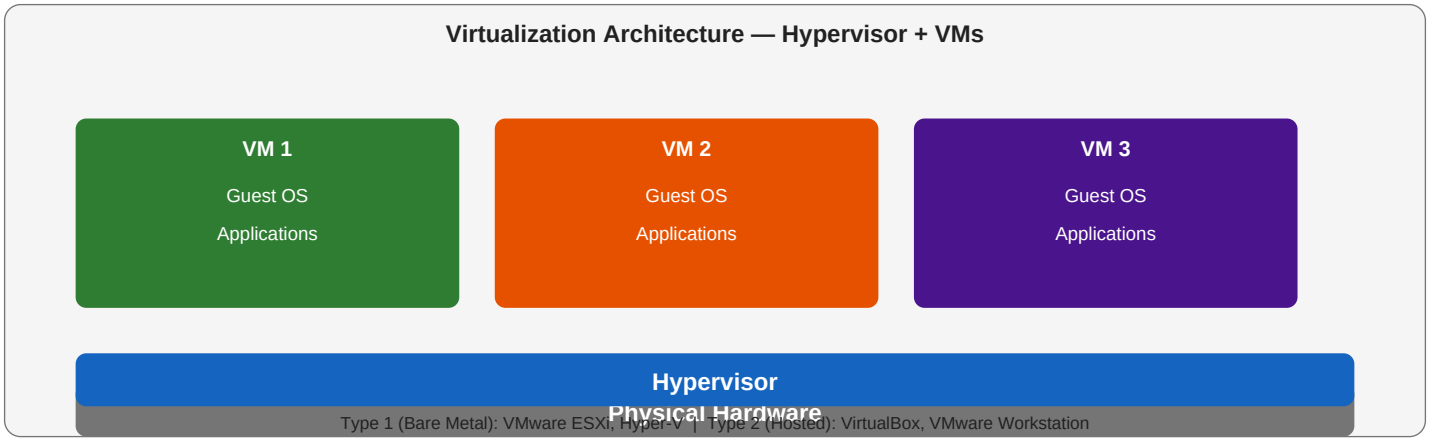
■ MEMORY ANCHOR

IaaS/PaaS/SaaS from bottom up: 'I Pulled Several S's from the cloud sky'
NIST cloud: On-demand, Broad, Resource, Elastic, Measured = 'OBREIM'
Hybrid cloud = 'best of both worlds' = private security + public scalability

PAGE 25 ■ Final Review + Rapid Recall Sheet

Core 1 & Core 2 Combined | Essential Facts, Mnemonics, Last-Minute Exam Prep

CompTIA A+



■ Hypervisor Types

Type	Description	Examples
Type 1 (Bare Metal)	Runs directly on hardware	VMware ESXi, Hyper-V, Xen
Type 2 (Hosted)	Runs inside host OS	VirtualBox, VMware Workstation

■ VM Components

- **vCPU** – Virtual CPU assigned to VM
- **vRAM** – Portion of host RAM allocated
- **vDisk** – Virtual disk file (.vmdk, .vhd, .vdi)
- **vNIC** – Virtual network card
- **Snapshot** – VM state capture for rollback
- **Template** – Pre-configured VM image for rapid deploy
- **Clone** – Full or linked copy of a VM

■ Container vs VM

Feature	Container	VM
OS	Shared kernel	Full OS each
Size	MB	GB
Start time	Seconds	Minutes
Isolation	Process-level	Full isolation
Overhead	Minimal	Significant
Tool	Docker	VMware/VBox

■■ VM Network Modes

Mode	Behavior
NAT	VM shares host IP; internet access
Bridged	VM gets own IP on LAN
Host-Only	VM talks to host only; no internet
Internal	VMs talk to each other only

■ Benefits of Virtualization

- Hardware consolidation – fewer physical servers
- Isolation – VMs don't affect each other
- Rapid provisioning – deploy in minutes
- Disaster recovery – snapshot and restore
- Testing – sandboxed environments
- Cost savings – power, cooling, space

■■ Resource Requirements

- CPU: Enable VT-x (Intel) or AMD-V in BIOS
- RAM: Host needs extra beyond VM allocations
- Storage: SSDs dramatically improve VM performance
- Network: Separate vLAN for VMs recommended
- Overcommit: Allocate more vRAM than physical (risky)

Virtualization Concept	Definition
Live Migration	Move running VM between hosts without downtime
vMotion (VMware)	Live migration technology
High Availability (HA)	Auto-restart VMs on failure

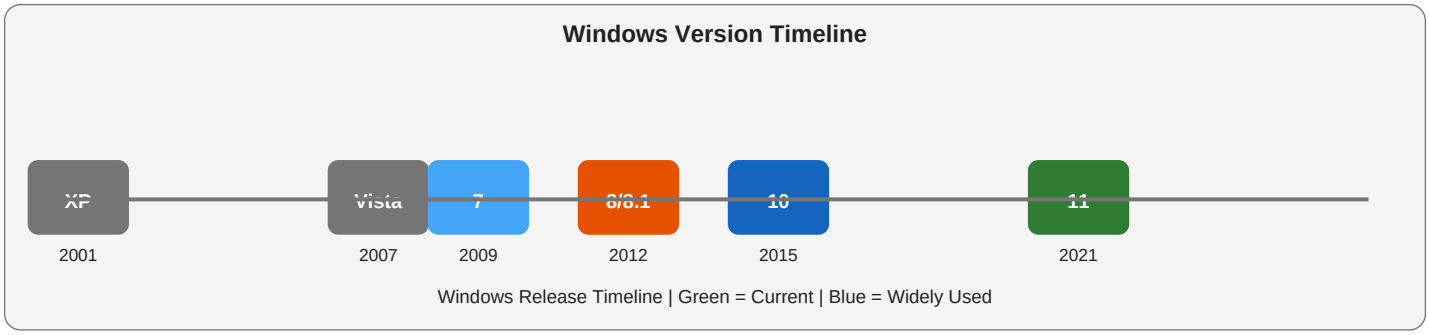
Virtualization Concept	Definition
DRS	Dynamic Resource Scheduling — balances load
VDI	Virtual Desktop Infrastructure — desktop from cloud
PaaS Containers	Platform uses containers behind the scenes

■ EXAM TIPS

- Type 1 hypervisor = more efficient = enterprise (bare metal).
- Type 2 hypervisor = easier to set up = home lab / testing.
- Containers are NOT VMs — they share the host OS kernel.
- Snapshots are NOT backups — they depend on original VM files.
- Enable VT-x/AMD-V in BIOS or VMs won't start in Type 2 hypervisors.

■ MEMORY ANCHOR

Type 1 = 'First-class on bare metal' | Type 2 = 'Second floor on top of an OS'
Container = 'apartment in a building (shared foundation)' | VM = 'separate house'
Snapshot ≠ Backup: 'Snapshots are for rollback, backups are for recovery'



OS	Key Features	File System	Command Shell
Windows 10	Start menu, WSL, Virtual desktops	NTFS, FAT32	CMD, PowerShell
Windows 11	TPM 2.0 req, new UI, Teams built-in	NTFS, ReFS	CMD, PowerShell
macOS Ventura+	Continuity, Handoff, Time Machine	APFS, HFS+	Zsh, Bash
Ubuntu Linux	APT packages, open source	ext4, btrfs	Bash, Zsh
Chrome OS	Web-based, Android apps	ext4	Crosh

■ Windows Editions

Edition	Key Difference
Home	Consumer; no domain join; no BitLocker policy
Pro	Domain join, BitLocker, Remote Desktop, Hyper-V
Enterprise	AppLocker, DirectAccess, BranchCache
Education	Enterprise features for schools
LTSC	Long-term servicing; no store apps
Server	Active Directory, DNS, DHCP, IIS roles

■ Linux Distributions

Distro	Based On	Best For
Ubuntu	Debian	Desktop/server
Kali	Debian	Pen testing
CentOS/RHEL	Red Hat	Enterprise server
Fedora	Red Hat	Cutting edge
Alpine	Independent	Containers
Raspbian	Debian	Raspberry Pi

■ macOS Unique Features

- Time Machine – automatic incremental backup
- Spotlight – system-wide search (Cmd+Space)
- Finder – file manager (like Windows Explorer)
- Disk Utility – partition/format/repair drives
- Activity Monitor – like Task Manager
- Terminal – Unix bash shell available

Concept	Windows	Linux/macOS
Package Mgmt	MSI, .exe, Store	apt, yum, brew, snap
File Permissions	ACL, NTFS	rwxrwxrwx (chmod)
Process Viewer	Task Manager	top, htop, ps
Disk Format	Disk Management	fdisk, gparted

Concept	Windows	Linux/macOS
Services	Services.msc	systemctl, service
Remote Access	RDP (3389)	SSH (22)

■ EXAM TIPS

- Windows Home cannot join a domain (Active Directory) — must use Pro or higher.
- NTFS supports permissions, encryption (EFS), and compression — FAT32 does not.
- macOS uses APFS (Apple File System) for SSDs since macOS High Sierra.
- Linux is case-sensitive: 'File.txt' and 'file.txt' are DIFFERENT files.

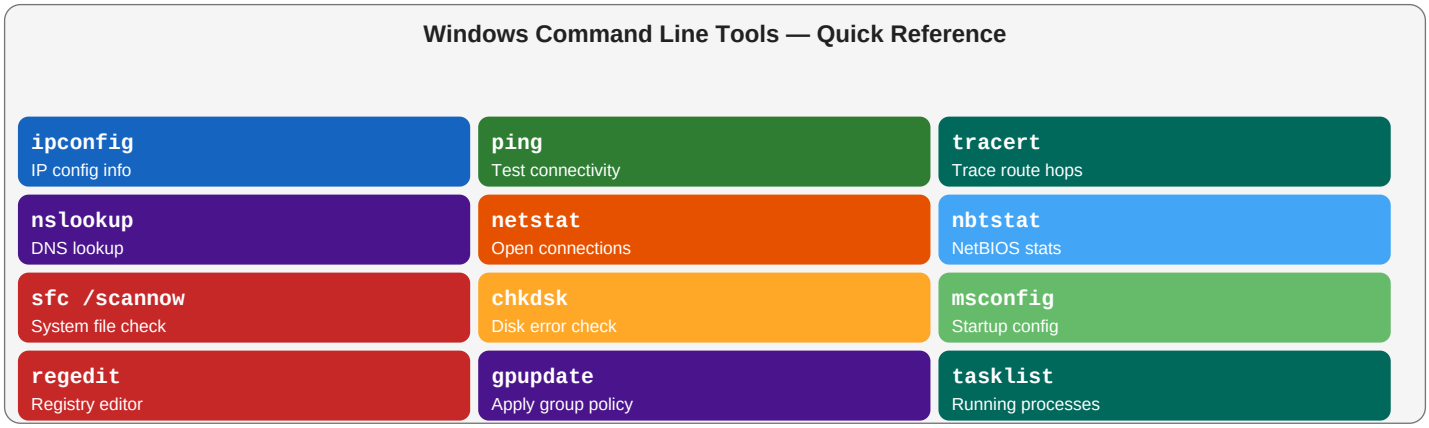
■ MEMORY ANCHOR

Windows Home vs Pro: Pro = 'Professional Domain' access

NTFS = 'No Trouble For Security' | FAT32 = 'Fat and Dumb (no permissions)'

Linux file ownership: rwxrwxrwx = User/Group/Other — chmod 755 = rwxr-xr-x

Windows Command Line Tools — Quick Reference



■■ Essential CMD Commands

Command	Function	Key Switch
ipconfig	Show IP config	/all /release /renew /flushdns
ping	Test connectivity	-t (continuous) -l (size)
tracert	Trace route	-d (no DNS resolve)
nslookup	DNS query	nslookup domain server
netstat	Connections	-a (all) -n (numeric) -b (process)
arp -a	ARP cache	Shows IP→MAC mappings
route print	Routing table	Shows gateway routes
nbtstat -n	NetBIOS names	-r (cache) -A (remote)
pathping	Ping + tracert combo	Shows loss per hop
net use	Map network drives	net use Z: \\server\share
net user	User accounts	net user /add name pass
shutdown	Shutdown/restart	/s /r /t 0 /f

■ PowerShell Commands

Cmdlet	Equivalent / Function
Get-Process	tasklist
Stop-Process	taskkill
Get-Service	List all services
Set-ExecutionPolicy	Allow scripts to run
Get-Command	List all cmdlets
Invoke-WebRequest	wget / curl
Get-NetIPAddress	ipconfig /all
Test-NetConnection	ping + port test
Get-EventLog	View event logs
Get-Acl	View permissions

■ File Management Commands

Command	Action
dir /a	List all files (hidden too)
copy / xcopy / robocopy	Copy files
del /f /q	Force delete
mkdir / md	Create directory
rmdir /s /q	Remove dir + contents
attrib +h +s	Hide/system attribute
sfc /scannow	Check system files
chkdsk /f /r	Fix disk errors
diskpart	Partition management
format	Format drive

■ EXAM TIPS

- ipconfig /flushdns clears DNS cache — fixes 'wrong site' loading issues.
- sfc /scannow repairs corrupted Windows system files — run as Administrator.
- chkdsk /f schedules disk check on next reboot (can't run on active drive).
- PowerShell Execution Policy: Set-ExecutionPolicy RemoteSigned (allows local scripts).
- runas /user:admin cmd — run command as different user (like sudo on Linux).

■ MEMORY ANCHOR

ipconfig shows WHERE you are | ping tests IF you can get there
tracert = 'trace route' = shows every hop between you and destination
nslookup = 'Name Server Lookup' = asks DNS servers for IP of a hostname
netstat -an = all active connections with port numbers (no DNS lookup = faster)

Windows system configuration tools allow administrators to manage startup, services, performance, and system settings. Knowing **where to find these tools** is a key A+ exam skill.

■■ Key Administrative Tools

Tool	Access	Function
Task Manager	Ctrl+Shift+Esc	Processes, performance, startup apps
Device Manager	devmgmt.msc	Hardware drivers, conflicts
Disk Management	diskmgmt.msc	Partitions, volumes, format
Services	services.msc	Start/stop/configure Windows services
Event Viewer	eventvwr.msc	System/app/security logs
Group Policy Editor	gpedit.msc	Policies (Pro/Enterprise only)
Registry Editor	regedit.exe	Windows registry (DANGER: back up first!)
System Config	msconfig.exe	Boot options, startup, services
Performance Monitor	perfmon.msc	Resource counters and graphs
Resource Monitor	resmon.exe	Real-time CPU/RAM/disk/network
Computer Management	compmgmt.msc	All-in-one MMC console
Local Security Policy	secpol.msc	Password policy, audit settings

■ Registry Hives

Hive	Contains
HKEY_LOCAL_MACHINE	System-wide settings
HKEY_CURRENT_USER	Current user settings
HKEY_CLASSES_ROOT	File associations
HKEY_USERS	All user profiles
HKEY_CURRENT_CONFIG	Hardware profile

■■ Control Panel Key Applets

- System → Comp name, domain, RAM, CPU info
- Device Manager → Driver rollback/update/disable
- Programs & Features → Uninstall software, Windows features
- Network & Sharing → Adapter settings, firewall
- Power Options → Sleep/hibernate/performance plans
- User Accounts → Local accounts, passwords, UAC
- BitLocker → Drive encryption (Pro/Enterprise)
- Windows Defender → Antivirus, SmartScreen
- Indexing Options → Search performance tuning
- Internet Options → Proxy, security zones, cache

■ Windows Update & Maintenance

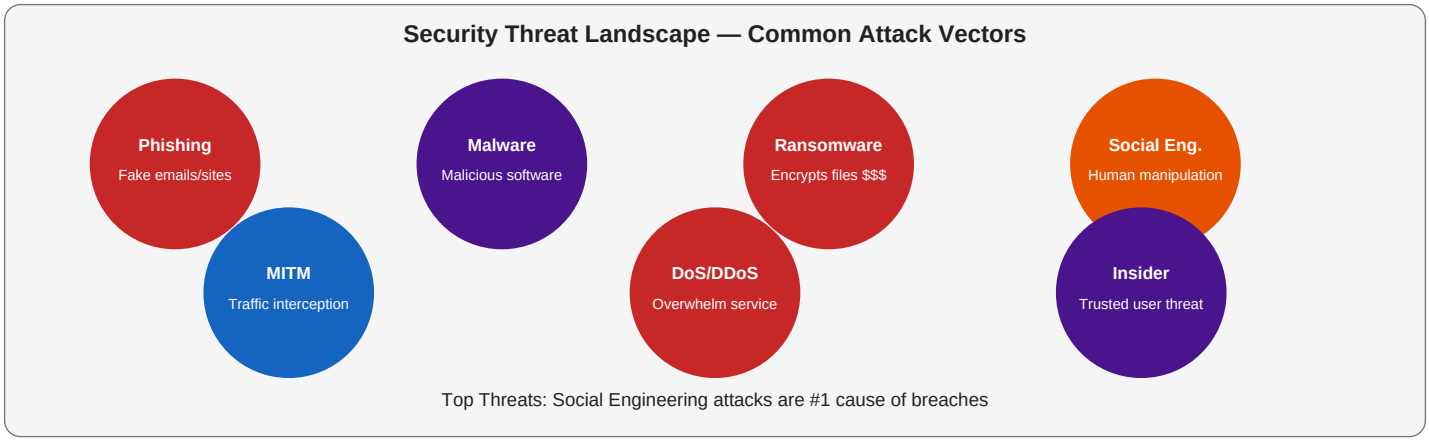
Task	Tool / Command	Notes
Windows Update	Settings → Update & Security	Check for patches; KB articles
Disk Cleanup	cleanmgr.exe	Removes temp files, old updates
Defragment HDD	defrag C: /U /V	Don't defrag SSDs!
Backup	File History / Backup & Restore	Win 7 Backup still in Win 10/11
System Restore	rstrui.exe	Restore point rollback
Reset This PC	Settings → Recovery	Keep files or full reset

■ EXAM TIPS

- msconfig → Boot tab → Safe Boot = boots into Safe Mode (remove malware, diagnose).
- Device Manager yellow ! = driver error | Gray = disabled | Red X = failed device.
- NEVER edit the registry without creating a backup/restore point first.
- UAC (User Account Control) prevents apps from making admin changes silently.
- Windows Startup folder: %AppData%\Microsoft\Windows\Start Menu\Programs\Startup

■ MEMORY ANCHOR

msconfig = 'My System's CONFIGuration' — controls startup items and boot
Event Viewer logs: System (OS), Application (apps), Security (logins) = SAS
Registry = 'The brain's memory' — back it up before touching anything!



■■ CIA Triad

Pillar	Definition	Example Control
Confidentiality	Only authorized access	Encryption, ACLs
Integrity	Data not altered	Hashing, checksums
Availability	Systems accessible	Redundancy, backups

■ Encryption Types

Type	Key Type	Speed	Use Case
Symmetric	Same key	Fast	AES file encryption
Asymmetric	Public/Private	Slow	SSL/TLS, email
Hashing	No key (one-way)	Fastest	Password storage

■ Common Algorithms

- AES-256 – Symmetric; gold standard
- RSA-2048/4096 – Asymmetric; certificates
- ECC – Asymmetric; smaller keys, strong
- SHA-256/512 – Hashing; passwords
- MD5 – Hashing; BROKEN for security
- DES/3DES – Symmetric; legacy; insecure

■ Attack Types

Attack	Description
Phishing	Fake email/site to steal credentials
Spear phishing	Targeted phishing (specific person)
Whaling	Targets executives/high-value users
Vishing	Voice phishing over phone
Smishing	SMS-based phishing
Tailgating	Follow authorized person through door
Shoulder surfing	Watch someone type credentials
Dumpster diving	Find sensitive info in trash
Man-in-the-Middle	Intercept communications
SQL Injection	Inject SQL into web forms
XSS	Inject scripts into web pages
DoS/DDoS	Overwhelm service with traffic
Brute force	Try all password combinations
Dictionary attack	Try common passwords
Rainbow table	Precomputed hash lookups

■ EXAM TIPS

- CIA Triad: Confidentiality = keep it secret, Integrity = keep it accurate, Availability = kee
- Asymmetric encryption: PUBLIC key encrypts, PRIVATE key decrypts.
- MD5 and SHA-1 are cryptographically BROKEN — use SHA-256 or higher.
- Social engineering exploits HUMANS, not technology — training is the best defense.
- Tailgating/piggybacking = physical security issue — enforce badge-only access.

■ MEMORY ANCHOR

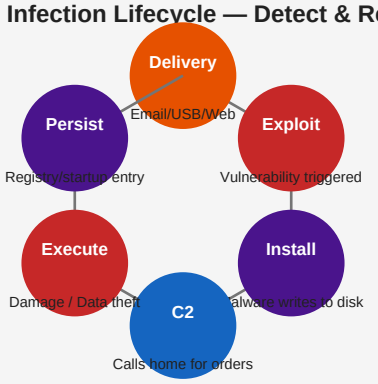
CIA = Confidentiality, Integrity, Availability (not the spy agency!)

AES = 'Awesome Encryption Standard' — symmetric, fast, secure

Phishing types: Email=Phishing, Voice=Vishing, SMS=Smishing, Targeted=Spear

Remember: 'The weakest link is always the human' — social engineering works!

Malware Infection Lifecycle — Detect & Respond



■ Malware Types Reference

Type	Behavior	Spreads Via
Virus	Attaches to files; replicates	File execution
Worm	Self-replicates over network	Network; no user action
Trojan	Disguised as legit software	Downloads, email
Ransomware	Encrypts files; demands payment	Email, web, RDP
Spyware	Secretly monitors user	Bundled software
Adware	Unwanted ads/pop-ups	Free software bundles
Rootkit	Hides deep in OS/firmware	Exploits, Trojans
Keylogger	Records keystrokes	Trojans, physical
Botnet	Infected army of PCs	Worms, exploits
Fileless	Lives in memory/registry	Scripts, macros
Logic Bomb	Triggers on condition	Insider threat
Backdoor	Hidden remote access	Trojans, exploits
PUP	Unwanted but not malicious	Software bundles

■ Malware Removal Steps

Step	Action
1. Identify	Symptoms: slow, popups, redirects
2. Quarantine	Disconnect from network immediately
3. Disable SR	Disable System Restore (hides malware)
4. Safe Mode	Boot into Safe Mode for scan
5. Remediate	Run anti-malware (Malwarebytes)
6. Schedule scan	Schedule post-reboot scan
7. Check SR/DNS	Enable System Restore; check hosts file
8. Educate user	Prevent re-infection

■■ Anti-malware Tools

- **Windows Defender** – Built-in; real-time protection
- **Malwarebytes** – On-demand scanner; excellent
- **MSRT** – Malicious Software Removal Tool
- **Sysinternals Suite** – Autoruns, Process Explorer
- **Kaspersky Rescue** – Bootable scanner (USB)
- **Norton/Bitdefender** – Third-party AVs

Malware Indicator	What It Means	Action
Browser redirects	DNS hijack / browser hijacker	Check hosts file, DNS settings
Excessive pop-ups	Adware / browser extension	Remove extensions, run scan
CPU at 100% idle	Cryptominer / botnet agent	Kill process, scan, patch
Ransom message	Ransomware active	Disconnect, don't pay, restore backup
Unknown startup apps	Persistence mechanism	Autoruns, remove entries
Security tools disabled	Rootkit / advanced malware	Boot from clean media

■ EXAM TIPS

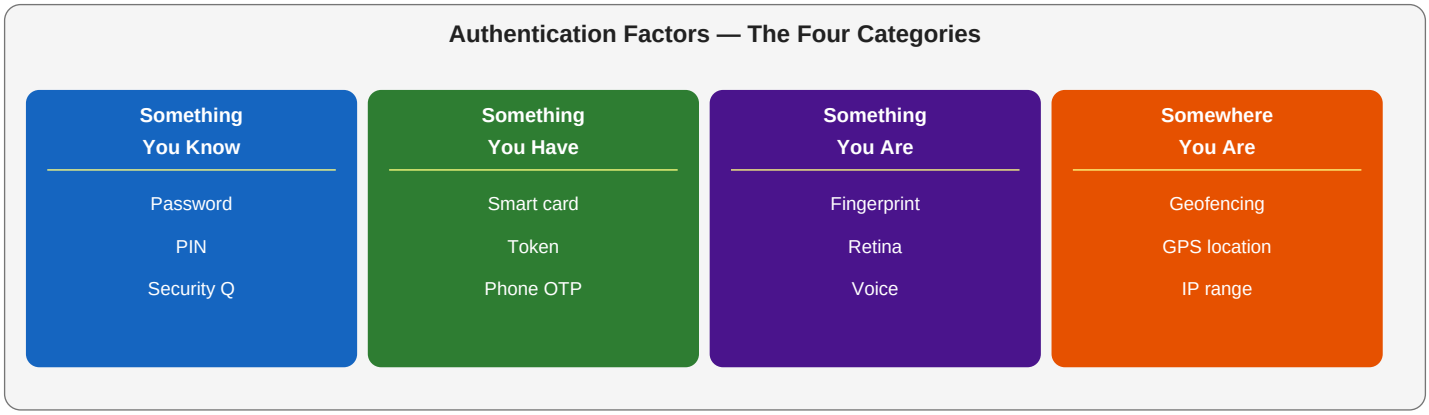
- Ransomware: disconnect immediately, DO NOT pay (no guarantee), restore from backup.
- Rootkits are the hardest to remove — often requires OS reinstall.
- Fileless malware lives in RAM/registry — traditional file scanners miss it.
- Check %AppData%, startup folders, and registry Run keys for persistence.
- The #1 malware vector is phishing email with malicious attachments.

■ MEMORY ANCHOR

Virus=file, Worm=network self-spread, Trojan=disguised, Ransomware=encrypt+$$

Malware removal: 'I Quit Doing Safe Remediation — Seek Education'

Identify, Quarantine, Disable SR, Safe Mode, Remediate, Schedule, Enable SR, Educate



■ Authentication Methods

Method	Factor	Security Level
Password	Know	Low (if weak)
PIN	Know	Low-Medium
Smart Card	Have	High
Token (RSA)	Have (TOTP)	High
Fingerprint	Are (biometric)	High
Facial recognition	Are (biometric)	High
Retina/Iris scan	Are (biometric)	Very High
Voice recognition	Are (biometric)	Medium
Geofencing	Where	Medium
SSO	Combined	Convenient

■ MFA & Password Policies

- **MFA** – Requires 2+ factors (have + know)
- **2FA** – Two-factor authentication subset
- Password length: minimum 12+ characters
- Complexity: upper, lower, number, symbol
- History: don't reuse last 5-10 passwords
- Lockout: 3-5 failures → account locked
- TOTP: Time-based One-Time Password (Authenticator app)
- HOTP: HMAC-based OTP (counter-based)

■■ Access Control Models

Model	Acronym	How It Works
Discretionary	DAC	Owner sets permissions (Windows NTFS)
Mandatory	MAC	System enforces labels (govt/military)
Role-Based	RBAC	Permissions tied to job role
Rule-Based	RuBAC	Firewall rules, time of day
Attribute-Based	ABAC	Multiple attributes combined

■■ Privilege Concepts

- **Least Privilege** – Give only minimum needed access
- **Separation of Duties** – No single person controls all
- **Need to Know** – Access only for job requirement
- **Account Auditing** – Log and review access
- **Privilege Creep** – Accumulated permissions over time
- **Zero Trust** – Verify every request; no implicit trust

■■ Directory Services

- **Active Directory** – Windows domain user/computer management
- **LDAP** – Protocol for directory queries
- **RADIUS** – Remote auth for network access
- **Kerberos** – Token-based auth in AD environments
- **SAML** – SSO for web apps (XML-based)
- **OAuth/OIDC** – Modern web auth delegation

■ EXAM TIPS

- MFA = Something you KNOW + HAVE or ARE — two DIFFERENT factor types required.
- RBAC is the most common enterprise model — permissions assigned to roles, not users.
- Least Privilege is the #1 principle of access control — limit everything by default.
- Guest accounts should be DISABLED unless actively needed (default in Windows).
- Kerberos uses 'tickets' — if clock skew > 5 minutes, Kerberos auth fails!

■ MEMORY ANCHOR

4 auth factors: 'Know, Have, Are, Where' = KHAW

MFA = 2+ DIFFERENT factors (two passwords = NOT MFA, just double passwords)

DAC=You decide | MAC=System decides | RBAC=Role decides

Zero Trust = 'Never trust, always verify' — assume breach is possible

Software troubleshooting requires a systematic approach. Always document steps, check recent changes first, and consider the simplest solution before complex ones.

■ Windows-Specific Issues

Problem	Likely Cause	Solution
BSOD	Driver/hardware fault	Check Event Viewer; update/roll back driver
Slow startup	Too many startup apps	msconfig → Startup; disable items
App won't open	Corrupt install/file	Reinstall; SFC /scannow
Windows won't boot	Corrupt BCD/MBR	bootrec /fixbcd /fixmbr
Profile corrupt	User profile issue	Create new profile; copy data
No sound	Driver / service	Update audio driver; restart Windows Audio
Printer offline	Spooler stuck	Restart Print Spooler service
Windows Update fail	Cache corrupt	net stop wuauserv; del SoftwareDistribution

■ macOS Troubleshooting

- Spinning beach ball → force quit (Cmd+Option+Esc)
- Won't boot → Recovery (Cmd+R); First Aid in Disk Utility
- Can't install apps → System Prefs → Security → Allow
- Slow → Activity Monitor → check CPU/RAM hogs
- WiFi issues → delete /Library/Preferences/SystemConfig/
- Reset NVRAM: Cmd+Option+P+R on boot (hold 20 sec)
- Reset SMC: Power off; Shift+Control+Option+Power

■ Linux Troubleshooting

- Service won't start → journalctl -xe; systemctl status
- Permission denied → check chmod and file ownership
- Package fails → apt update && apt upgrade first
- Boot issues → GRUB rescue; update-grub
- Disk full → df -h to check; du -sh * to find hogs
- Network down → ip addr show; systemctl restart NetworkManager

■ Application Troubleshooting Flow

Step	Action	If It Fails...
1	Restart the application	Proceed to step 2
2	Restart the computer	Proceed to step 3
3	Check for updates (app + OS)	Proceed to step 4
4	Check Event Viewer for errors	Proceed to step 5
5	Uninstall and reinstall app	Proceed to step 6
6	Check compatibility (OS version)	Proceed to step 7
7	Run in compatibility mode	Proceed to step 8
8	Create new user profile; test	Escalate to Tier 2

BSOD Stop Code	Common Cause
0x0000007E – SYSTEM_THREAD_EXCEPTION	Driver crash
0x00000024 – NTFS_FILE_SYSTEM	Hard drive issue
0x0000001E – KMODE_EXCEPTION	Driver/hardware fault
0x000000D1 – DRIVER_IRQL	Network driver
0xC000021A – WINLOGON_FATAL_ERROR	System file corrupt

■ EXAM TIPS

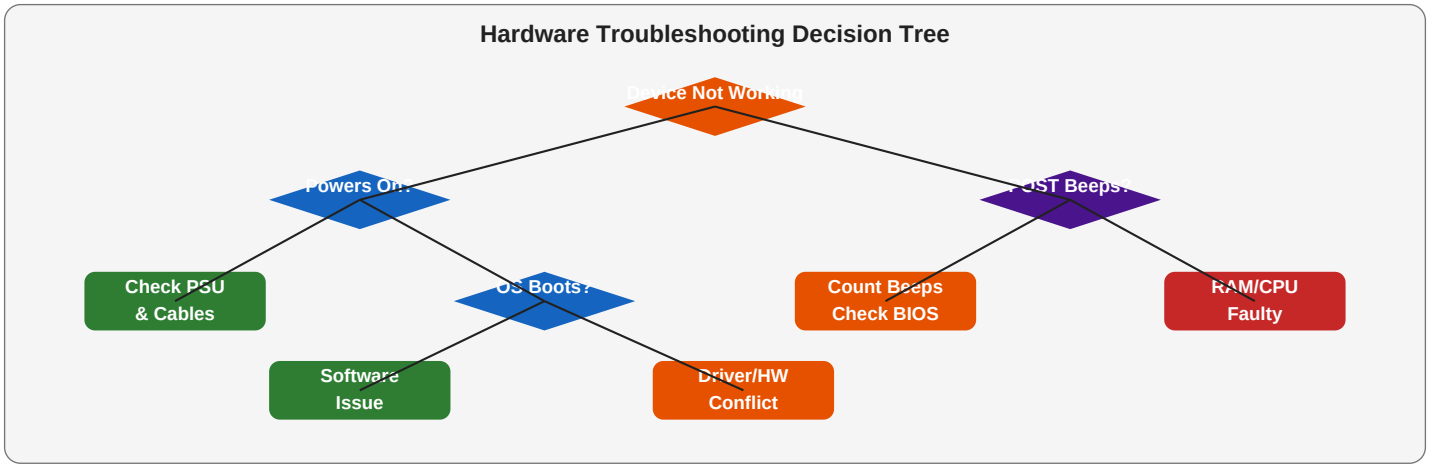
- Always ask 'What changed recently?' — new software, update, or hardware is usually the culpri
- Event Viewer → Windows Logs → System/Application is the first place to check for errors.
- Compatibility mode can run old apps on newer Windows versions (right-click → Properties).
- Safe Mode loads minimal drivers — if problem disappears in Safe Mode, it's a driver/software

■ MEMORY ANCHOR

Troubleshooting 'hierarchy': Restart > Update > Reinstall > Escalate

BSOD = 'Blue Screen Of Doom' — always note the STOP code before rebooting

Event Viewer = 'Windows Diary' — records everything that went wrong



■■ Display Troubleshooting

Symptom	Cause	Fix
No display at POST	Bad GPU/cable/RAM	Reseat GPU; test with onboard
Flickering screen	Refresh rate/cable	Change Hz; try different cable
Dead pixels	LCD panel failure	Panel replacement needed
Image burn-in	OLED/plasma long display	Screen saver; rotate content
Dim display (laptop)	Backlight/inverter	Adjust brightness; replace backlight
Wrong colors	Color profile issue	Recalibrate in display settings

■ Storage Troubleshooting

Symptom	Action
Slow read/write	SMART test; check PCIe/SATA cable
Drive not detected	Check BIOS; try different port; reseat
Clicking sounds	HDD failure — backup IMMEDIATELY
Bad sectors	chkdsk /r; consider replacing
SMART warnings	Replace drive; restore from backup
Full disk	Disk Cleanup; move files; larger drive

■■ Input Device Issues

- Keyboard not working → Try USB on different port; check Device Manager
- Mouse erratic → Clean sensor; check mousepad; update driver
- Touchscreen unresponsive → Clean screen; calibrate; check driver
- Missing keystrokes → Replace; check USB polling rate
- Wireless keyboard lag → Replace batteries; move receiver

■■ Printer Troubleshooting

Problem	Fix
Offline	Restart spooler; check network
Paper jam	Clear jam; check rollers
Poor quality	Clean heads; calibrate
Won't duplex	Enable in driver settings
Wrong tray	Check paper size settings

Hardware Test Tool	What It Tests
MemTest86	RAM errors (run overnight for full test)
CrystalDiskInfo	SSD/HDD SMART data and health
HWMonitor / HWiNFO	CPU, GPU, motherboard temps and voltages
Prime95	CPU stress test; detects cooling issues

Hardware Test Tool	What It Tests
FurMark	GPU stress test; reveals artifacts and crashes
MHDD / Victoria	Advanced HDD surface scan
PC-Check	Bootable comprehensive hardware diagnostics

■ EXAM TIPS

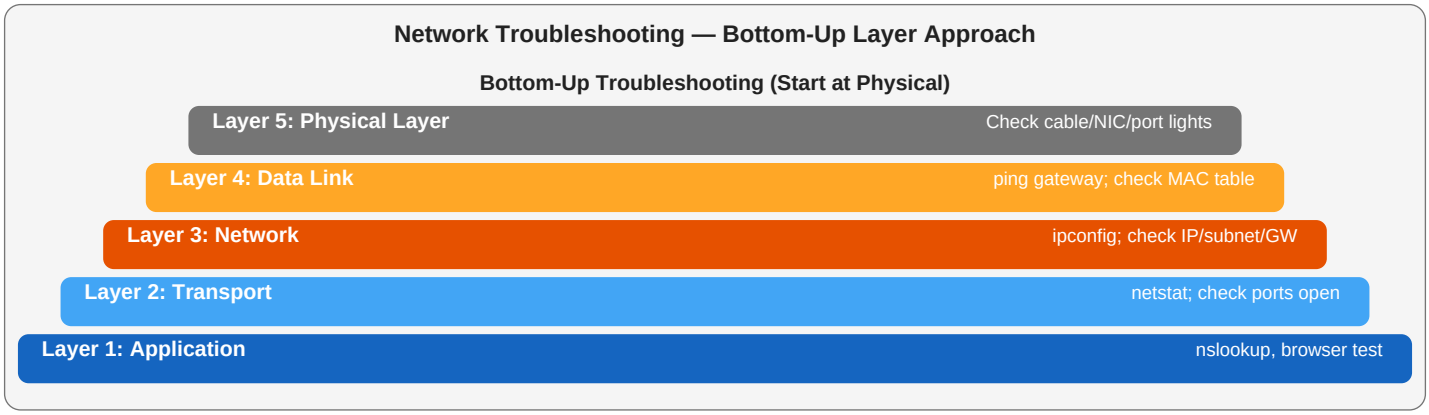
- Clicking/grinding sounds from HDD = imminent failure — stop using, backup NOW.
- Run MemTest86 overnight (multiple passes) for definitive RAM test.
- POST beep codes are BIOS-specific — look up the manufacturer's code table.
- Swapping known-good components is the fastest diagnostic method (component isolation).

■ MEMORY ANCHOR

Hardware troubleshoot order: Simple → Complex (cable before motherboard!)

Clicking HDD = 'Dead drive clicking, copy everything quick!'

SMART = 'Self-Monitoring Analysis Reporting Technology' — drive health early warning



■ Common Network Problems

Symptom	Likely Cause	Fix
No internet, can ping GW	DNS failure	ipconfig /flushdns; change DNS to 8.8.8.8
Can't ping gateway	IP config wrong	ipconfig /renew; check subnet
Limited connectivity	DHCP not responding	Static IP temp; restart DHCP
Intermittent drops	Cable/port flapping	Replace cable; check switch port
Slow internet only	ISP issue / QoS	Speedtest; contact ISP
Can't reach server name	DNS issue	nslookup servername
IP conflict	Duplicate static IP	Release DHCP; fix static IP
Can't share files	Firewall / SMB	Enable File Sharing; check firewall

■ Diagnostic Commands Workflow

- **Step 1:** ipconfig — confirm IP, subnet, gateway
- **Step 2:** ping 127.0.0.1 — loopback (TCP/IP stack works?)
- **Step 3:** ping [local IP] — NIC works?
- **Step 4:** ping [gateway] — local network OK?
- **Step 5:** ping 8.8.8.8 — internet connectivity?
- **Step 6:** ping google.com — DNS working?
- **Step 7:** tracert google.com — where does it fail?
- **Step 8:** nslookup — DNS server responding?

■■ DHCP Troubleshooting

- 169.254.x.x APIPA = DHCP server not found
- ipconfig /release then /renew = force new lease
- Check DHCP scope on server (is it full?)
- DHCP relay required across subnets
- Wireshark capture: look for DORA packets

■ Network Tools Reference

Tool	OS	Function	Key Usage
ping	All	Test reachability	ping -t (Win) | ping -c 4 (Linux)
tracert/traceroute	All	Trace hops	tracert 8.8.8.8
nslookup/dig	All	DNS query	nslookup domain [server]
netstat	All	Connections	netstat -an | grep LISTEN
arp -a	All	ARP cache	Maps IP to MAC
Wireshark	All	Packet capture	Filter: ip.addr==x.x.x.x
nmap	All	Port scanner	nmap -sV -p 1-1000 target
tcpdump	Linux/Mac	CLI packet capture	tcpdump -i eth0 port 80
route print	Windows	Routing table	Shows all routes

Tool	OS	Function	Key Usage
ip route	Linux	Routing table	Linux routing equivalent

■ EXAM TIPS

- 169.254.x.x (APIPA) = No DHCP response — check DHCP server or use static IP.
- Ping works but can't browse? → DNS issue (try ping 8.8.8.8 vs ping google.com).
- Tracert stops at a specific hop = router/firewall blocking ICMP at that point.
- nmap is an important network scanner — know it but ONLY use on networks you own.

■ MEMORY ANCHOR

APIPA 169.254.x.x = 'A Problem Is Probably Applicable' — no DHCP found

Ping test sequence: Lo→Local IP→Gateway→8.8.8.8→google.com = 'Loop Local Gate Google'

DNS fix: ipconfig /flushdns or change DNS to 8.8.8.8 (Google) or 1.1.1.1 (Cloudflare)

Operational procedures ensure IT services are delivered consistently, safely, and professionally. CompTIA A+ tests your ability to follow industry best practices, not just technical skills.

■ Professional Communication

- Listen fully before responding — don't interrupt
- Use plain language; avoid jargon with end users
- Maintain positive attitude even with difficult users
- Set realistic expectations for repair timelines
- Follow up to confirm problem is resolved
- Document all actions taken in tickets
- Respect user privacy — don't snoop on files
- Avoid personal calls/distractions during visits

■ Physical Security

Control	Description
Mantrap	Double-door entry; one opens at a time
Badge access	RFID/smart card entry control
Biometric entry	Fingerprint/retina door locks
CCTV	Camera surveillance
Cable locks	Secure laptops to desks
Privacy screens	Prevent shoulder surfing
Clean desk policy	No sensitive info visible
Visitor logs	Sign in all non-employees

■■ Environmental Controls

Standard	Requirement
Temperature	68-77°F (20-25°C) for servers
Humidity	40-60% relative humidity
Hot aisle/cold aisle	Separates airflow in data center
UPS (Battery)	Provides power during outages
Generator	Long-term power backup
HVAC	Maintains temperature/humidity
Fire suppression	FM-200 or Halon (data centers)
PDU	Power Distribution Unit in rack

■■ Data Disposal Methods

Method	Security Level	Use For
Delete/Recycle	Zero	Non-sensitive only
Format	Low	Low-sensitivity reuse
Overwrite	Medium	General reuse
Secure Erase	High	SSDs before reuse
Degauss	High	HDDs (destroys magnetically)
Shredding	Very High	Physical destruction
Incineration	Highest	Classified media

■ EXAM TIPS

- On A+ exam: always be professional, follow company policy, and escalate appropriately.
- Data destruction: SSDs cannot be degaussed — use Secure Erase or physical destruction.
- UPS = protects from power surge AND provides runtime during outage.
- Chain of custody = track who handled evidence (important for forensics investigations).
- Always get permission BEFORE accessing user's files or system remotely.

■ MEMORY ANCHOR

Data destruction: Delete → Format → Overwrite → Degauss → Shred → Burn

UPS = 'Uninterruptible Power Supply' — buys time for proper shutdown

Mantrap = 'Man Trapped Between Two Doors' — prevents tailgating

Hot aisle = exhaust | Cold aisle = intake — keep them separated!

Documentation and change management are critical in enterprise IT. The A+ exam tests your understanding of proper processes, ticketing, and safety procedures.

■ Change Management Process

Step	Activity
1. Request	Submit change request with details
2. Approval	CAB (Change Advisory Board) reviews
3. Planning	Document steps, rollback plan
4. Test	Test in lab/staging environment
5. Implement	Execute during maintenance window
6. Verify	Confirm change works as expected
7. Document	Record outcomes, update diagrams
8. Close	Close change ticket; notify stakeholders

■ Key Documentation Types

- **Network diagrams** – Logical and physical topology
- **Asset inventory** – All hardware/software tracked
- **Runbooks** – Step-by-step operational procedures
- **SOPs** – Standard Operating Procedures
- **Knowledgebase articles** – Solutions to common issues
- **Incident reports** – Post-event documentation
- **Regulatory compliance** – HIPAA, PCI-DSS, SOX docs

■ Ticketing System Essentials

Field	What to Include
Date/Time	When issue was reported
User/Device	Who/what is affected
Category	Hardware/Software/Network/Security
Priority	Critical/High/Medium/Low
Description	Symptoms; what user was doing
Steps Taken	Everything you tried
Resolution	What fixed the issue
Root Cause	Why it happened

■■ Safety Procedures

Hazard	Safety Measure
Electrical	Power off + unplug before working
ESD	Anti-static wrist strap; ESD mat
Sharp edges	Gloves when handling chassis
Heavy equipment	Lift with knees; use cart for racks
Chemical (toner)	Gloves; don't breathe toner dust
Laser printers	Let cool; fuser is very hot
CRT monitors	Capacitor holds charge — extreme danger
Battery disposal	Hazmat/recycling; never incinerate

Compliance Standard	Industry	Focus Area
HIPAA	Healthcare	Patient data privacy and security
PCI-DSS	Retail/Finance	Credit card data protection
SOX (Sarbanes-Oxley)	Public companies	Financial reporting accuracy
GDPR	EU companies	Personal data protection (EU citizens)
FERPA	Education	Student educational records

■ EXAM TIPS

- Change management: Always have a rollback plan before implementing any change.
- CRT monitors store lethal voltage even when unplugged — do NOT open them.
- Toner is a fine powder — use toner vacuum (not regular) to clean; cold water for skin.
- HIPAA violation can result in massive fines — data breach notification is mandatory.

■ MEMORY ANCHOR

Change management: 'Request, Approve, Plan, Test, Implement, Verify, Document, Close'
Safety first: 'Power off before touching' — ESD, electrical, and mechanical hazards
CRT monitors = 'Can Really be Terrible' — capacitors hold deadly charge after unplugging

FINAL REVIEW — Use this page as a last-minute rapid recall sheet before your exam. Scan each section and visualize the concepts.

■ Core 1 Rapid Recall (220-1101)

Topic	Remember This
CPU sockets	LGA1700=Intel, AM5=AMD — NOT interchangeable
RAM types	DDR4=288-pin, DDR5=288-pin, SO-DIMM=laptop
Storage speed	NVMe > SATA SSD > HDD
PSU 80 PLUS	White → Bronze → Silver → Gold → Platinum → Titanium
RAID 0	Striping — speed, NO redundancy
RAID 1	Mirroring — full redundancy, 50% usable
RAID 5	Stripe+Parity — needs 3+ drives, 1 drive fault tolerance
USB colors	Black=2.0, Blue=3.x, Red=always-on charging
Cable types	Cat5e=1Gbps/100m, Cat6=10Gbps/55m, Cat6a=10Gbps/100m
WiFi security	WEP=broken, WPA=weak, WPA2=ok, WPA3=best
OSI layers	7=App, 4=Transport, 3=Network, 2=Data Link, 1=Physical
Cloud models	IaaS=most control, SaaS=least control
Hypervisor types	Type 1=bare metal, Type 2=hosted OS

■ Core 2 Rapid Recall (220-1102)

Topic	Remember This
Windows editions	Pro=domain+BitLocker+RDP, Home=consumer only
NTFS vs FAT32	NTFS=permissions+encryption+>4GB files
Laser print steps	Processing→Charging→Exposing→Developing→Transfer→Fuse→Clean
Key ports	22=SSH, 53=DNS, 80=HTTP, 443=HTTPS, 3389=RDP, 3306=MySQL
Malware removal	Identify→Quarantine→Disable SR→Safe Mode→Remediate→Educate
CIA Triad	Confidentiality, Integrity, Availability
Auth factors	Know/Have/Are/Where — MFA = 2+ DIFFERENT factors
Access control	DAC=owner, MAC=system, RBAC=role
Encryption	AES=symmetric, RSA=asymmetric, SHA=hashing
APIPA	169.254.x.x = no DHCP server found
Boot order diagnosis	POST→BIOS→MBR/GPT→Boot Loader→OS→Login
Troubleshoot steps	Identify→Theory→Test→Plan→Implement→Verify→Document
Data destruction	Overwrite → Degauss → Shred → Incinerate (most secure)

■ Master Mnemonic List

Mnemonic	Stands For
'All People Seem To Need Data Processing'	OSI layers 7→1: App/Pres/Session/Transport/Network/Data/Physical
'DORA'	DHCP process: Discover, Offer, Request, Acknowledge
'Please Charge Every Dev To Fix Code'	Laser printer: Processing, Charging, Exposing, Developing, Transfer, Fusing, Cleaning
'I Quit Doing Safe Remediation — Seek Education'	Malware removal: Identify, Quarantine, Disable SR, Safe Mode, Remediate, Schedule, Enable SR, Educate
'WEP=Weak, WPA=Weak-Plus, WPA2=Working, WPA3=Winner'	Wireless security evolution
'Can Robots Make Gears, Please Stay?'	PC components: CPU, RAM, Motherboard, GPU, PSU, Storage

■ EXAM TIPS

- Read ALL answer choices before selecting — the 'best' answer is what CompTIA is looking for.
- When stuck: eliminate 2 wrong answers, then use context/common sense for remaining two.
- Time management: ~1 minute per question. Flag uncertain answers; return at end.
- Don't change answers unless you have a clear reason — first instinct is often correct.
- For scenario questions, visualize yourself as the IT tech on the ground.
- Get 8 hours of sleep the night before — mental sharpness matters more than last-minute crammi

■ MEMORY ANCHOR

■ *You've got this! The A+ exam tests practical knowledge — think like a tech!*

Pass scores: Core 1 = 675/900 | Core 2 = 700/900

Certification is valid for 3 years — earn CEUs or retake to renew.

Good luck! CompTIA A+ opens the door to an IT career — you're ready!