

**CompTIA A+ Certification
(Exam 220-901)
Official Study Guide**

Study Notes

Acknowledgements

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Module 1 / Peripheral Devices

CompTIA A+ Certification 220-901 Domain Areas	Weighting
1.0 Hardware	34%
2.0 Networking	21%
3.0 Mobile Devices	17%
4.0 Hardware and Network Troubleshooting	28%

Refer To	Domain Objectives/Examples
Unit 1.1 / Motherboard Components	<p>1.2 Explain the importance of motherboard components, their purpose, and properties</p> <p>Sizes (ATX, Micro-ATX, Mini-ITX, ITX) • Expansion slots (PCI, PCI-X, PCIe, Mini PCI) • RAM slots • CPU sockets • Chipsets (Northbridge, Southbridge) • CMOS battery • Power connections and types • Fan connectors • Front/Top panel connectors (USB, Audio, Power button, Power light, Drive activity lights, Reset button) • Bus speeds</p>
Unit 1.2 / Connection Interfaces	<p>1.4 Install and configure PC expansion cards</p> <p>Sound cards • Video cards • Network cards • USB cards • Firewire cards • Thunderbolt cards • Storage cards • Modem cards • Wireless/cellular cards • TV tuner cards • Video capture cards • Riser cards</p>
Unit 1.2 / Connection Interfaces	<p>1.7 Compare and contrast various PC connection interfaces, their characteristics and purpose</p> <p>Physical connections • USB 1.1 vs. 2.0 vs. 3.0, Connector types: A, B, Mini, Micro • Firewire 400 vs. Firewire 800 • Other connector types (RJ-45, RJ-11) • Wireless connections (Bluetooth, RF, IR, NFC) • Characteristics (Distance limitations, Data transfer speeds, Quality, Frequencies)</p>
Unit 1.2 / Connection Interfaces	<p>1.11 Identify common PC connector types and associated cables</p> <p>Device cables and connectors (USB, Firewire [IEEE1394], PS/2) • Adapters and convertors (USB A to USB B, USB to Ethernet, PS/2 to USB)</p>
Unit 1.2 / Connection Interfaces	<p>1.12 Install and configure common peripheral devices</p> <p>Input devices (Mouse, Keyboard, Biometric devices, Game pads, Joysticks, Motion sensor, Touchpads, Smart card readers) • Input & Output devices (Touchscreen, KVM)</p>
Unit 1.3 / Display Devices	<p>1.7 Compare and contrast various PC connection interfaces, their characteristics and purpose</p> <p>Other connector types (VGA, HDMI, DVI, Thunderbolt) • Characteristics (Analog, Digital, Distance limitations, Data transfer speeds, Quality, DRM)</p>

Module 2 / Unit 1

Mass Storage Devices

Objectives

On completion of this unit, you will be able to:

- Install and configure magnetic hard disk drives, solid state drives, and hybrid drives.
- Install and configure a RAID array.
- Troubleshoot hard drives and RAID arrays with appropriate tools.

Hard Drives

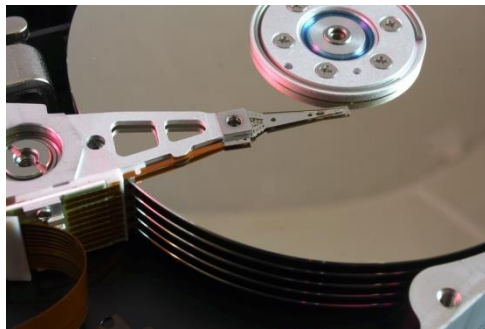


Even with the advances in the speed and capacity of other types of storage technology, the **Hard Disk Drive (HDD)** remains the primary method of persistent storage for PC data. On a workstation PC, the hard disk drive will store the operating system files, application program files, system software files (such as drivers) and user data. On a server PC, the hard disks will store individual user files and shared sources of information, such as databases. Advances in hard disk technology have enabled disks of up to 8 terabytes (8000 GB) to be produced.



HDD with drive circuitry and casing removed showing
1) Platters; 2) Spindle; 3) Read/write heads; 4) Actuator

Data is stored on a number of metal or glass platters coated with a magnetic substance. The top and bottom of each platter is accessed by its own read/write head, moved by an actuator mechanism.



Stack of platters on spindle

The heads do not actually touch the surface of the platters. The platters are mounted on a spindle and spun at high speed and the heads "float" above them at a distance of less than a millionth of an inch. The disk unit is kept sealed to maintain a constant air pressure (important for keeping the drive heads at the correct distance from the platters) and to prevent the entry of dust.

Each side of each platter is divided into circular **tracks** and each track contains a number of **sectors**, each with a capacity of 512 bytes. The collection of tracks in the same place on each platter is called a **cylinder**. This low-level formatting is also referred to as the drive *geometry*.

There are two main formats for HDDs. 3.5" units are the mainstream type used in PCs. 2.5" form factors are used for laptops and as portable external drives. There is also a 1.8" form factor but it is not widely used.

Hard Disk Performance

The performance of a hard disk is a measure of how fast it can read and write data. There are a number of factors that determine overall hard disk performance. One factor is the speed at which the disks can spin (measured in **Revolutions Per Minute [rpm]**). The higher the rpm, the faster the drive is. High performance drives are rated at 15,000 or 10,000 rpm; average performance is 7200 or 5400 rpm.

RPM is one factor determining **access time** (measured in milliseconds), which is the delay (**latency**) that occurs as the read/write head locates a particular position on the drive. A high performance drive will have an access time below 3 ms; a typical drive might have an access time of around 6 ms. The **internal transfer rate** (or data or disk transfer rate) of a drive is a measure of how fast read/write operations are performed on the disk platters. The **external transfer rate** (often simply described as the transfer rate) measures how fast data can be transferred to the CPU across the bus. Cache memory can help to sustain better transfer rates. A high performance disk may feature an 8 MB or better cache.



Generally the burst transfer rate is quoted. This is the maximum possible transfer rate under ideal conditions and cannot be sustained over a long period.



*Some HDDs are now being fitted with a substantial cache of **flash memory** (see below) to improve performance. These are referred to as **hybrid** drives.*

The other crucial factor that impacts HDD performance is *reliability*. Reliability is rated by various statistics, including **Early-life Failure Rate**, **Mean Time Between Failures (MTBF)**, which is the number of hours that a device should operate (under optimum conditions) before a critical incident can be expected, and **life expectancy**, which is the duration for which the device can be expected to remain reliable. All drives now feature **Self-Monitoring Analysis and Reporting Technology (S.M.A.R.T.)** to pass status information and alerts back to monitoring software. This can provide advance warning that a drive is about to fail.

Some of the major hard drive vendors include Seagate, Western Digital, Maxtor, Hitachi, Fujitsu, Toshiba, and Samsung.

Installing a SATA Drive



SATA ports

Most internal HDDs for desktop computers are connected via a SATA interface. Each drive is connected to a SATA port on the motherboard or on an SATA host adapter card. The connectors are keyed to prevent incorrect insertion. There are no device settings to configure. Generally speaking, you should install the boot drive into the lowest numbered port (SATA0).



SATA drive with 1) SATA power connector; 2) SATA data port; 3) Molex power connector



If the drive is not recognized, check that the controllers are enabled in system setup. You might also want to change the adapter mode. You can usually choose between ATA compatibility mode and Advanced Host Controller Interface (AHCI) mode.

Some drives only feature newer SATA power connectors. If your PSU does not have any SATA power connectors, you will need an adapter to connect a Molex power connector to these. If the drive has a legacy Molex power connector, you should only use one of the connectors (do not plug a power cable into both).



SATA power to Molex conversion connector

Configuring a Hard Drive

Once a hard disk drive has been physically installed, there are two further checks that need to be made before the device can be used. Firstly, you should check that the device has been recognized by the computer's system firmware. If the drive is not listed in the startup configuration pages, enter system setup and check that the drive's host adapter is enabled.

When the drive is recognized in firmware, you can access it using the Windows Setup program or operating system to format and partition it. Partitioning the drive defines one or more discrete storage areas on the same physical disk. This is useful for installing multiple operating systems or for defining system and user data storage areas.



You may see references to "low-level formatting". This is the division of the disk surface into sectors. This is done at the factory by the manufacturer.

Each partition can be formatted using a different file system. Under Windows, this means either **New Technology File System (NTFS)** or **File Allocation Table (FAT)**. The choice of file system is driven by software compatibility. The partition used to install Windows must be NTFS.

You can use the **Disk Management** tool in Windows to partition and format a disk. Alternatively you can use the command line tools. Use the `diskpart` command to create and delete partitions and assign drive letters. Use `format` to create a file system. Note that the formatting process deletes any data existing on the drive.

```
Microsoft DiskPart version 5.1.3565
Copyright (C) 1999-2003 Microsoft Corporation.
On computer: JAMESU3

DISKPART> select disk 0
Disk 0 is now the selected disk.

DISKPART> detail disk

SEAGATE ST336607LW SCSI Disk Device
Disk ID: 6AAF6AAF
Type      : SCSI
Bus       : 2
Target    : 0
LUN ID    : 0

  Volume ###  Ltr  Label          Fs      Type          Size      Status       Info
  -----  -  -
  Volume 1    C           NTFS      Partition    17 GB      Healthy      System

DISKPART>
```

diskpart program showing a hard disk partition structure



File system choices and drive management are discussed in detail in the "CompTIA A+ Certification Exam 220-902 Official Study Guide".

Solid State Drives

Flash memory is being incorporated onto a new generation of **Solid State Drives (SSD)** designed to replicate or supplement the function of the hard drive.



HP SSD with SATA interface (© Hewlett-Packard Development Company)

The advantages of flash memory-based SSDs are that the lack of moving parts makes them quieter, more power efficient, and less prone to catastrophic failure or damage due to shock (dropping or moving a device rapidly for instance). Read times are better because seek time and consequently the effect of file fragmentation is eliminated. They are also less susceptible to data loss in the event of power failure. Most drives still feature DRAM-based write cache to improve performance. In the event of a power failure, unwritten cache would be lost. However, the DRAM cache may be backed up by a battery to cover this eventuality.

The main disadvantage is the high cost; a *64 GB* SSD costs a bit more than a *2 TB* HDD (a *1 TB* SSD can cost the same as a top-end server).

SSD Interfaces

An SSD might be installed as the computer's only internal drive or as a system drive for use with an additional hard drive. The SSD would normally be used to install the OS and software applications while the HDD would be used for user data files. In this configuration, both drives are available to the user.

An SSD might be installed to a SATA port as with a mechanical HDD but the 6 Gbps interface can be a bottleneck to the best performing SSDs. Consequently, SSDs are now often provided as PCIe adapter cards or as drives that connect to a SATA Express interface. SATA 3.2 defines SATA Express (SATAe) as a means of interfacing a physical SATA port with a 2-lane PCI Express bus.

Where SATA uses the **Advanced Host Controller Interface (AHCI)** to communicate with the bus, PCIe-based SSDs use the **Non-Volatile Memory Host Controller Interface Specification (NVMe)** or **NVM Express (NVMe)** for short.

SSD Performance

SSDs normally outperform HDDs but there are situations where they can perform worse than HDDs, when serving large (GB) files for example.

When making a detailed comparison between different types of storage technology, you need to compare performance against different types of data transfer. For example, read and write performance are not equivalent. There are also differences between sequential access (reading data from the same "block" as might happen when transferring a large file) and random access (reading data from different locations on the drive or transferring lots of small files for instance). Along with the data throughput (measured in Mbps) and latency / access time, you may need to consider the number of Input / Output Operations per Second (IOPS) that can be achieved by a device for different kinds of data transfer operation.

Flash chips are also susceptible to their own type of degradation over the course of many write operations, so the drive firmware and operating system must use **wear leveling** routines to prevent any single storage location from being overused and optimize the life of the device.

eMMC Storage

The MultiMedia Card (MMC) format is a legacy type of memory card, similar to SD cards. An **embedded MMC (eMMC)** adapter is essentially a flash memory card installed as part of the motherboard chipset. An eMMC will generally not perform as quickly as a PCIe SSD as the adapters may use less sophisticated drive controllers and firmware.

Hybrid Drives and Dual-drives

Solid state storage may also be incorporated on a **hybrid drive**. In a hybrid drive, the SSD portion functions as a large cache, containing data that is accessed frequently. The magnetic disc is only spun up when non-cached data is accessed. Version 3.2 of the SATA standard defines a set of commands to allow the host computer to specify how the cache should be used (also referred to as **host-hinted** mode). Alternatively the drive firmware can run **self-optimizing** routines. The user does not have direct control over files stored on the cache.

Another option is for separate SSD and HDD units to be installed in a **dual-drive** configuration. In this case the system chipset and storage drivers, usually based on **Intel Smart Response Technology (SRT)**, make the caching decisions. Again, the user does not have control over the use of the SSD.



SRT can only use caches up to 64 GB (at the time of writing). If the SSD is larger, SRT can reserve part of the drive for caching and the remainder of the capacity is then available to the user and can be manipulated via the OS disk and file management tools.

Troubleshooting Hard Drives



Hard drives are most likely to fail due to mechanical problems either in the *first few months* of operation or after a *few years*, when they begin to reach the end of their useful life. Sudden loss of power can also damage a disk, especially if it is in the middle of a read/write operation.

Common Symptoms of Disk Failure

A hard drive that is failing will display the following symptoms:

- Read/write failure - when trying to open or save a file, an error message such as "Cannot read from the source disk" is displayed.
- Bluescreen of Death (BSoD) - a failing hard disk and file corruption may cause a particularly severe read/write failure, resulting in system STOP errors (a crash screen).
- Bad sectors - when you run the `chkdsk` program it can test the surface of the hard disk. If more bad sectors are located each time the test is run, it is a sure sign that the disk is about to fail.



Use the Check Disk utility regularly to check that the drive is in good condition.

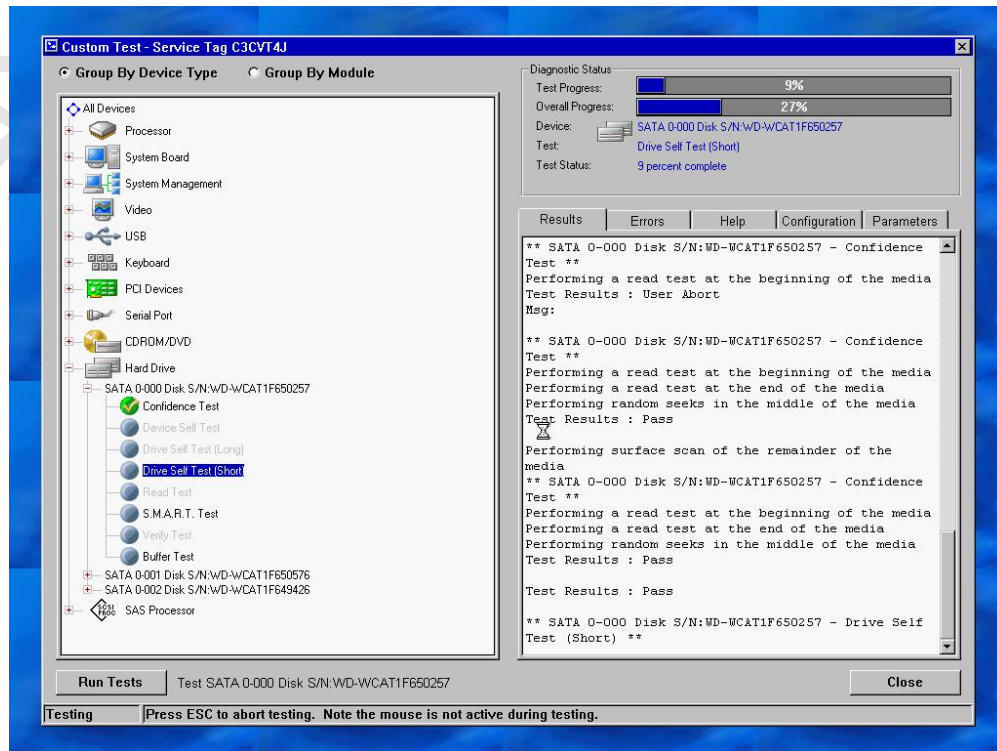
- Constant LED activity. "Disk thrashing" can also be a sign that there is not enough system RAM as data is continually moved between RAM and the pagefile.
- Noise - a healthy hard disk makes a certain low-level noise when accessing the platters. A loud or grinding noise or any sort of clicking is a sign of a problem.

In this scenario, replace the disk as soon as possible to minimize the risk of data loss.

You can use the Windows `chkdsk` utility to verify the integrity of a formatted disk. Most hard drives run a self-diagnostic program called **S.M.A.R.T (Self-Monitoring, Analysis, and Reporting Technology)** that can alert the operating system if reliability is compromised. In Windows, you can run the following command to perform a S.M.A.R.T check:

```
wmic /node:localhost diskdrive get status
```

If you suspect that a drive is failing you should try to run more advanced diagnostic tests on the drive. Most hard drive vendors supply utilities for testing drives or there may be a system diagnostics program supplied with the computer system.



Using system diagnostics software to test a hard drive

You can also use Windows utilities to query S.M.A.R.T. and run manual tests:

Attribute	Value	Worst	Warn	Raw
Raw Read Error Rate	117	99	6	000008A48628
Spin Up Time	99	99	0	000000000000
Start/Stop Count	99	99	20	00000000062A
Reallocated Sector Count	100	100	10	000000000000
Seek Error Rate	71	60	30	000B09EF5DEB
Power On Hours Count	96	96	0	000000000EB7
Spin Retry Count	100	100	97	000000000000

Viewing S.M.A.R.T. information via the SpeedFan utility

Failure to Boot

If the hard drive is not detected at boot (or if a second hard drive is not shown under Windows), first check that it is powering up. Drive activity is usually indicated by an LED on the front panel of the system unit case. If this is inactive, check that the drive has a power connector attached. If the PC has no LEDs, or you suspect that they may be faulty, it is usually possible to hear the hard drive spinning up. Once you have determined that the drive is powering up try the following:

- If the system is not booting correctly from the hard drive, check that the boot sequence is set correctly in the PC firmware system setup program and that there are no removable disks in floppy or optical drives.
- Check the data cables are not damaged and that they are correctly connected to the drive.
- If the drives are connected to a motherboard port, check that it has not been disabled by a jumper or via system setup.

Once you have determined that the drive configuration is correct try the following. If a boot hard drive is detected by the firmware hardware check (Power On Self-Test [POST]) but not by Windows (for example, if you get an error such as "OS not found"), there is probably a problem with the file system. Boot into the recovery environment using the Windows setup disc and type `C:` at the command prompt. If this produces the error message **Invalid media type**, the disk has no valid file system structure on it. This may be caused by surface errors or by a virus.

You may be able to recover from this by running the `bootrec` tool at a boot command prompt (see "Repairing Boot Blocks" below) or by reformatting the disk (at the expense of any data of course). If you type `C:` at the command prompt and this produces the error message **Invalid drive specification**, the drive may have an invalid partition structure. You can check the drive's partition structure with `diskpart`.

Repairing Boot Blocks



c4219

One of the unwelcome actions that malware can perform is to damage the boot information on the hard drive. There are two ways of formatting the boot information: MBR and GPT.

In the **Master Boot Record (MBR)** scheme, the MBR is located in the first sector of the first partition and contains information about the partitions on the disk plus some code that points to the location of the active boot sector. The **Boot Sector** is located either on the sector after the MBR or the first sector of each other partition. It describes the partition file system and contains the code that points to the method of booting the OS (the Boot Configuration Database for a Windows system). Each partition can contain a boot sector but only one of them can be marked active.

With the **GUID (Globally Unique ID) Partition Table (GPT)** boot scheme, the boot information is not restricted to a single sector but still serves the same basic purpose of identifying partitions and boot loaders. GPT is associated with UEFI firmware but can also be used by most legacy BIOS firmware if supported by the OS (32-bit Windows has problems booting from a combination of GPT and BIOS). GPT is not subject to the restrictions on number and size of partitions that limit MBR; there are still limits but not ones that are likely to be reached in practice.



GPT often uses a "protective" MBR to prevent disk tools from overwriting the GPT.

Whether the disk is using an MBR or GPT partitioning scheme, damage to these records results in boot errors such as "OS not found" or "Invalid drive specification". If this problem *has* been caused by a virus (it can also occur due to disk corruption or installing operating systems with conflicting boot loaders in multiboot configurations), the best way to resolve it is to use the boot disk option in your anti-virus software. This will include a basic anti-virus scanner that may detect the virus that caused the problem in the first place.

If you don't have the option of using a recovery disk created by the anti-virus software, you can try to use the repair options that come with the Windows product disc. Do be aware that these may not work completely reliably if the system is still infected with a virus.



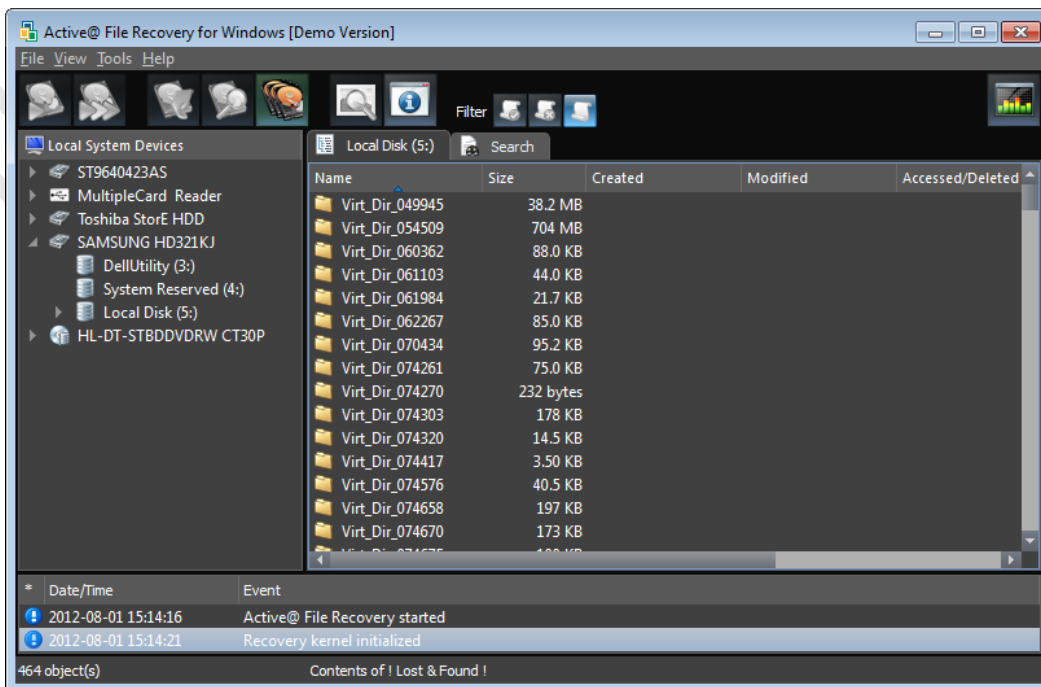
Also note that these tools may not be suitable for use with multiboot configurations if one of the other OS has created a non-standard partition table.

- 1) Boot from the product disc and choose the **Repair** option.
- 2) First, use the **Startup Repair** option. If this does not work, choose the **Command Prompt** option.
- 3) Enter `bootrec /fixboot`.
- 4) Enter `bootrec /fixmbr`.
- 5) Restart the PC.

External Enclosures and File Recovery Software

If the computer will not boot from a hard disk, you may want to try to recover data from it. To do this, you will usually need to remove the drive from its internal enclosure (use an appropriate screwdriver) and connect it to another PC. External enclosure kits are available to provide the data and power connectors required. The enclosure will then generally be interfaced to the PC via a USB port and the disk can be mounted using Disk Management (if it is in a state to be recognized by Windows) or analyzed using file recovery software.

If a file is corrupted, it may be possible to use software to rebuild it (or at least, to recover some data from it). `chkdsk` restores file fragments from bad sectors to the root of the volume (as `filennnn.chk` files), but these are rarely directly usable. Third-party file recovery software is available and can be more successful.



Using file recovery software to scan a disk

Formatted Capacity

Another disk issue is that of capacity. A user may purchase a 300 GB disk and discover on formatting it that it is "only" 286 GB. Most disk vendors use decimal measurements to advertise the capacity of disk drives, as this results in a higher value. The decimal definition of mega or giga is 1000 while the binary definition is 1024; dividing a value by 1000 rather than 1024 can make the drive seem much larger than it really is, especially when you get to drives of 100 GB+ capacity.

Windows reports capacity using binary values, but with decimal units (the approved IEEE binary units are MiB and GiB but these are almost never used in practice). The "lost" capacity is due to this conversion error.

Low Disk Space, Slow Performance, and Defragmentation

As a general note, **slow disk performance** is often a bottleneck for modern computer systems. In this case the best solution may be to add more RAM rather than replace the disk or to upgrade the disk to an SSD or hybrid drive.

Disk performance can be improved by ensuring that file fragmentation is minimized. **Disk defragmentation** is a process whereby the contents of a disk are moved around to optimize disk access times. The components of a file (known as clusters) are placed adjacent on the disk surface (they are said to be contiguous). Windows normally tries to run the defragmenter periodically as a scheduled task but this process can be interrupted by user file access requests. It may be necessary to run the tool manually during a "downtime" period.

Low disk capacity can also be a cause of slow performance. When a disk is 90% full, its capacity meter is shown in red in Explorer. Windows warns the user via the notification area when disk space is critically low (below 200 MB). If the disk continues to be filled up, system performance will be very severely impacted. You can use the Disk Cleanup program to free up space but the user may have to take manual steps, such as moving or deleting files, uninstalling unnecessary applications, and so on.

Installing RAID Arrays



sw90o

With **RAID (Redundant Array of Independent Disks)**, many hard disks can act as backups for each other to increase reliability and fault tolerance or they can act together as one very large drive.



RAID can also be said to stand for "Redundant Array of Inexpensive Disks" and the "D" can also stand for "devices".

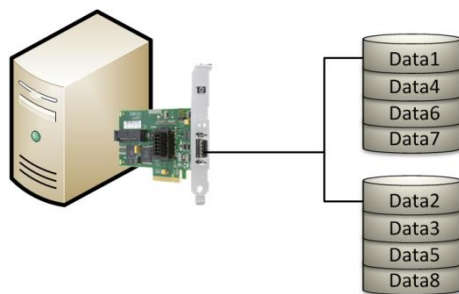
The RAID advisory board defines RAID levels. The most common levels are numbered from 0 to 6 where each level corresponds to a specific type of fault tolerance. Only levels 0, 1, and 5 are of much relevance at the desktop however.

RAID 0 (Striping without Parity)

Disk striping is a technique where data is divided into blocks and spread in a fixed order among all the disks in the array. RAID 0 requires at least two disks. Its principal advantage is to improve performance by spreading disk I/O over multiple drives.

The logical volume size is the combined total of the smallest capacity physical disk in the array. When building a RAID array, all the disks should normally be identical in terms of capacity and ideally in terms of type and performance, though this is not mandatory. If disks are different sizes, the size of the smallest disk in the array determines the maximum amount of space that can be used on the larger drives. RAID 0 adds no storage overhead and is a means of obtaining a large logical volume from multiple, low capacity disks.

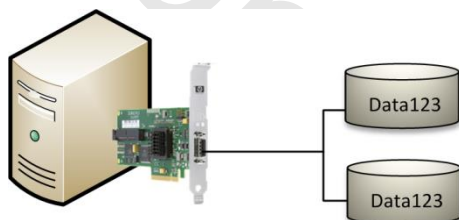
However, because it provides *no redundancy*, this method cannot be said to be a true RAID implementation. If *any* physical disk in the array fails, the *whole logical volume* will fail, causing the computer to crash and requiring data to be recovered from backup. Consequently, RAID 0 would never be used for live data storage.



RAID 0 (striping) - data is spread across the array

RAID 1 (Mirroring)

Mirroring requires two hard disks. The mirror disk is a duplicate of the data disk. Each write operation is duplicated on the second disk in the set, introducing a small performance overhead. A read operation can use either disk, boosting performance somewhat. This strategy is the simplest way of protecting a single disk against failure. If one disk fails (**degrading** the array), the other takes over. There is little impact on performance during this time (obviously the boost of having two drives available for read operations is lost), so availability remains good, but the failed disk should be replaced as quickly as possible as there is no longer any redundancy. When the disk is replaced, it must be populated with data from the other disk (**rebuilding**). Performance while rebuilding is reduced, though RAID 1 is better than other levels in that respect and the rebuilding process is generally shorter than parity-based RAID.

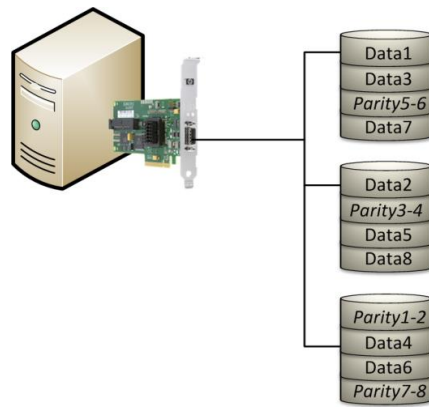


RAID 1 (mirroring) - data is written to both disks simultaneously

In terms of cost per gigabyte, disk mirroring is more expensive than other forms of fault tolerance because disk space utilization is only 50 percent. Also the total volume size cannot exceed the available capacity of the physical disks. However, disk mirroring usually has a lower entry cost because it requires only two disks and a relatively cheap RAID controller (or software RAID). The availability of cheap, large HDDs makes the 50% overhead less of a drawback.

RAID 5 (Striping with Distributed Parity)

Striping with parity (RAID 5) writes parity information across all the disks in the array. The data and parity information are managed so that the two are always on different disks. If a single disk fails, enough information is spread across the remaining disks to allow the data to be completely reconstructed. Stripe sets with parity offer the best performance for read operations. However, when a disk has failed, the read performance is *degraded* by the need to recover the data using the parity information. Also, all normal write operations suffer reduced performance due to the parity calculation.



RAID 5 (striping with parity)

RAID 5 requires a minimum of three drives but can be configured with more. This allows more flexibility in determining the overall capacity of the array than is possible with RAID 1. A "hard" maximum number of devices is set by the controller or OS support but the number of drives used is more likely to be determined by practicalities such as cost and risk. Remember that adding more disks increases the chance of failure.

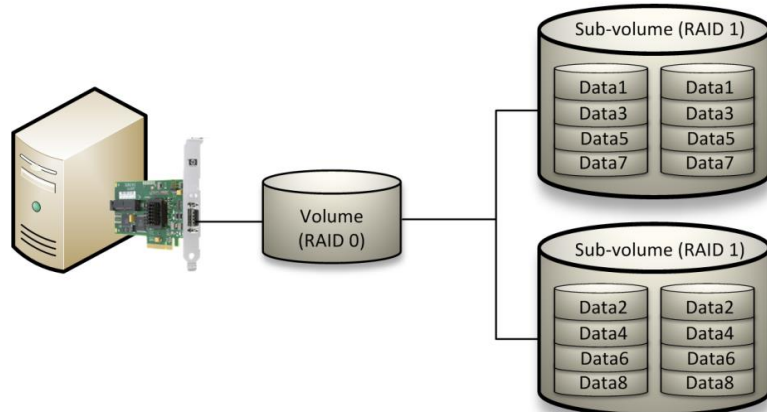
The level of fault tolerance and available disk space are inverse. As you add disks to the set, fault tolerance decreases but usable disk space increases. If you configure a RAID 5 set using 3 disks, a third of each disk is set aside for parity. If four are used, one quarter is reserved on each disk. Using a three 80 GB disk configuration, you would have a 160 GB usable volume.



If the disks are different sizes, the size used is that of the smallest disk. Extra disk space on larger drives is wasted.

RAID 1+0 (RAID 10)

As described above, RAID 0 is striping with no parity (that is, no fault tolerance is provided). This provides high throughput, but leaves the data at risk. RAID 1 provides mirroring; the highest achievable disk fault tolerance. RAID 1+0 (also called RAID 10) is a combination of both these configurations (nested RAID). A logical striped volume is configured with two mirrored arrays. This configuration offers excellent fault tolerance as one disk in each mirror can fail and the array will still function.



RAID 10 - either disk in each of the sub-volumes can fail without bringing down the main volume

You will need at least four disks to create this configuration and there must be an even number of disks. Note that it carries the same 50% disk overhead that mirroring does.

Implementing RAID

It is possible to implement RAID using either hardware or software.

Hardware Solutions

A hardware solution means that creating volumes from an array of physical disks is an operation supported by a plug-in controller card or by the motherboard, independently of the installed operating system. Hardware solutions are principally differentiated by their support for RAID levels. Entry-level controllers might support only RAID 0 or RAID 1 while mid-level controllers might add support for RAID 5 and RAID 10.

In addition, hardware RAID is often able to hot swap a damaged disk (replace the failed unit without shutting down Windows), thereby keeping the system operational all the time. Hot swapping is a feature of high-end hardware RAID solutions and requires a compatible controller *and* disk units. When the new disk is installed, the RAID controller transparently synchronizes it with the remaining disks in the set.

On the downside, hardware RAID is more expensive than a software solution and may lock you into a single vendor solution.

Modern low cost RAID solutions may use SATA while **Serial Attached SCSI (SAS)** is a popular technology for server-class machines.

```

LSI Corp Config Utility For Dell PERC H200 v7.01.09.00 (2010.03.22)
Create New Volume -- SAS2008
Volume Type:                RAID 1
Volume Size(GB):            -----

Slot  Device Identifier      RAID  Hot  Drive  Pred  Size
Num   ID                    Disk  Spr  Status  Fail  (GB)
-----
0     ATA      WDC WD2502ABYS-13B05  [No]  [No]  -----  No   232
1     ATA      WDC WD2502ABYS-13B05  [No]  [No]  RAID    No   232

```

Esc = Exit Menu F1/Shift+1 = Help
Space/+/- = Select disk for volume or hot spare C = Create volume

Configuring a volume using RAID controller firmware

Software Solutions

Windows provides the option to set up software-based RAID using standard disks and controllers, but most desktop versions of Windows are restricted to striping, which provides no fault tolerance. Windows Server versions support fault tolerant mirrored (RAID 1) and striping with parity (RAID 5) arrays. Windows 7 Professional, Enterprise, and Ultimate also support mirroring (but the equivalent Vista editions do not). The Professional and Enterprise editions of Windows 8 come with the Storage Spaces features, which provides mirroring and parity-based RAID-like functionality. In a software solution, internal disks using different types of interface can be combined in an array but USB- or Thunderbolt-connected external drives are not supported. A software solution is cheaper, as RAID controller cards can be expensive.

Hot swappable Drives

A system configured for RAID might support hot swappable drives. While this is usually a server-level feature it might be implemented on high-end workstations. Rather than using cabled connectors, hot swappable drives plug (or "mate") into a combined data and power port on the enclosure. This means that drives can be easily added and removed from the front of the case without having to open the chassis. The drives are secured and released from the enclosure using a latch.



HP MediaSmart Server with hot swappable drive enclosure (© Hewlett-Packard Development Company)

Troubleshooting RAID

RAID is usually a means of protecting data against the risk of a hard disk drive failing. The data is either copied to a second drive (mirroring) or additional information is recorded on multiple drives to enable them to recover from a device failure (parity). RAID can be implemented using hardware controllers or features of the operating system.

RAID Not Found

If Windows does not detect a RAID array during setup or at boot time, check that the drivers for the RAID controller are installed and use the RAID configuration utility to verify its status.

```

F10 = System Services
F11 = BIOS Boot Manager
F12 = PXE Boot
One 2.40 GHz Quad-core Processor, Bus Speed:4.80 GT/s, L2/L3 Cache:1 MB/8 MB
System Memory Size: 4.0 GB, System Memory Speed: 1067 MHz

Broadcom NetXtreme II Ethernet Boot Agent v5.0.5
Copyright (C) 2000-2009 Broadcom Corporation
All rights reserved.
Press Ctrl-S to Configure Device (MAC Address - 842B2B19E291)

Dell PERC H200/6Gbps SAS HBA BIOS
MPT2BIOS-7.01.09.00 (2010.03.22)
Copyright 2000-2009 LSI Corporation.

Integrated RAID exception detected:
Volume (Hd1:079) is currently in state INACTIVE/OPTIMAL
Enter the Dell PERC H200/HBA Configuration Utility to investigate!

Press Ctrl-C to start Dell PERC H200/HBA Configuration Utility..

```

Boot message indicating a problem with the RAID volume - press Ctrl+C to start the utility and troubleshoot

If you cannot access the configuration utility, then the controller itself could have failed.

RAID Stops Working

One of the purposes of using RAID (or at least RAID 1 / 5 / 10) is that it is much less likely than a simple disk system to just "stop working". If one of the underlying disks fails, the volume will be listed as "degraded" but the data on the volume will still be accessible.



RAID 0 has no redundancy so if one of the disks fails it will stop working - in this scenario you had better hope that you have a recent data backup.

The precise process for managing a disk failure with an array will be dependent on the vendor that supplied the array and the configuration being supported. All array controllers will be capable of generating an event to the OS system log and perhaps of generating an alert message for the administrator.

```

LSI Corp Config Utility For Dell PERC H200 v7.01.09.00 (2010.03.22)
View Volume -- SAS2008
Volume                1 of 1
Identifier
Type                  RAID 1
Size(GB)              232
Status                Inactive

Manage Volume

Slot  Device Identifier RAID Hot Drive Pred Size
Num  Num              ID          Disk Spr Status Fail (GB)
---  ---              ---      --- --- --- ---
  1   ATA      WDC WD2502ABYS-13B05  Yes  No  Inactive No   232
  ---  ---              ---      --- --- --- ---

```

Esc = Exit Menu F1/Shift+1 = Help
Enter=Select Item Alt+N=Next Volume

Diagnosing RAID errors using the configuration utility - this volume is missing one of its disks

Most desktop-level RAID solutions can only tolerate the loss of one disk, so it should be replaced as soon as possible. If the array supports hot swapping, then the new disk can simply be inserted into the chassis of the computer or disk chassis. Once this is done, the array can be rebuilt using the RAID configuration utility (if a hardware RAID controller is used) or Disk Management (if you are using dynamic disks to implement "software" RAID). Note that the rebuilding process is likely to severely affect performance as the controller is likely to be writing multiple gigabytes of data to the new disk.



When hot swapping a faulty disk out, take extreme caution not to remove a healthy disk from the array as making a mistake could cause the array to fail, depending on the configuration. Disk failure is normally indicated by a red LED. Always make a backup beforehand.

If a volume is not available, either more than the tolerated number of disks has failed or the controller has failed. If the boot volume is affected then Windows will not start. If too many disks have failed, you will have to turn to the latest backup or try to use file recovery solutions. If the issue is controller failure, then data on the volume should be recoverable, though there may be file corruption if a write operation was interrupted by the failure. Either install a new controller or import the disks into another system.



Review Questions / Module 2 / Unit 1 / Mass Storage Devices

Answer these questions to test what you have learned in this unit. You can submit your answers and review the model answers on the [course website](#).

- 1) True or false? The read/write heads on a hard disk require regular cleaning to obtain optimum performance from a hard disk.
- 2) What basic factor might you look at in selecting a high-performance drive?
- 3) What is a S.M.A.R.T. hard disk?
- 4) True or false? SATA is an interface for hard drives only.
- 5) In what two ways could a PC be configured to use an SSD cache?
- 6) If you have a computer with three hard disks, what type of RAID fault-tolerant configuration will make best use of them?
- 7) You are upgrading a drive. You have removed the main panel from the PC, disconnected the data and power cables, and removed the screws holding the drive to the cage but it will not slide out. What is your next step?
- 8) You are configuring four 120 GB drives in a RAID 5 array. How much space will be available?
- 9) You are trying to install Windows from the setup disc but the computer will not boot from the CD. What should you do?
- 10) If you experience an error such as "Invalid drive specification" on booting, what action could you take?
- 11) A user reports hearing noises from the hard disk - does this indicate it is failing and should be replaced?
- 12) A PC displays the message "Invalid drive specification" when you try to access it from a command prompt. What is the likely cause?
- 13) A user reports that there is a loud clicking noise when she tries to save a file. What should be your first troubleshooting step?
- 14) You are investigating a disk problem. The system can no longer access the C: drive. What command could you use to try to repair the error?
- 15) A RAID utility reports that the volume is degraded. What should you do?

Cooling Systems



bt0nn

Heat is a by-product of pushing electric current through the various electronic components in the computer. The faster the components work, the more heat is produced. Excessive temperatures can cause the components to malfunction or even damage them. One of the most significant problems with CPUs (and graphics cards) is their thermal output. While Intel and AMD are both focusing on making new CPU designs more thermally-efficient, all CPUs require cooling. Also, a specific CPU model requires a specific cooling system as some run hotter than others (later Pentium 4s being a good example).

Heatsinks and Thermal Paste

A **heatsink** is a block of metal with fins. As the fins expose a larger surface area to the air around the component, a greater cooling effect by convection is achieved. The heatsink is "glued" to the surface of the chip using **thermal paste** (also referred to as thermal grease or compound) to ensure the best transfer of heat. A heatsink is a **passive cooling** device. Passive cooling means that it does not require extra energy (electricity) to work. In order to work well, a heatsink requires good airflow around the PC. It is important to try to keep "cable clutter" to a minimum.

Fans

Many PCs have components that generate more heat than can be removed by passive cooling. A **fan** improves air flow and so helps to dissipate heat. Fans are used for the power supply and chassis exhaust points. The fan system will be designed to draw cool air from vents in the front of the case over the motherboard and expel warmed air from the back of the case.

Typically, the speed of the fan is varied according to the temperature and sensors are used to detect whether a fan has failed.

Smaller fans may be used to improve the performance of the heatsink on the CPU, GPUs, and even hard disks.



PSU (1) and chassis (2) fans on an HP Compaq PC
(© Hewlett-Packard Development Company)



Fan assembly on a CPU (left) and ATI Radeon graphics processor (right)

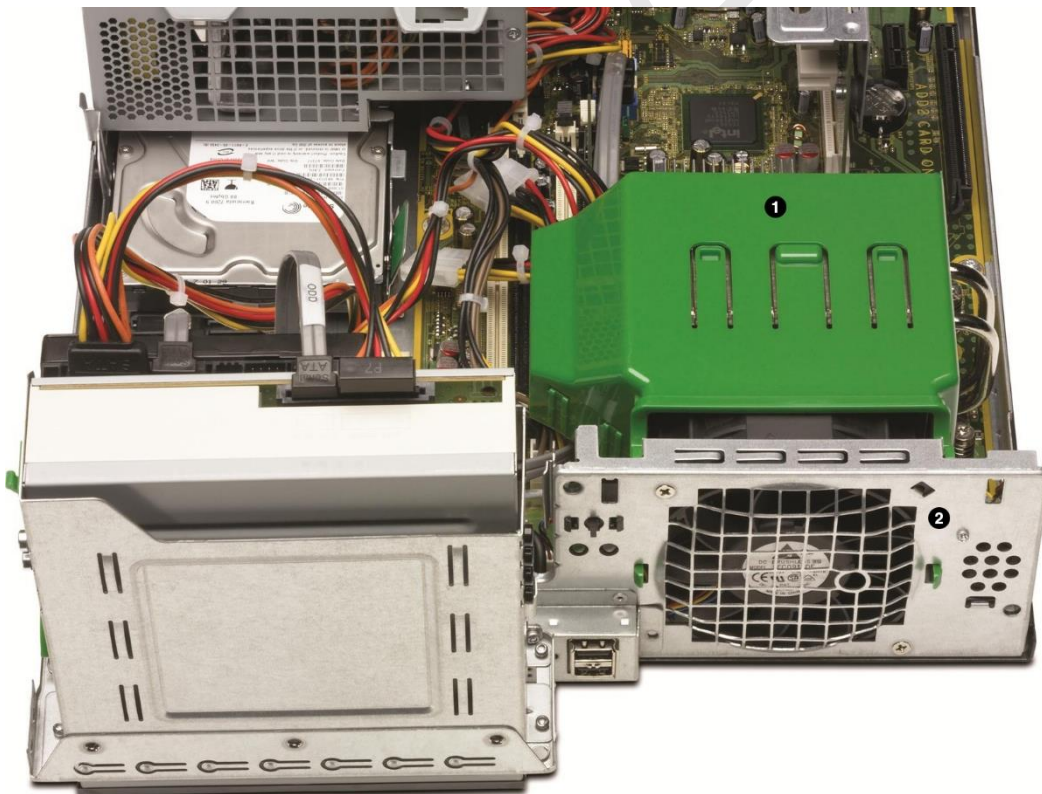
A fan is an **active cooling** device. It requires power to run. Power is supplied to a CPU or case fan by connecting its power connector to an appropriate header on the motherboard (make sure you plug the CPU fan into the header marked "CPU Fan" to ensure that the BIOS can run the fan at an appropriate speed). Power connectors and headers for fans are 3-pin or 4-pin.

- 3-pin models control fan speed by varying the voltage.
- 4-pin models control fan speed by switching the voltage on and off (using a Pulse Width Module [PWM] signal carried by the fourth wire). This gives better control over fan speed.

Fans with a 3-pin connector can usually be used with 4-pin headers but the system may not be able to vary the fan speed (or may need special configuration to be able to do so). A fan with a 4-pin connector will usually work with a 3-pin header but will not be able to use PWM.

The main problem with fans, especially at the lower end of the market, is that they generate *noise*. A fan also needs to be matched to the CPU model to ensure that it is powerful enough to cope with the processor's thermal output.

Some chassis designs incorporate a plastic shroud or system of baffles to cover the CPU and channel the flow of air.



Plastic shroud (1) covering the CPU and channeling the air to the fan exhaust (2) on an HP PC system (© Hewlett-Packard Development Company)

Heat Pipes and Heat Spreaders

A **heat pipe** is a sealed tube containing some type of coolant (water or ethanol). The liquid close to the heat source evaporates then condenses at a cooler point in the pipe and flows back towards the heat source. The cool parts of the pipe are kept so by convection. This mechanism is more effective than a simple heatsink and fan assembly. It is necessary for a CPU that runs particularly hot or where there is not much space for airflow within the chassis. A **dual heat pipe** has two tubes, providing better cooling.



CR-95C cooler (Image © 2015 NOFAN Corporation. www.nofancomputer.com)

A **heat spreader** uses the same design but is a flat container rather than a pipe. This design is better suited to portable computers. If used without fans, heat pipes and spreaders are classed as passive cooling.

Liquid-based Cooling Systems

PCs used for high-end gaming (those with twin graphics cards for instance) and with overclocked components may generate more heat than basic thermal management can cope with. PCs used where the ambient temperature is very high may also require exceptional cooling measures.



Liquid-cooled PC designed by Puget Systems (Image © 2014 Puget Custom Computers pugetsystems.com)

Liquid-based cooling refers to a system of pumping water around the chassis. Water is a much more effective coolant than air convection and a good pump can run more quietly than numerous fans. On the downside, liquid cooling makes maintenance and upgrades more difficult, requires comparatively more power to run, and is costly. Liquid cooling is an active cooling technology as the pump requires power to run.

Module 3 / Unit 3

Mobile Devices

Objectives

On completion of this unit, you will be able to:

- Explain the characteristics of smartphones, tablets, and wearable technology.
- Identify connection types and accessories for mobile devices.

Mobile Device Types



Driven by the iPhone and iPad, the last few years have seen huge uptake in the use of mobile devices. In some instances they have replaced traditional computer form factors (laptop and desktop) for day-to-day tasks, such as messaging / email and browsing the web.

Mobile devices have a custom operating system (typically Apple iOS, Android, or Windows Mobile) and an app ecosystem, which allows for applications to be downloaded to add functionality to the device.

Smartphone

As the name suggests, a **smartphone** is a phone with computer capabilities. Previous handheld computers (Personal Data Assistants [PDA]) were restricted by clumsy user interfaces. Modern smartphones use capacitive multitouch screens with LED displays, making them much easier to operate. Newer smartphones incorporate tactile feedback to provide for different levels of touch.

Most smartphones have a screen size of 3-5". Leading smartphones provide high resolution screens, like the 1334x750 resolution of the iPhone 6.

Smartphones have fast multi core CPUs, 1-2 GB system memory, and plenty of flash memory storage. They come with features such as 8-20 megapixel cameras, input sensors like accelerometers, and Global Positioning System (GPS) chips. They can establish network links using Wi-Fi and a cellular data plan.



A mobile device's internet connection can be shared with other devices, such as a PC. See [Unit 5.2](#) for more information about portable hotspots and tethering options.



Apple's iPhone 6s smartphone (Image © 2015 Apple Inc. www.apple.com)

Tablet

Prior to the iPad, tablet PCs were usually laptops with touchscreens. The iPad defined a new form factor; smaller than a laptop and with no keyboard. Tablets tend to be sized at around either 10" or 7" screens. Popular resolutions include 1024x600 and 1280x800. iPads 1, 2, and mini are 1024x768 while the iPads 3 and 4 have a resolution of 2048x1536.



Microsoft Surface Pro 4 tablet featuring clip on keyboard and stylus (Image © 2015 Microsoft www.microsoft.com)

Tablets are an alternative computing device. Some are referred to as slate computers and offer no keyboards using the multitouch screen to provide a virtual keyboard. Accessories such as clip on or Bluetooth keyboards built into a cover are also available. Network links are mainly established using Wi-Fi though some tablets come with a cellular data option too.

Their popularity is due to the success of their portability due to the size allowing for simple computing tasks. They often trade productivity to achieve this level of portability.

Current successful devices are the iPad series, Google Nexus and Samsung Galaxy devices, and Microsoft's Surface range. Other manufacturers are using the free to develop Android OS to create cheaper tablets.

Phablet

Phablets sit between smartphones and tablets in terms of size and usability. The name is a portmanteau of Phone and Tablet.

They were first popularized by Samsung with their successful Note devices. Phablets have screen sizes between 5.1 and 6.99 inches allowing for better mobile browsing and multimedia viewing. These devices usually come with a stylus which can be used for note taking, sketching, and annotations.

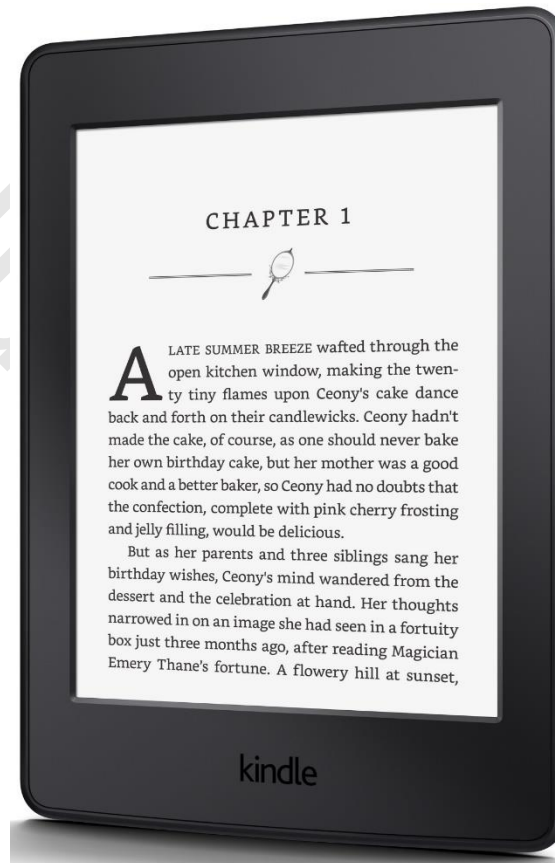


Samsung Galaxy Note 5 smartphone / phablet with a 5.7" screen and stylus (Image © 2015 SAMSUNG www.samsung.com)

Phablets always come with cellular data and a connection to the phone system, as well as Wi-Fi. Examples include Samsung Note 5, iPhone 6S, and Lumia 650XL.

e-Readers

Unlike a tablet, an **e-Reader** is designed for the sole purpose of reading books and magazines (with perhaps the option to add annotations). e-Readers are based on **e-Ink** technology, which allows for screens with very low power consumption. This technology allows for high contrast reading in a variety of light conditions. In typical conditions these screens are not backlit, saving power and extending battery life. It is not unusual to get several days or usage on a single charge for these devices.



Amazon's Kindle Paperwhite eBook Reader (Image © Amazon.com, Inc. www.amazon.com)

e-Readers are manufactured for major book retailers such as Amazon and Barnes and Noble. They have Wi-Fi connectivity to download ebooks directly from the retailer's webstore.

Wearable Technology Devices

Electronics manufacturing allows a great deal of computing power to be packed within a small space. Consequently computing functionality is being added to wearable items, such as watches, bracelets, and spectacles.

Smartwatches

Smartwatches have risen in popularity in the recent years. Current competing technologies are based on the **Android Wear OS**, **Samsung's Tizen OS**, and **Apple iOS** with their own separate app ecosystems. A smartwatch is likely to be customizable with different watch faces and wrist straps.



Samsung Gear S2 smartwatch (Image © 2015 SAMSUNG www.samsung.com)

Most smartwatches use Bluetooth to pair with a smartphone. They are able to display key information at a glance (emails, messages, and social media status for instance), allowing the user to better interact with the phone. Some newer smartwatches are starting to appear with their own Wi-Fi connectivity, allowing use of the watch without proximity to a paired phone.

As well as helping with personal information management, many smartwatches come with health features. Technologies bundled include heart rate monitors via Infrared (IR) sensors, accelerometers to measure sleeping patterns and movement for exercise, plus cameras and IR sensors to operate devices such as TVs.

Fitness Monitors

As the name suggest, **fitness monitors** focus on exercise and health uses rather than a range of computing tasks. This makes them cheaper devices than smartwatches. They also have smaller, customized screens and are a more rugged construction. They usually connect via Wi-Fi or Bluetooth to send data to a mobile app or PC software for analysis. Some feature a GPS tracker to allow runners to map their exercise accurately.



Fitbit Charge activity tracker (Image © 2015 Fitbit Inc. www.fitbit.com/)

Smart Glasses

Smart glasses were pioneered by Google with their Google Glass range. Other models are made by Microsoft (HoloLens) and AiR for industrial applications. They are sometimes also referred as **Digital Eye Glass**. Smart glasses use an **Optical Head Mounted Display (OHMD)** that implements a small virtual display at eye level to relay information to the wearer.



Google Glass featuring camera and OHMD (Image courtesy Mikepanhu / Wikimedia Commons CC-SA-3.0)

Network connectivity and pairing with other mobile devices is provided by Wi-Fi and/or Bluetooth. Most smart glasses also come with a camera and there are issues arising due to the potential invasion of privacy or breach of confidentiality such a relatively concealed recording camera could pose.

Input methods allowing the user to control the software running on the glasses include buttons, eye tracking, natural language voice input, plus gesture controls.

Smart Cameras

Smart cameras come with high resolution touch screens to allow the user to control the device as well as compose shots and preview images. They may be equipped with Wi-Fi and cellular data adapters to allow connection to the internet and posting of images directly to social media sites.

A smart camera may also be equipped with a Global Positioning System (GPS) receiver, allowing an image to be tagged with information about where it was taken (geotagging).

Module 3 / Unit 4

Troubleshooting Mobile Devices

Objectives

On completion of this unit, you will be able to:

- Install and configure laptop components using appropriate procedures.
- Diagnose and repair laptops and mobile devices from common symptoms.

Laptop and Mobile Disassembly



When it comes to performing upgrades or replacing parts, there are some issues specific to laptops and mobile devices that you should be aware of.

Hand Tools and Parts

Laptops and mobile devices use smaller screws than are found on desktops. You may find it useful to obtain a set of jeweler's screwdrivers and other appropriate hand tools.

It is also much easier to **strip** the screws (remove the notch for the screwdriver) - take care and use an appropriately sized screwdriver!

You need to document the location of screws (they are often different sizes) and the location and orientation of ribbon cables and other connectors. It can be very easy to remove them quickly during disassembly and then to face a puzzle during reassembly.



A useful tip is to take a photo of the underside of the laptop and print it out. As you remove screws, tape them to the relevant point in your picture. This ensures you will not lose any and will know which screw goes where. Photograph each stage of disassembly so you know where to re-fit cables and connectors.

As with a desktop, organize parts that you remove or have ready for installation carefully. Keep the parts away from your main work area so that you do not damage them by mistake. Keep static-sensitive parts (CPU, memory, and adapter cards for instance) in anti-static packaging.



The effect of ElectroStatic Discharge (ESD) on electronics and suitable precautionary measures against it is covered by objectives on the 902 exam. Refer to the "CompTIA A+ Certification Exam 220-902 Official Study Guide" for more information.

Laptop Form Factors

Many laptops are built using proprietary components and are fairly limited in terms of scope for customization and upgrade. However, as laptops have become cheaper and more popular, there are more vendors offering "bare bones" laptops and compatible components.

The laptop chassis typically incorporates the motherboard, power supply, display screen, keypad, and touchpad.

Make sure you obtain the manufacturer's service documentation. This should explain how to disassemble the chassis and remove tricky items, such as plastic bezels, without damaging them.

Mobile Device Form Factors

Mobile devices are even less likely than laptops to have field serviceable parts. The electronics will be densely packed and often soldered or glued together. Most will require return to the manufacturer to replace failed components such as a battery, display screen, or storage device.



Mobile handset with cover removed - note the slot for the SIM card in the top-right and that the battery is accessible but not designated as user-removable

Some mobiles have a user-replaceable battery, accessed by removing the cover. There will also be a port for a Subscriber Identity Module (SIM) card for GSM-based cellular access. This may also be fitted by removing the case. Refer to the device documentation for instructions on removing the case. Always power off the device before opening the case.



While it would usually void the warranty to further disassemble the device, there may be some circumstances in which you want to replace a part yourself. The best guide to doing so is a website hosting gadget "teardown" videos and repair guides, such as ifixit.com.

Upgrading Laptop FRUs

Laptops have fewer Field Replaceable Units (FRU) than desktops. That said, laptop components and designs have become better standardized (though using components sourced from the laptop vendor is still recommended). Basic upgrade options, such as memory and disks, have become much simpler as it reduces warranty support costs for the vendors.

Accessing FRUs in a Laptop

Some Field Replaceable Units (FRU) can be accessed easily by removing a screw plate on the back cover (underside) of the laptop. This method generally provides access to the disk drive, optical drive, memory modules, and possibly Mini PCI / PCIe adapters such as Wi-Fi cards and modems. The connectors can usually be flipped up and down to allow easy insertion and removal.

Laptop Hard Disk

Laptop hard drives are usually 2.5" form factor drives though sometimes the 1.8" form factor is used. Compared to 3.5" desktop versions, magnetic 2.5" drives tend to be slower (usually 5400 rpm models) and lower capacity (up to 4 TB). Within the 2.5" form factor, there are also reduced height units designed for ultraportable laptops. A standard 2.5" drive has a z-height of 9.5mm; an ultraportable laptop might require a 7mm (thin) or 5mm (ultrathin) drive.



Laptop hard disk drive with SATA interface (© Hewlett-Packard Development Company)



See [Unit 2.1](#) for notes on the features of magnetic, SSD, and hybrid drives.

Magnetic and hybrid drive typically use ordinary SATA data and power connectors, though the connectors on the drive mates directly to a port in the drive bay, without the use of a cable. 1.8" drives might require the use of the Micro SATA (uSATA) connector.

A laptop typically supports one internal hard drive, with extra storage being plugged in via a media bay or attached to an external port. The internal HDD and optical drives plus a smart card reader (if present) may be accessed via a panel or you may have to open up the chassis.

SSD flash storage devices might use the SATA interface and drive form factors but could also use an adapter or memory card-like interface:

- mSATA - an SSD might be housed on a card with a Mini-SATA (mSATA) interface. These cards resemble PCIe mini cards (see below) but are not compatible with PCIe mini slots.
- M.2 - this is a new set of form factors for mini card interfaces. An M.2 SSD can either use SATA or PCI Express natively.

Laptop System Memory

Some Field Replaceable Units (FRU) can be accessed easily by removing a screw plate on the back cover (underside) of the laptop. This method generally provides access to the disk drive, optical drive, memory modules, and possibly Mini PCI / PCIe adapters such as Wi-Fi cards and modems. The connectors can usually be flipped up and down to allow easy insertion and removal.

Laptop DDR and DDR2/3 SDRAM is packaged in small modules called Small Outline DIMM (SODIMM). Both DDR and DDR2 use 200-pin packages, but the key position for DDR2 is *slightly* different to prevent insertion in a slot designed for DDR. DDR3 uses a 204-pin SODIMM module. Ordinary SDRAM uses a 144-pin package.



Open the panel to access the RAM module(s) then flip the catch to pop the card up

The memory is typically fitted into slots that pop-up at a 45° angle to allow the chips to be inserted or removed.

Laptop Adapter Cards

Depending on the design, adapters for modems, wireless cards, and SSD storage cards may be accessible and replaceable via screw-down panels. A wireless card will feature an additional cable that connects to the antenna (usually positioned around the screen in the laptop's lid).



Adding a Mini PCI wireless adapter - note the wires for the antenna on the left

Note that there are a number of adapter formats, notably Mini PCI, Mini PCIe, mSATA, and M.2, none of which are compatible with one another.

Changing and Charging a Battery

Before inserting or removing the battery pack, you must always turn the machine off and unplug it from the AC wall outlet. A portable battery is usually removed by releasing catches on the back or underside of the computer or in a media bay.



Replacing the battery on an HP Pavilion laptop (© Hewlett-Packard Development Company)

A portable computer's battery can be charged in three ways:

- Plug the computer into an AC wall outlet with the computer turned off. This method is called a quick charge. It takes a couple of hours to fully charge a flat battery.

- Charge the battery while the computer is plugged into an AC wall outlet and turned on. This method is called a trickle charge. Trickle charging is slower because the primary use of power is for operating the PC, rather than for charging the battery. It can take several hours to charge a battery while the machine is turned on.
- Use a battery charger. This method charges the battery while it is not in the computer, but involves purchasing an extra charging unit.

To maximize battery life, different battery types require different charging regimes. Always consult the manufacturer's instructions for obtaining optimal battery life for a specific product.

Modern Li-ion batteries should *not* be allowed to fully discharge, as this reduces battery life. They benefit from regular charging and cannot be over-charged. They have circuitry to prevent over-charging because they will explode if over-charged. However, some degree of caution should be exercised when leaving batteries to recharge unattended (for example, overnight) as this circuitry has been known to fail. Do not leave a battery charger close to flammable material and ensure there is plenty of ventilation around the unit.

Li-ion batteries are also sensitive to heat. If storing a Li-ion battery, reduce the charge to 40% and store at below 20°C.



Li-ion batteries hold less charge as they age and typically have a maximum usable life of around 2-3 years. If you charge a battery and the run time is substantially decreased, you may need to purchase a new battery.

Upgrading Laptop System Components

To access components such as the CPU and graphics card (and possibly one or more of the memory slots), you need to disassemble the laptop. The general process is as follows, though do be aware that you need to obtain the specific steps for the brand and model of laptop you are upgrading or repairing.

Disassembling a Laptop

- 1) Make a backup of data stored on the local drive and, as you would for a PC, lay out your work area with any tools and reference material you will need and take anti-static precautions.
- 2) Disconnect peripheral devices and PCI ExpressCard adapters and eject discs from drives. Disconnect the AC power **and** battery.
- 3) Turn the unit upside down. Make a diagram of the screw locations.

- 4) Open any compartments on the underside of the laptop and remove the FRUs (these should include the hard drive, memory, and possibly the optical drive and mini adapter cards also).



Remove the battery, any add-in cards, and the hard drive then unscrew the case, making a careful note of which screw goes where



Store components that you remove in protective anti-static packaging.

- 5) Remove the screws holding the chassis together and put them somewhere safe.
- 6) Flip the laptop over again and remove the plastic bezel at the top of the keyboard. This might be difficult but take care not to snap it.

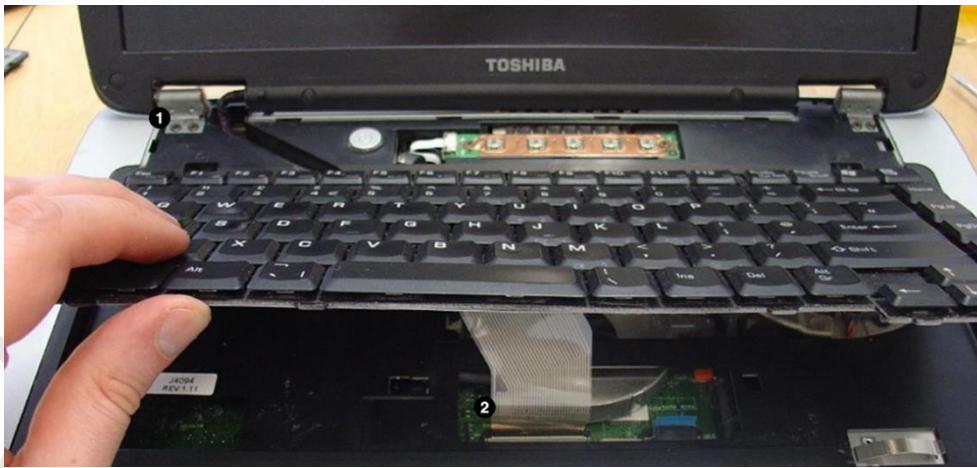


Depending on the age of the laptop, replacement plastics may be available from the vendor but are unlikely to be cheap. For older laptops, you may be able to source spare parts from auction sites such as eBay.

- 7) Unscrew the keyboard and partially lift it (carefully!) Disconnect the cable that attaches it to the motherboard then fully remove the keyboard.
- 8) Similarly, unscrew or unclip the palmrest and touchpad assembly, disconnect the signal cable, and lift away.



If you are upgrading the keyboard or touchpad (rather than replacing the same part), you may need to install a new driver and configure settings via the Mouse and Keyboard applets.



1) Unclip the plastic bezel (carefully) then 2) unscrew the keyboard and lift to disconnect

- 9) You may also be able to access the speaker(s) at this point. As with other components, you need to disconnect the signal cable as well as the speakers themselves.
- 10) Disconnect the LCD cable and LCD power connector connecting the display to the motherboard. There is also likely to be a cable connecting the radio antenna (running around the screen) to the wireless adapter.

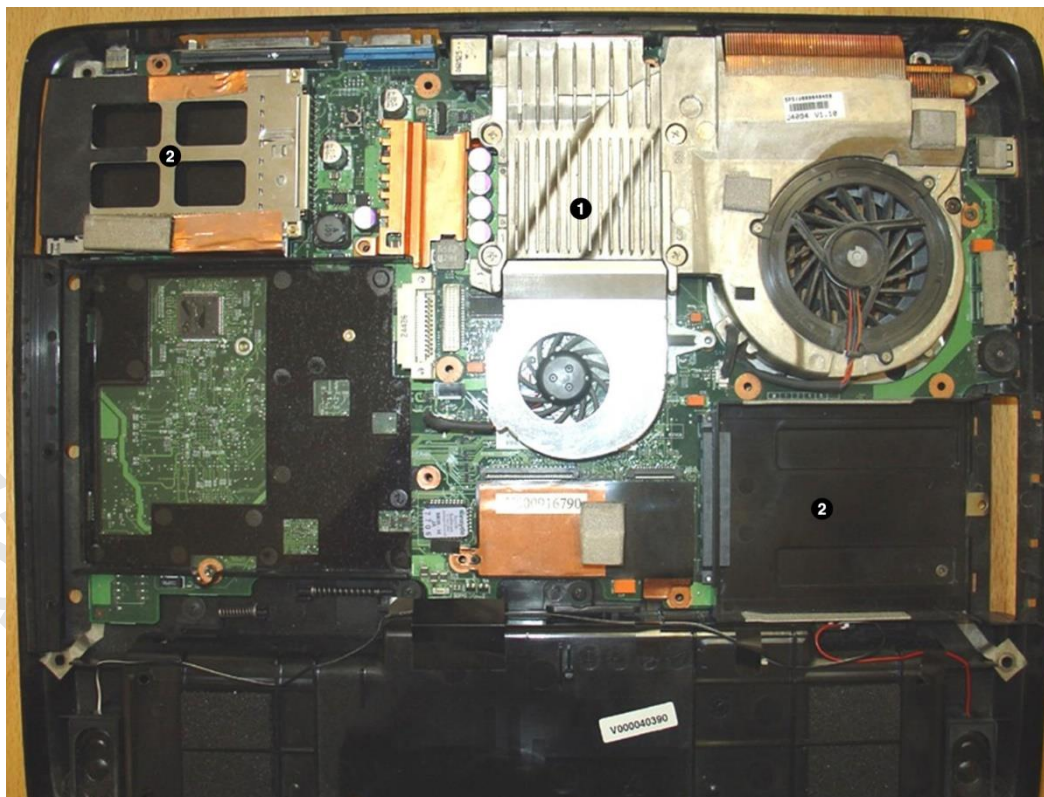


Disconnect the LCD cable making a note of how it is connected then remove the lid and display assembly from the motherboard



Make sure that you continue to record the position and orientation of cables and connectors.

- 11) Lift off the display (if you need to replace the display, unscrew it from the lid then screw the new panel in its place).
- 12) Remove any internal drive cages or heat pipes covering the components you want to replace. As with a desktop, make a careful note of how fan power connectors are attached.



Remove the heatsink and fan assembly (1) and drive / adaptor card bays (2) to access components on the motherboard, such as CPU, graphics, and CMOS battery

Devices such as the screen, keyboard, touchpad, system board, heat pipe, fans, speakers, or DC jack should be replaced using vendor-supplied parts.

Upgrading Laptop CPU and System Board

The CPU is generally upgradeable so long as the new device is supported by the motherboard.

The CPU is covered by a heatpipe rather than a heat sink. This is a long, flat metal strip that conducts heat toward the fan. Otherwise, it is locked into place in much the same way as a desktop CPU.



Some laptop CPUs (using Ball Grid Array [BGA] sockets) are soldered to the motherboard and therefore are not upgradeable.

There will be few occasions when it is economic to replace the system board itself. If you do need to do so, detach the stand-offs that hold the board to the chassis. If *upgrading* the system board, you will probably also need to update the chipset driver (or notebook system software) and allow Windows to discover the new device using Plug-and-Play.

Upgrading Laptop Graphics and Other Adapters

Laptops often use an **integrated** graphics adapter (as part of the system chipset), especially at the lower end of the market. Integrated graphics can be advantageous in terms of battery life and cooling. However, as laptops get used more-and-more as desktop replacements (particularly as games machines), **dedicated** graphics becomes more-and-more important. Cheaper graphics adapters may also feature a limited amount of on-board memory (or none at all). In this scenario, they share system memory with the CPU. Obviously, this decreases the amount of system memory available. Few graphics cards are actually *upgradeable*, though they may be *replaceable*. This is because high-end cards tend to have specific power and cooling requirements and a modular approach is not possible given the limited space available.

Troubleshooting Mobile Power



9b54m

The same basic approach to troubleshooting applies for mobile devices as it does for desktop PCs, though there are some issues specific to laptops and portables that you should be aware of.

Power Problems

If there is a power problem, first establish how the laptop *should* be operated and confirm that this procedure is being followed. For example, some laptops require that a battery be present, even on AC power.

If working from the battery, first check that it is inserted correctly and seated properly in its compartment. An LED may be present to indicate when the laptop is running on battery power or an LED may simply show when a battery is being charged.

If the battery is properly inserted and still does not work, it is most likely completely discharged. If the battery will not hold a charge, it could be at the end of its useful life. You can test this by using a "known good" battery; if this does not work then there is something wrong with the power circuitry on the motherboard.



Most adapters contain a circuit breaker to prevent overloads. If this trips, it will be a few minutes before the adapter will work again.

If you experience problems working from AC power, first test the outlet with a "known good" device (such as a lamp). Next check that an LED on the AC adapter is green; if there is no LED, check the fuse on the plug and if available, try testing with a "known good" adapter. If this does not work, inspect the DC socket on the laptop for any sign of damage. You could also check the AC adapter using a multimeter



Most adapters contain a circuit breaker to prevent overloads. If this trips, it will be a few minutes before the adapter will work again.

Sometimes AC adapters can get mixed up. If an underpowered adapter is used (for example, a 65W adapter is plugged into a 90W system), the system will usually display a warning at boot time. Other symptoms include the battery not charging, slow performance, and devices not functioning.

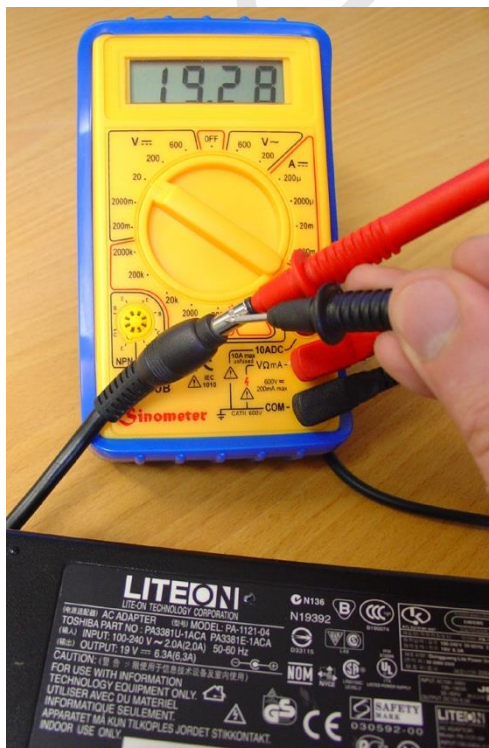
As with desktops, spontaneous reboots may indicate a power problem, though a more likely cause is overheating. Another possibility is that peripherals are trying to draw down too much power. Try disconnecting drives from the media bays or USB then re-booting to see if the problem is fixed. Note that larger hard drives and external CD/DVD writers will typically require their own power supply, even if connected via USB.

Testing an AC Adapter

You can use a multimeter to check the output of most types of AC adapter.

The expected outputs will be shown on the AC adapter label.

- 1) Set the meter up to test for the appropriate voltage range.
- 2) Insert the red probe into the middle of the DC jack.
- 3) Turn on the multimeter.
- 4) Touch the black probe to the metal part of the outside of the DC jack.



Testing an AC adapter