16th Edition
Understanding Computers
Today and Tomorrow
Comprehensive

Chapter 4
Input and Output

Deborah Morley
Charles S. Parker

Keyboards

- A **keyboard** is an input device used to enter characters at the location marked by the insertion point or cursor
  - Can be built-in, wired, or wireless
  - Converted to ASCII/Unicode by OS
  - Typically contains:
    - Standard alphanumeric keys
    - Numeric keypad
    - Function keys
    - Delete and Backspace keys
    - Ctrl and Alt keys
    - Arrow keys
    - Special-purpose keys

Pointing Devices

- **Pointing devices** are used to:
  - Select and manipulate objects
  - Input data
  - Issue commands to the computer
- Common types of pointing devices:
  - Mouse
  - Pen/stylus
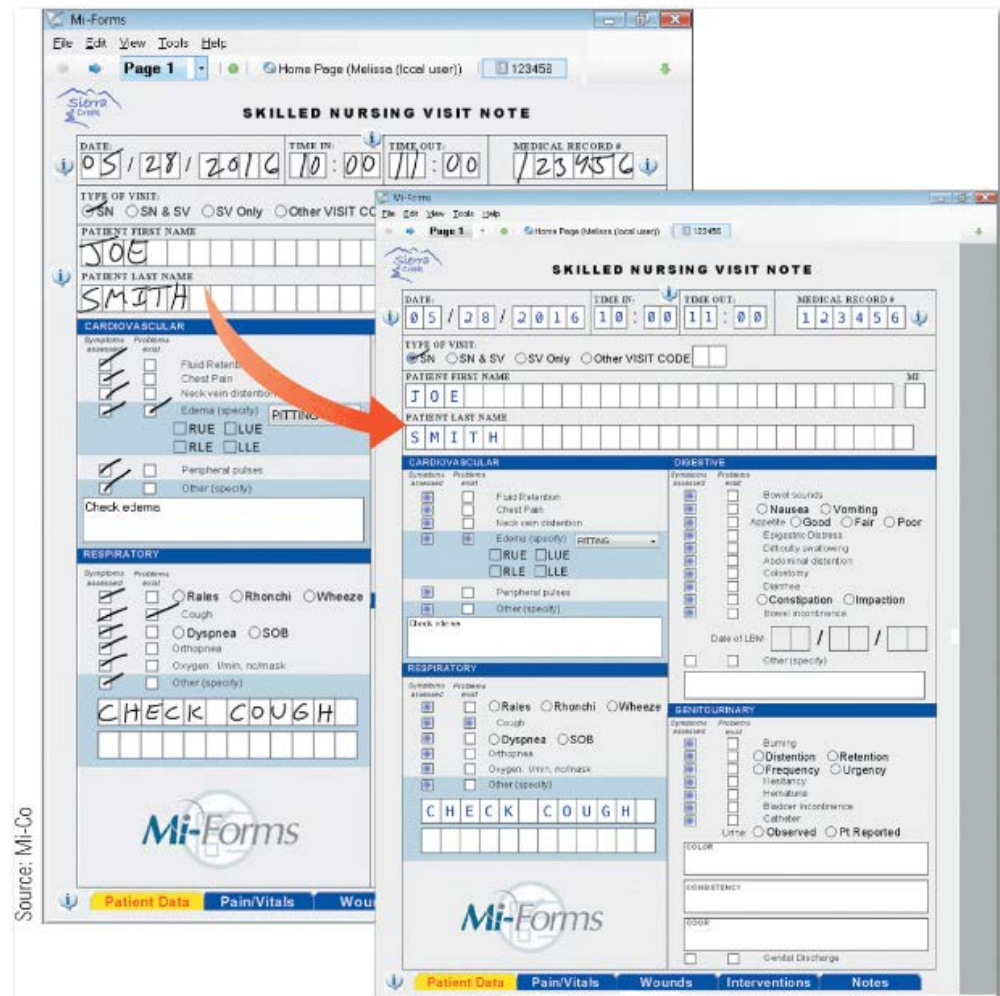 - Devices that use touch input

Pens/Styluses

- A **stylus** is a pen-like device used to draw or write electronically on the screen
  - Also called digital pen, electronic pen, or pen
  - Pen input is being used for:
    - Photography, graphic design, animation
    - Industrial design, document processing, and healthcare applications
    - Navigating through a document
    - Issuing commands
    - Handwritten input and drawings

Digital Forms

- With **handwriting recognition**, written text can be converted to editable typed text
- The use of digital forms is increasingly

FIGURE 4-6

Digital forms. If the software supports it, the text handwritten on a digital form can be converted by the computer to typed text.

Touch Screens

- **Touch screens** are display devices that are touched with the finger to select commands or otherwise provide input to the computer
  - Common on portable computers, smartphones, and other mobile devices
  - Multi-touch screens can recognize input from more than one finger at a time
  - Some support both touch and pen input
  - Surface Hub (large multi-touch wall-mounted display)
  - Table PC (large computer either built into a table or designed to be used on a table)

Perceptual Computing

Perceptual Computing

- Users control devices with 3D gestures, voice commands, and facial expressions

- Noncontact system

- Allows for full body input and input from a slight distance away or through a glass window

Courtesy Leap Motion

The Leap 3D System

Scanners, Readers, and Digital Cameras

- Some devices capture data initially in digital form
- Others capture data from source documents
  - Already exist in physical form (photographs, checks, invoices, or product labels)
  - Source data automation
    - Saves time
    - Increases accuracy
    - Utilizes scanning or reading devices

FIGURE 4-10
Source data automation.

RECORDING DATA DIRECTLY INTO A COMPUTER

CAPTURING DATA FROM ITS SOURCE DOCUMENT

Source: Motion Computing

Courtesy Honeywell International Inc.

Scanners

- A **scanner** (optical scanner) is an input device that captures an image of an object in digital form
  - Data is typically input as a single image
    - => Bitmapped/Raster Image Representations
  - Can scan photos, documents, images, etc.
  - Types of scanners
    - **Flatbed scanners** (scan flat objects one page at a time)
    - **Portable scanners** (scan objects while on the go)
    - 3D scanners (scan objects in 3D)
    - There are also task-specific scanners, such as receipt and business card scanners

Scanning Quality and Resolution

- Quality of scanned images indicated by optical resolution
  - Measured in number of dots per inch (dpi)
  - Can often be specified when image is scanned
  - Can be changed when scanned image is edited
- Higher resolution means better quality but larger file size

96 dpi
(833 KB)

300 dpi
(1,818 KB)

600 dpi
(5,374 KB)

RESOLUTION

Most scanners let you specify the resolution (in dpi) to use for the scan. High-resolution images look sharper but result in larger file sizes.

FIGURE 4-12
Scanning resolution.

Digital Cameras

- **Digital cameras** take pictures and records them as digital images
  - Can be still cameras and/or video cameras
  - Integrated into portable computers, smartphones, and tablets
- Digital still cameras
  - Primary appeal is that images are immediately available
  - Camera quality is measured in megapixels
  - Typically use flash memory for storage
  - Slight delay when taking photos

Optical Mark Readers (OMR) and Optical Character Recognition (OCR)

- Optical mark readers (OMRs) input data from optical forms to score or tally exams, questionnaires, ballots
- **Optical character recognition (OCR)** recognizes text characters and converts them to electronic form as text, not images
  - Identifies each character and convert it to editable text
  - Used to process turnaround documents like monthly bills
  - Read by OCR devices
  - Optical characters are designed to be read by OCR devices but can still be read by humans

Barcodes and Barcode Readers

- **Barcodes** are machine-readable optical codes that represent data as a set of bars
- **Barcode readers** are input devices that read barcodes
- Types of barcodes
  - Read by traditional barcode reader
    - Universal Product Code (UPC)
    - ISBN
    - Code 39
  - Read by mobile apps
    - QR Codes (two-dimensional; hold much more data)
    - Digital watermarks (icons)

Examples of Barcodes and Digital Watermark Icons

ISBN CODES

UPC (UNIVERSAL PRODUCT CODE) CODES

CODE 39 CODES

INTELLIGENT MAIL CODES

QR CODES

DIGITAL WATERMARK ICONS

Source: Motorola Solutions

FIGURE 4-13

Barcodes and digital watermark icons.

Biometric Readers

- **Biometric readers** are used to input biometric data such as an individual's fingerprint or voice

    - Can be stand-alone readers or built into another piece of hardware

    - Most often used for access control, to authorize electronic payments, and to log on to secure Web sites
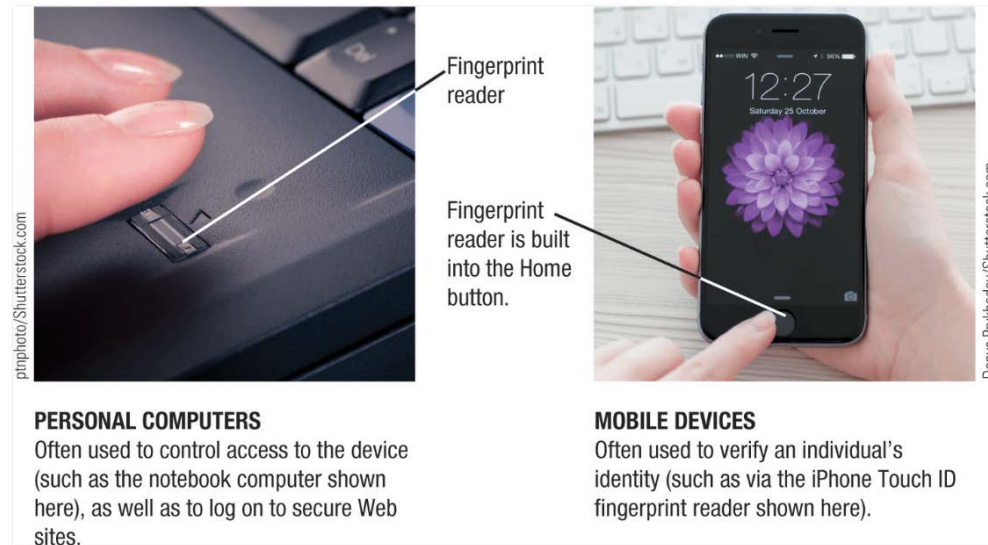

Fingerprint reader

Fingerprint reader is built into the Home button.

PERSONAL COMPUTERS
Often used to control access to the device (such as the notebook computer shown here), as well as to log on to secure Web sites.

MOBILE DEVICES
Often used to verify an individual's identity (such as via the iPhone Touch ID fingerprint reader shown here).

ptnphoto/Shutterstock.com

Denys Prykhodov/Shutterstock.com

FIGURE 4-20
Biometric readers.

Radio Frequency ID (RFID)

- **Radio Frequency Identification (RFID)** is a technology that stores, reads, and transmits data located in RFID tags
- **RFID tags** contain tiny chips and radio antennas
  - Can be attached to objects
  - Read by **RFID readers**
    - Handheld, portal, and stationary
  - Tags only need to be within range of the reader, rather than in line of sight
- Used for a variety of applications
  - Tracking inventory and assets
  - Electronic toll collection
  - Tracking patients in hospitals
  - Ticketing applications
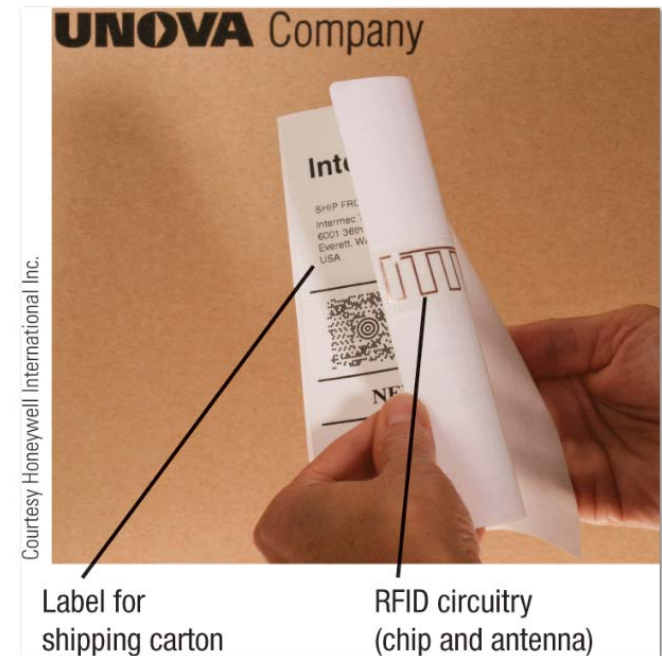 - IDs (driver licenses, U.S. passports, etc.)

Courtesy Honeywell International Inc.

UNOVA Company

Label for shipping carton

RFID circuitry (chip and antenna)

FIGURE 4-15
RFID tags.

Near Field Communications (NFC)

- **Near Field Communications (NFC)** is a short-range wireless communication standard based on RFID
  - Used to transfer information between smartphones or between a smartphone and an NFC-enable reader
  - Used for contactless mobile payments
    - Credit card or smartphone containing the NFC technology needs to be within an inch or so of the NFC-enabled payment terminal
      - More appropriate than conventional RFID for mobile payments

Augmented Reality

Augmented Reality

- Overlays computer generated images on top of real-time images

- Today, most often with smartphones using camera input, location info, and other data

- Displays appropriate information related to images captured by the smartphone

A smartphone AR app pointing at a business district.

Audio Input

- Audio input
  - The process of entering audio data into the computer
  - => Digitized (bit depth x sampling rate)
- Voice input
  - Inputting spoken words and converting them to digital form via microphone or headset
  - Used in conjunction with sound recorder software
  - **Speech recognition systems** enable the device being used to recognize voice input as spoken words
    - Detects Phonemes
    - Can be used for dictation as well to as to issue commands to the device
  - Usually incorporated into smartphones, GPS systems, and other mobile devices

Music Input Systems

- Music input systems input music into a computer or other device
  - Existing music can be input using CDs or a Web download
  - For original compositions, microphones, keyboard controllers, and guitar controllers can be used to input music
  - Inputted music can be edited, saved, played, etc.

Gines Romero/Shutterstock.com

FIGURE 4-24
Music input systems. Musicians can input original compositions into a computer via microphones, MIDI keyboards and guitars, and other devices.

Display Devices

- **Display devices** present output visually on some type of screen
  - **Monitors** are display devices typically used with a desktop computer
  - **Display screens** are built into a variety of devices
    - Notebook and other portable computers
    - Smartphones and mobile devices
    - Handheld gaming devices, home entertainment devices, kitchen appliances
    - Digital photo frames, e-book readers, smart watches
    - Digital signage systems, digital billboards

Display Device Characteristics

- Color vs. monochrome displays
  - Images are formed using **pixels**
  - Most displays today are color displays
- CRT vs. flat-panel displays
  - Cathode ray tube (CRT) displays: large, bulky, and heavy
  - Flat-panel displays: take up less desk space; use less power

MULTIPLE MONITOR SETUPS
Can be used with a single computer to extend a desktop, which can increase productivity.

SECOND DISPLAY FOR PORTABLE COMPUTERS
Can be used to extend the desktop when needed; this curved screen has a wider viewing angle than a traditional display.

FIGURE 4-26
Flat-panel displays.

Source: Hewlett-Packard Development Company, L.P.

cobalt88/Shutterstock.com

Size, Aspect Ratio, and Screen Resolution

- Size and aspect ratio
  - Device size measured diagonally from corner to corner
  - Wide variety of sizes available
  - Most are wide-screen displays (16:9 aspect ratio)
- Screen resolution
  - The number of pixels used on a display determines its resolution
  - Affects the amount of information that can be displayed on the screen at one time
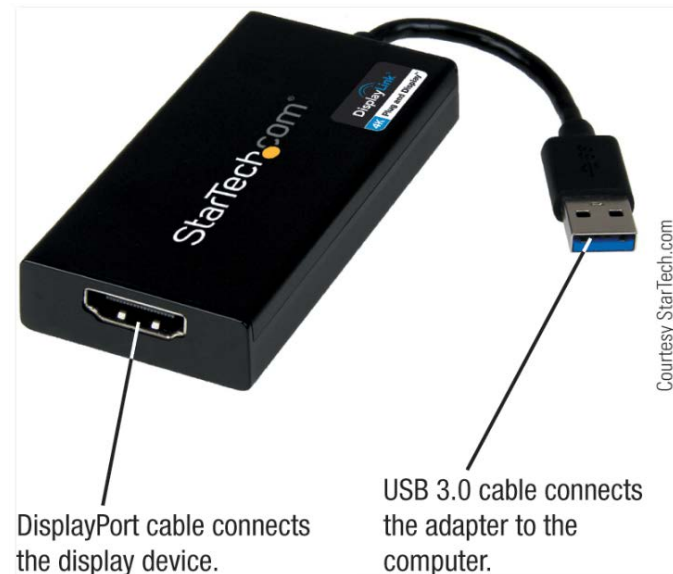 - Can be changed to match users' preference

What is 720P

- 720p => 720 horizontal scan lines
  - P is for Progressive (non-interlaced)
  - 720 vertical pixels
- Typically 1280 × 720 px
  - 16:9 aspect ratio (AR)
  - HD ready but 1080p is now most common HD
  - Requires ~1/2 bandwidth than 1080p
  - 720p is 1280 x 720 < 1 million pixels
  - 1080p is 1920 x 1080 > 2 million pixels

Video Adapters, Interfaces, and Ports

- Video cards determine the graphic capabilities of a computer

- VGA, DVI, and HDMI are the three most common interfaces to connect monitors to a computer

- Ports exposed in the system unit cases connect monitors to computers
  - Newer option is to use USB ports

FIGURE 4-28
A USB to DisplayPort 4K adapter.

DisplayPort cable connects the display device.

USB 3.0 cable connects the adapter to the computer.

Courtesy StarTech.com

Wired, Wireless, and High-Definition Displays

- Wired vs. wireless displays
  - Wired display are physically connected to the system via a cable
  - Wireless displays connect using a wireless network connection (Wi-Fi, Bluetooth)
- High-definition displays
  - Most common HD format is 1080p
  - **Ultra HD (4K)** uses about four times as many pixels as 1080p displays

Flat Panel Display Technologies

- **Liquid crystal displays (LCDs)** use charged liquid crystals between sheets of glass or plastic
  - Requires backlighting
- **Light emitting diode (LED)** displays use LCD panels and LED backlighting
- **Organic light emitting diode (OLED)** displays use layers of organic material
  - Emit visible light so do not require backlighting
  - More energy efficient
  - Are thinner and have a wider viewing angle
  - Incorporated into many digital cameras, smartphones, TVs, and other consumer devices

Electronic Paper (E-Paper) Displays

- **Electronic paper (e-paper)** displays use electronic ink (e-ink)
  - Used for e-readers and other devices
  - Easier to read in direct sunlight
  - Content can change wireless
  - Only uses power to change images, not maintain an image
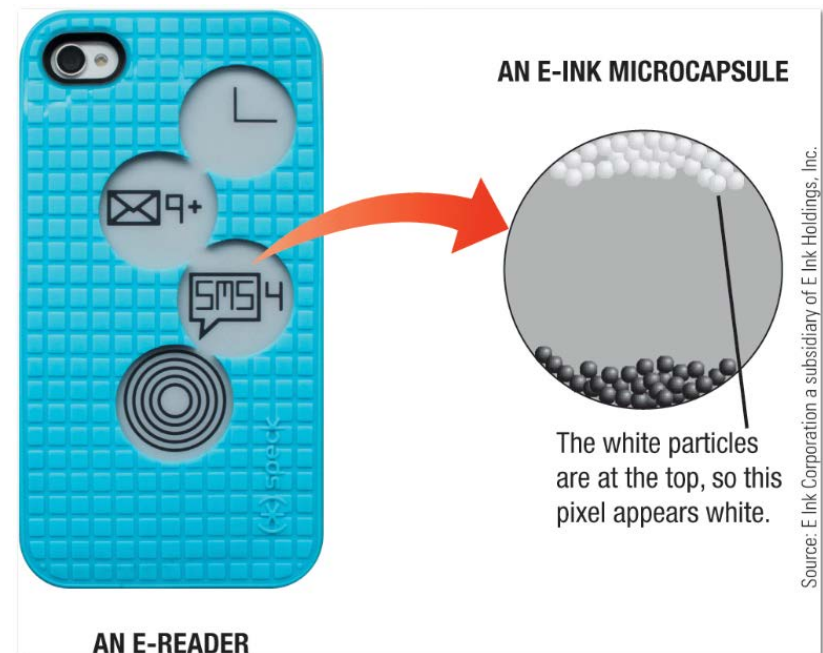 - Can be monochrome or color

AN E-INK MICROCAPSULE

The white particles are at the top, so this pixel appears white.

Source: E Ink Corporation a subsidiary of E Ink Holdings, Inc.

AN E-READER

FIGURE 4-33
How e-paper works.

Other Types of Flat Panel Displays

- Interferometric Modulator (IMOD) displays
  - Essentially a complex mirror that uses external light to display images
  - Designed initially for mobile phones and portable devices
  - Images are bright and clear, even in sunlight
- **Plasma displays** use layers of gas between two plates of glass
  - Being replaced by LCDs

Source: Qualcomm Technologies, Inc.

FIGURE 4-34
IMOD displays.

Wearable and Touch Displays

- Wearable displays project images from a mobile device to a display screen
  - **Smart glasses**
- Touch and gesture capabilities
  - Kiosks
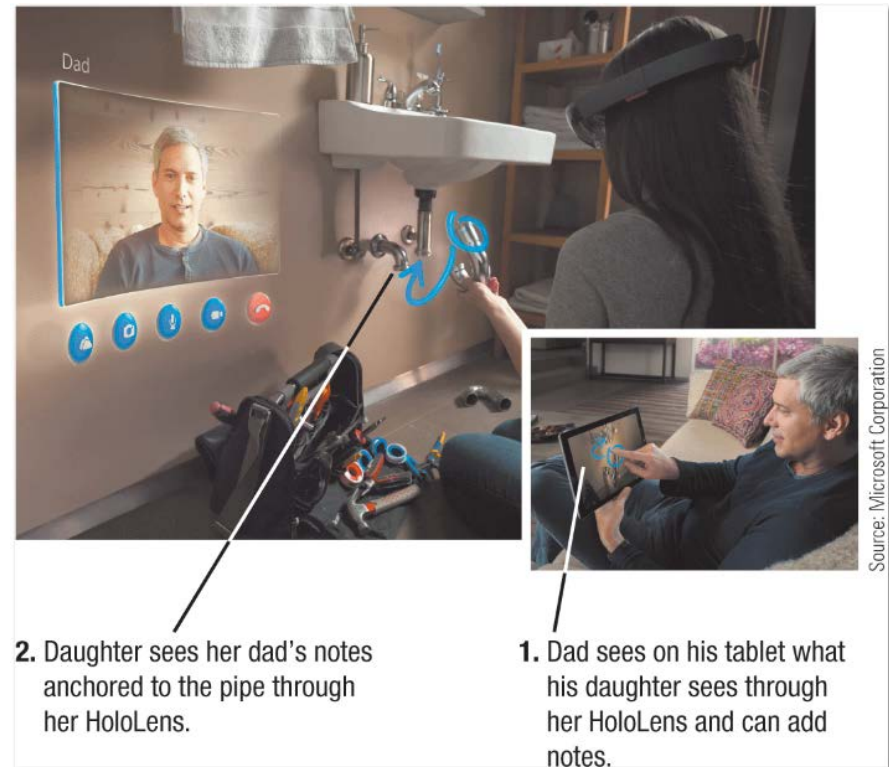 - Portable gaming devices
  - Smartphones
  - Tablets

FIGURE 4-30
Smart glasses.

AR Holographic Displays

Wearable Holographic Displays

- Project images on top of what the person wearing the display is already seeing

- Microsoft HoloLens

  - Essentially a head-mounted computer

  - Does not need to connect to a smartphone or computer to function

Source: Microsoft Corporation

2. Daughter sees her dad's notes anchored to the pipe through her HoloLens.

1. Dad sees on his tablet what his daughter sees through her HoloLens and can add notes.

Microsoft HoloLens

Data and Multimedia Projectors

- **Data projectors** (multimedia projectors) display output from a computer to a wall or projection screen
  - Found in classrooms and conference rooms
  - Can be wireless or integrated into devices
  - Some contain an iPod dock
- Pico projectors are pocket-size and connect to mobile and portable devices
- Keyboard projectors project virtual keyboards
- 3D projectors can project images used with 3D glasses or holograms

Printers

- **Printers** produce hard copy
  - Impact printers (dot-matrix)
    - Print mechanism strikes an inked ribbon to transfer ink to the paper
    - Used to produce multipart forms
  - Non-impact printers (ink-jet/laser)
    - Use liquid ink or toner
    - Produce higher quality images
    - Much quieter than impact printers
  - Can be color or black-and-white printers

Laser Printers

- **Laser printers** use toner powder and technology similar to that of a photocopier to produce images on paper
- The standard for business documents
  - Print one entire page at a time
  - Generally faster and have better quality output than ink-jet printers
- Use toner cartridges; toner is transferred to the paper and fused with heat
- Color printers use four toner cartridges

Ink-Jet Printers

- **Ink-jet printers** spray droplets of ink to produce images on paper
  - Use ink cartridges
  - Usually print in color
  - Often the choice for home use
  - Relatively inexpensive with good-quality output
  - Print more slowly than laser printers
  - Potential applications for the future
    - Dispensing liquid metal, computer chips, "printing" human tissue, silk and protein ink, etc.

Printer Characteristics

- Print resolution
  - Measured in dpi (dots per inch) or images per minute (IPM)
  - More dots per inch results in higher quality output
  - 300 dpi for general purpose printing; 1,200 dpi for photographs; 2,400 dpi for professional applications
- Print speed
  - Measured in pages per minute (PPM)
  - Range from about 15 to 65 ppm

Printer Capabilities

- Personal vs. network printers
  - Personal printers connect directly to a single computer
  - Network printers connect directly to a home or an office network; some can perform cloud printing
  - Cloud printing (over Internet often with Web interface)
- Connection options
  - USB connection, wired network, Wi-Fi, Internet
- **Multifunction devices (MFDs)** or all-in-ones
  - Copy, fax, scan, print

FIGURE 4-39
A multifunction device (MFD).

Source: Epson America, Inc.

3D Printers

- **3D printers** form output in layers to build a 3D version of the desired output
  - Can print using plastic, metal, ceramic, wood, glass, sugar, etc.
  - Additive manufacturing
  - Print customized objects on demand
    - Personal products
    - Medical products
    - Prototypes or custom parts
    - Can contain moving parts
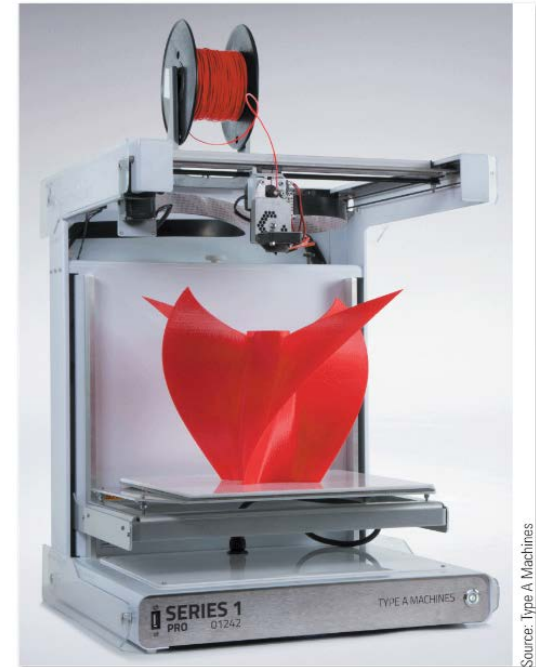 - Issues such as 3D-printed weapons

FIGURE 4-45
3D printers. Can print using a variety of materials (plastic is shown here).

Source: Type A Machines

Audio Output

- Audio output includes voice, music, and other audible sounds
  - Common audio output devices
    - **Computer speakers**
    - **Headphones**, **headsets**, and **earbuds**

COMPUTER SPEAKERS
Used to output sound from a computer.

PORTABLE SPEAKERS
Connect wirelessly to output sound from a smartphone or tablet.

EARBUDS
Used to deliver sound from a smartphone or other mobile device to one individual.

FIGURE 4-46
Audio output devices.

Summary

- Keyboards
- Pointing and Touch Devices
- Scanners, Readers, and Digital Cameras
- Audio Input
- Display Devices
- Printers
- Audio Output
- **Haptics (critically missing from text)**
  - **any form of interaction involving touch**