I. The computer: a tool for rearranging information.
   A. Information is the **basic raw material** of computer work.
      1. **Numeric** format
         a) In general terms, anything that can be described with numbers is information to the computer. This does not limit it to mathematics alone, however:
            (1) Colors: three numbers, for hue, saturation, and intensity, ranging from 0 to 255, will provide a choice among over 16 million different colors on a monitor.
            (2) Shapes: an average of 40 pairs of coordinate numbers can represent any character in a laser printer's sans-serif typeface.
            (3) Sounds: 44 thousand numbers per second, each ranging from 0 to just over 32,000, are music—any audible piece of music—to a Compact Disc player.
            (4) And a quantity of other things largely irrelevant to mathematicians but of great interest to artists…
      2. **Sources** and **destinations** of information
         a) A computer takes information from the user—e.g., the motion of his/her hand—and rearranges it into a different form—for instance, a picture.
            (1) No information is *created* within the computer, only transformed. The credit or blame for the finished piece still rests squarely on the artist's shoulders.
            (2) The computer can rearrange the same original information into unlimited other formats: colors, shapes, sounds, etc.
            (3) Computers differ from other art tools in that their function is not built in at the factory. They can be readily converted to perform a variety of tasks.
   B. A computer is a computer when it can perform these **basic functions**:
      1. **Acquire** information: input.
      2. **Retain** information: storage.
      3. **Control flow** of information: software.
      4. **Transform** information: processing.
      5. **Return** information—output.
   C. The functions listed above are performed by the following **parts of a computer system**:
      1. **Hardware**—the actual machinery.
         a) **Input devices.**
            (1) **Keyboard**. Input text and commands.
               (a) Standard on nearly every type of computer.
               (b) Basically a typewriter keyboard, but notice:
                  i) Numeric keypad
                     (1) Speeds up repetitive entry of numbers
                  ii) Cursor control keys (arrows, Home, Page Up/Down, End)
                     (1) Not always supported on the Macintosh. May replace pointing device in some instances.
                  iii) Function keys (F1 through F10, or more)
                     (1) Not always supported on the Macintosh. Used to invoke command sequences with a single keystroke.
                  iv) Escape (ESC) key
                     (1) Not always supported on the Macintosh. Used to back out of the current operation.
                  v) Modifier keys (keys held down while pressing another key to change the function of the latter)

(1) Shift key
    (a) Uppercase letters
    (b) Special function in most Macintosh programs:
        i) Extends/reduces selection (e.g. to select more than one icon, click on each in turn while holding shift down).
        ii) "Regularizes" drawings: horizontal and vertical lines, regular rectangles (squares), regular ovals (circles), etc.
(2) Command (Apple) key
    (a) Macintosh-only: primarily used to *invoke* menu commands from the keyboard (*command key equivalents*).
(3) Option key
    (a) Macintosh-only: primarily used to type special and non-English characters.
    (b) In most paint programs, also used to duplicate selection.
(4) Control key
    (a) Seldom used on the Macintosh. On other computers, it is used to invoke commands.
(5) ALT key
    (a) Not used on the Macintosh. On IBM-compatibles, used to type characters from alternate sets.

(2) Pointing devices. Move onscreen cursor.
  (a) Relative. Indicate to the computer in which direction and distance to move the cursor starting at its current location. Often faster, conserve space, cheaper.
    i) Mouse
      (1) Mechanical. Cheaper and easier to use. Moving parts pick up dirt and eventually jam.
      (2) Optical. Sturdier. Requires special surface to operate.
    ii) Trackball. Does not move, requires least space. Very hard to draw with.
    iii) Joystick. Does not move, requires least space, very sturdy. Nearly impossible to draw with.
  (b) Absolute. Tell the computer to move the cursor to a specific position on the screen. Allow tracing. Slightly more expensive.
    i) Graphics tablet.
      (1) Stylus or Pen. Most similar to a conventional drawing tool—ideal for freehand work.
        (a) Pressure-sensitive. Responds to how hard the hand presses on the tool, widening or darkening the stroke.
      (2) Puck or Cursor. Lies perfectly flat on the tablet and provides crosshair sights—ideal for tracing.
    ii) Touch screens and pads. Can be used directly with bare fingers—no special tool to lose or break. Not quite accurate enough for drawing.
    iii) 3D devices. Allow tracing and pointing in space. Mid-range to expensive, not widely supported.

(3) Image digitizers. Input line art, photographs, and motion pictures.
  (a) Scanner. Limited to input of flat art. Image quality not limited by video standards.
    i) Sheet fed. Inexpensive, limited to single loose leaves.

  ii) Flatbed. Slightly more expensive, images require lots of disk space. Allow scanning from bound books, generally more accurate.

  iii) Laser drum. Extremely expensive, enormous files. By far the best quality, used routinely for high quality color print jobs.

  iv) Slide. Mid-range price, very large files. Input 35mm and larger transparencies with mid-range results.

 (b) Video digitizer. May input any image that can be framed through a video camera.

  i) Slow scan. Requires several seconds to complete an image. Inexpensive, creates interesting—but overused—effects when the subject moves.

  ii) Frame grabber. More expensive. Completes image in 1/30 of a second, compatible with video frame rate.

  iii) Full motion video. Captures 30 or 60 images per second. Usually involves hardware-assisted compression.

(4) Sound digitizers. Input from a microphone or other audio source.

 (a) "Telephone" quality. Inexpensive. Acceptable quality for speech.

 (b) "CD" quality. Mid-range price, requires large and fast hard disk. Any sound imperfections are beyound the audible range.

b) Storage devices

(1) Main storage: "memory"

(a) Trade-offs

 i) Extremely fast—used to hold the information that the user is currently working on.

 ii) Relatively expensive—usually makes up a small part of the system's total storage.

 iii) Either rewritable (i.e., the user can add to, and remove from, its contents) and impermanent (contents will only last while the power is on); or read-only (not readily changeable by the user) and permanent;

(b) Devices

 i) Now invariably made up of solid state devices commonly known as microchips. On recent computers, memory chips are sold in groups of 8 (most Macintoshes) or 9 (IBM-compatibles) on small circuit cards called SIMMs (Single In-line Memory Modules), making memory installation easier.

  (1) The size of a chip refers to the amount of information that it can store. As we have seen already, the fundamental unit used in this case is the bit. Due to the way that information is logically arranged in the chips, however, the next unit up is not the byte but the kilobit, amounting to 1024 bits, followed by the megabit, or 1024 kilobits. As a result, 8 chips of the 1-megabit size variety are required to obtain 1 megabyte of memory.

  (2) Part of the main memory in your computer is pre-recorded at the factory and cannot be modified. This area is called ROM (Read-Only Memory), since a program can read the contents of the chips, but cannot write additional information on them.
The rest of the computer's main memory is available for programs to write and read to/from, and is called RAM (Random-Access Memory—a bit of a misnomer, actually).

(3) Some types of RAM chips (called Dynamic RAM—or DRAM) require frequent attention (in the form of refresh cycles) from the processor—lest they lose the information they contain. Chips that will not lose information even if neglected are called Static RAM—or SRAM. DRAMs will naturally slow down the computer's operation by keeping the processor busy but—since they're much cheaper than SRAMs (and will also contain more information)—they usually make up the bulk of a computer's RAM.

(4) A memory chip's speed (measured in nanoseconds) indicates how quickly it will respond when in use. Slow chips will affect the computer's performance, and they may be altogether incapable of keeping up with a fast processor.

(2) Mass storage: "disks"

  (a) Trade-offs

    i) Wide range of speeds, all substantially slower than main memory.

    ii) Widely variable, but generally lower, range of prices. Makes up the bulk of the typical system's storage.

    iii) Contents not erased when power is turned off. Shelf life may vary. Available in rewritable, write-once, and read-only formats.

  (b) Fixed devices

    i) Hard disk (high capacity, high speed devices)

  (c) Removable devices

    i) Random access (allow quick location of an item anywhere on the storage device. Relatively lower capacity).

      (1) Magnetic discs (small to mid-range capacity, slow to mid-range speed)

        (a) Floppies (diskettes). Most widely used personal computer storage and distribution medium.

          i) 3.5"

          ii) 5.25"

          iii) Non-standard

        (b) Removable hard disk

        (c) Bernoulli cartridge

      (2) Optical discs (very high capacity, mid-range speed devices)

        (a) Read-only

          i) CD-ROM

        (b) Write-once

          i) WORM

          ii) CD-R

        (c) Read/Write/Erase

          i) Phase-change discs

      (3) Magneto-optical discs (high to very high capacity, mid-range speed, read/write devices).

      (4) Memory cards. Very high speed, high cost, low capacity. Essentially a conveniently removable piece of main storage.

    ii) Sequential access (offer large recording surface—thus, higher capacity. Take relatively longer to locate information).

      (1) Magnetic tape

        (a) Analog audio cassette (small capacity, slow speed)

(b) Open reel (mid-range to high capacity, mid-range speed)
(c) Cartridges and data cassettes (mid-range to high capacity, mid-range to high speed)
(d) Video cassettes (very high capacity, mid-range to high speed)
(e) DAT (Digital Audio Tape) (very high capacity, mid-range to high speed)
  (2) Optical tape (mind-boggling capacity, unknown speed and availability)

c) Processing devices
  (1) Generally, single-chip devices called **microprocessors**.
  (2) Microprocessor **capabilities** are mainly determined by:
   (a) Data path width: determines how many bits can be processed at once.
      i) The earliest microprocessor could only process 4 bits at a time. Most current processors handle 32 bits, but the industry is gradually moving to 64 bits.
      ii) Some processors have different data path widths for their internal and external buses.
   (b) Clock speed: determines how often the processor will fetch information and execute program instructions.
      i) Early microprocessors ran at under 1 MegaHertz (1MHz = 1 million times per second). Current speeds up to 250 MHz. This figure is constantly growing.
      ii) Some processors clock their internal and external buses differently.
   (c) Architecture: determines how efficiently the operation of the processor can be streamlined.
      i) CISC (Complex Instruction Set Computers): older approach, favoring ease of programming over speed of execution.
      ii) RISC (Reduced Instruction Set Computers): allows simultaneous execution of multiple instructions when properly programmed.
   (d) Cache size: determines how much data and instructions are kept in very high speed memory (SRAM), with very high speed connections to the processor.
      i) Absent in early processors. Most current processors have some cache memory on the CPU chip (Primary Cache), which may be supplemented by cache memory outside the chip package (Secondary Cache)
      ii) Impact of cache on performance depends on the type of data processed.
   (e) Address space: determines how many memory addresses — hence, how much memory — the processor can keep track of.
      i) Early microprocessors limited to 64 KiloBytes. Currently up to 4 GigaBytes.
  (3) Most **common types** of microprocessors:
   (a) General-purpose: Central Processing Unit (**CPU**)
      i) Always present—the "brains" of the system.
      ii) Will handle a variety of tasks. Optimized for math involving integers.
   (b) Math-specific: Floating-Point Unit (**FPU**)
      i) Sometimes sold as standard equipment, otherwise installed as optional. Current trend is to embed them in the CPU chip.

        ii) Optimized for math involving numbers with a variable number of digits after the decimal point. Unnecessary for some types of graphics (paint programs), but indispensible for other (3D modeling and rendering).

   (c) Memory-management co-processors.

        i) Allow the use of a portion of the hard disk as main memory (Virtual Memory). Embedded in modern CPUs.

   (d) Graphics co-processors.

        i) Speed up refresh and update of the display.

   (e) Digital signal processors **(DSP)**

        i) Optimized for repeated application of the same operation on continuous streams of data.

        ii) Used for communications (e.g., modems), sound, and image processing.

        iii) Media processors: Philips TriMedia, Texas Instruments C8X, 3DO M2

  (4) Note that some computers increase performance by using **multiple CPUs**

   (a) Multiprocessing, or **parallel processing**, is made possible by a number of hardware and software features.

   (b) Multiprocessing is not the same as **multitasking** (the appearance of multiple programs running at the same time).The latter is a software feature which can be implemented on single processors.

d) Output devices

  (1) Monitor

  (2) Printer

  (3) Plotter

  (4) Film recorder

  (5) Videotape recorder

e) PwrMac 8500 datasheet

2. Software—the information flowing through the hardware.

a) Data—the numbers that represent pictures, music, etc.

b) Programs—the step-by-step instructions that tell the computer what to do with data.

  (1) System Programs—perform basic tasks not directly relevant to the user's work. Must be present for the computer to function at all. Often come with the hardware.

   (a) Operating System—a collection of instructions to perform simple, frequently needed, operations.

   (b) System Shell—an easy way for the user to take advantage of the operating system's capabilities. For instance, to look up the data on a disk.

  (2) Application Programs—perform useful work for the user. Generally purchased separately, according to specific needs.

   (a) Examples include: word processors (to type), sequencers (to compose music), database management systems (to store and retrieve facts and figures), and a variety of graphics programs.

   (b) Any one application program can only be used on *one* specific combination of hardware and system programs—the type of computer *system* it is compatible with.

3. Communications hardware and software—few computers operate in isolation.

a) details will be covered later in the class