I. Operating systems
   a. What the operating system has to do
      i. Get things started
      ii. Control all resources of the computer
         1. Runs other programs
         2. Manages memory (RAM and disk)
         3. Manages information on disk (file system)
         4. Controls peripheral devices
      iii. Provides a level of abstraction above the raw hardware
         1. Makes the hardware easier to connect with
         2. Makes programming much easier
   b. History of operating systems
      i. 1950’s – machine had a single user; not much operating system
      ii. 1960’s – operating systems largely batch; many users but one at a time
         1. Step forward was multiple users in sequence
      iii. Late 60’s, 70’s – time sharing – many users with perception of all at once
         1. Step forward was multiple users at once
      iv. 1980’s – personal computers
         1. Step backward was one user; step forward was multiple programs at once
      v. 1990’s – add PDAs
         1. Step forward was size; step backward was one program at a time
      vi. 2000’s – Windows vs Linux/Unix (which was what Apple was)
         1. Consolidation down to two main operating systems
      vii. 2010’s – Apple vs. Google (smart phones)
         1. Growth to four main operating systems
         2. Phones largely do not multitask
            a. When a new app starts, the previous app freezes in place
            b. But some apps can run while others are running
               i. Music
               ii. Location services
               iii. Push notifications
               iv. Phone
   c. Embedded systems (eg computers in car) do not have Operating systems
   d. Examples of operating systems
      i. DOS, Windows *, Unix/Linux, Mac OS X, IOS, Android
         1. Windows and window manager are different beasts
      ii. As time has gone by, the size of operating systems has grown. Why??
   e. How operating systems developed
      i. Multics → UNIX → Linux
         1. Bell Labs → Berkeley → ATT → Linus Torvalds (Linux)
      ii. MS/DOS
         1. Built on 86-DOS developed by Seattle Computer Products
         2. 86-DOS based on CP/M based on VMS (from DEC)
3. Still exists under Windows
   iii. Classic MacOS
      1. Largely influenced by Xerox PARC

II. How the operating system works
   a. What happens when the machine is turned on?
      i. User experience
         1. Screen comes on
         2. Desktop appears
         3. Interaction devise (mouse/keyboard) come to life
      ii. What’s really happening
         1. System boots
            a. BIOS comes on to allow you to talk to hardware
               i. Change order devices are turned on
            b. Boot program starts
               i. Loads from some disk
            c. Operating system kernel is loaded and system starts
         2. System enters fetch/execute cycle
            a. Fetch a command
            b. Parse the command
            c. Execute the command
   b. Example commands
      i. Mouse movement, mouse button click
      ii. Key up, key down
      iii. Input from other device
   c. Executing the commands
      i. Identify the window you are in
         1. Where did the command occur?
      ii. Identify the action being called for
         1. Text into Word window
         2. Start new application
            a. By typing name
            b. By clicking on icon
         3. Resize window
      iii. Execute command
         1. Text into Word window
         2. Command in window of existing program
         3. Command from icon
         4. Resize window
            a. Program running here is windowing system
   iv. Different ways to start Word
      1. Launchpad
      2. Click on Word document
a. How does it know?
   i. Registry in Windows
   ii. File associations in Mac

3. Click on Word icon
   v. When started
      1. Move executable code for command to RAM
         a. von Neumann model

d. managing RAM
   i. work an example

e. What if you run out of memory?
   i. Virtual memory on disk

f. If you run out of disk?

g. Review of what an operating system does
   i. Finds executables on disk and loads them into RAM
   ii. Keeps track of all running programs
   iii. Manages RAM
   iv. Manages window manager

h. Discussion of hierarchy of memory – register, cache, Ram, disk, cloud

III. Estimation problem
   a. How many windows on the Princeton campus

IV. Creepy or not
      i. FDA clearance for 13 clinical applications, including obstetric exams, musculoskeletal checks, and cardiac scans,
      ii. Butterfly iQ can be purchased by any licensed healthcare practitioner or facility in the United States permitted to perform diagnostic ultrasound in their state of practice. Butterfly iQ is a prescription device and is not yet available for use by consumers.
      iii. Under $2K
   
      i. 8 years ago – Google moonshot
      ii. Launched Waymo as stand-alone company 12/15
      iii. Minivan experiment started in Phoenix in April
      iv. Being extended to no safety driver soon
      v. Why Arizona?
         1. Wild wild west so little regulation
         2. Roads are straight and wide
         3. Weather is cooperative