1. What is the difference between volatile and nonvolatile memory? Is RAM volatile or nonvolatile? Is ROM volatile or nonvolatile?
    a. Volatile Memory: A device that can hold data as long as it is connected to a power source. No power source, no memory.
    b. Non Volatile Memory: A device that can hold data even if it isn't connected to a power source.
    c. RAM: Volatile Memory
    d. ROM: Non Volatile Memory
2. What does ALU stand for? What does CU stand for? What is a register? Be precise. Name several different kinds of values that a register might hold. What is the purpose of the instruction register?
    a. ALU: Arithmetic Logic Unit
    b. CU: Control Unit
    c. Register: A small, permanent high speed storage location in the CPU used for a particular purpose
    d. Instruction Register: The register in the CU that holds the instruction currently being executed
3. Describe the fetch-execute cycle. Explain the importance of a CPU's clock cycle. For example, what would it mean for a CPU to run at 4.77MHZ
    a. Fetch-Execute Cycle: The computer fetches the instruction from its memory and executes it. Repeat from when the computer is turned on to when it is shut down.
    b. CPU Clock Cycle: The clock controls when each step in the instruction takes place. The pulses are separated sufficiently to assure each step has time to complete, before the next step.
    c. CPU at 4.77MHZ: The clock would have 4.77 million pulses per second.
4. Explain the advantage in implementing separate fetch and execute units in a CPU. What additional task is implemented in the fetch unit as a performance enhancement measure?
    a. Separate fetch and execute units: When you have fetch and execute as 2 separate units, you can fetch the next instruction at the same time as you execute the current instruction.
    b. Additional task: You need to add a decode unit.
5. Most CPUs today are superscalar. What does that mean?
    a. Superscalar: A microprocessor design that allows for more than one instruction to be executed in one clock cycle.
6. What are the advantages of flash memory over hard disk storage? What are the advantages of hard disk over flash memory storage? What are the advantages of both hard disk and flash memory storage over RAM? What is the major advantage of RAM over other types of storage?
    a. Flash Memory: Flash memory is faster, more durable, small, quiet, efficient.
    b. Hard Disk Storage: Cheaper, more available, higher capacity.
    c. Both over RAM: Cheaper, readily available.
    d. RAM overall: Faster.

7. When a system has multiple levels of cache memory, L2 always has more memory than L1. Why is this necessary?
    a. L2 exists to speed up the case where there is an L1 cache miss. If L2 wasn't bigger than L1, it would not be able to have more lines than L1 to deal with L1 cache misses.
8. Suppose that a CPU always executes the two instructions following a branch instruction, regardless of whether the branch is taken or not. Explain how this can eliminate most of the delay resulting from branch dependency in a pipelined CPU. What penalties or restrictions does this impose on the programs that are executed on this machine?
    a. This eliminates the delay because the CPU doesn't have to wait for the branch to tell it the result in order to continue. If both branches run, there will be a much smaller delay in a pipeline CPU.
    b. Restrictions: The CPU can only execute linear code, so the code can only be so complex.
9. In general, what purpose does an interrupt serve? Stated another way, suppose there were no interrupts provided in a computer. What capabilities would be lost?
    a. Interrupts increase the overall efficiency of a computer. Without interrupts, the processor would need to poll every device periodically to check if any of them need attention.
10. What is the difference between polling and polled interrupt processing?
    a. Polling: An interrupt signal that includes which device is sending the interrupt signal.
    b. Polled interrupt: An I/O interrupt that notifies the computer that a device is ready to be read/handled, but doesn't include which device. It would need to poll each device to find which one needs attention.
11. In terms of the nature of the data, how does a keyboard differ from a hard disk as an input device?
    a. Keyboard vs hard disk: Input from a keyboard is ASCII code and text. Hard disk input can be symbolic or encoded as well.
12. Although CPU remain the same over the years, various improvements occurred in their architecture. Descried them in details.
    a. Improvements:
        i. More transistors per chip: This allows them to be faster, and smaller.
        ii. Better clock speed: This allows them to execute more instructions in a shorter amount of time.
        iii. Superscalar: This allows them to execute more instructions in a single clock cycle.
        iv. Dual-Core: This allows them to multitask more efficiently.
13. That's the problem with designing smaller CPU and the Moore's law.
    a. Moore's Law states that the number of transistors on a dense integrated circuit doubles approximately every 2 years. This can only go on for so long, eventually the transistors get so small that they become unreliable.
14. Provide the Arduinos Uno specification

a. Specifications:
    i. Microcontroller: ATmega328
    ii. Operating Voltage: 5V
    iii. Input Voltage(recommended): 7-12V
    iv. Input Voltage(limits): 6-20V
    v. Digital I/O Pins: 14 (6 provide PWM output)
    vi. Analog Input Pins: 6
    vii. DC Current Per I/O Pin: 40 mA
    viii. DC Current Per 3.3V Pin: 50 mA
    ix. Flash Memory: 32 KB (0.5KB used by bootloader)
    x. SRAM: 2 KB
    xi. EEPROM: 1 KB
    xii. Clock Speed: 16 MHz

15. Write a small program in assembly that calculates the following equation: 2x^2-3+4

```
.include "m328def.inc"
inc r16
.def x = r16
main:
  ldi x, 2
  ldi r17, 2
  ldi r18, 3
  ldi r19, 4
  mul x, x ; x = x^2
  mul r0, r17 ; x = 2*x
  sub r0, r18 ; x = x - 3
  add r0, r19 ; x = x + 4
  mov r20, r0 ; 2x^2 - 3 + 4
```