Multiple Choice

1. What is voltage?
    a. The electric potential of a point
    b. The rate of flow of electric charge through a point
    c. The difference in electromotive force between two points
    d. How difficult it is to push current through part of a circuit

Answer: C. This is the definition of voltage, and the key information is that voltage is a difference between two points.

2. Which of the following is least likely to cause a short circuit?
    a. Connecting an output pin to an input pin
    b. Using only a transistor and resistors to drive a DC motor
    c. Applying forward current to a capacitor with the positive lead to GND
    d. Achieving reverse voltage with a diode

Answer: A. Connecting an output pin to an input pin feeds signal back into the Arduino without needing a current limiting resistor. On the other hand, a DC motor should have a diode to protect it, the capacitor should have its negative lead to GND, and achieving reverse voltage with a diode can cause it to hit a breakpoint and short circuit.

3. Given an input voltage of +5V, what is the output voltage of a potentiometer with linear resistance when the knob is turned halfway?
    a. +0V
    b. +0.5V
    c. +2.5V
    d. +5V

Answer: C. Using the equation Vo = Vi(R2/(R1+R2), if the potentiometer knob is at the halfway point of a wire with linear resistance, then R1 = R2 and (R2/(R1+R2)) = 0.5. With Vi = +5V, 5(0.5) = 2.5 = Vo.

4. Which of the following is incorrect about capacitive sensing?
    a. Your finger can act as a second capacitor pad
    b. Only the human body works as a pad due to the salt water inside
    c. Capacitive sensing can be done with digital pins
    d. A charge pump circuit is a simple option for capacitive sensing

Answer: B. Many things can be used as a second capacitor pad such as metal plates, conductive thread, conductive paint, plants that hold water inside, etc.

5. The Arduino clone built on a custom PCB requires a 16MHz resonator in the circuit for serial communications. What is the resonator for?
    a. Oscillating at a frequency that aligns with electrical pulses
    b. Resonating to create a baseline tone for audio playing
    c. Synchronizing the ATmega328P clock with real time
    d. Telling the ATmega328P when to read valid bits of data

Answer: D. Serial communications means sending data in bits over time. It is not specified in the lecture notes whether the ATmega328P uses asynchronous or synchronous communication, but both methods determine what data is valid to read.

Long Answer

1. Machine learning and data analysis can be used to improve gadgets. Name three gadgets and explain how their sensor data inputs can be transformed with machine learning to create new features. Pick one of those ML-enhanced gadgets. What is the importance of properly fitted and tested classifications from the perspective of a user of this gadget? Are there potential issues of using this ML-enhanced gadget?

Three gadgets that collect data that can be trained upon and used for new features are the house water flow gadget, unique wristwatches with GPS tracking data, and context aware desk tools. The water flow detector that used audio and pressure data could have a machine learning model trained on its signals' waveforms to tell a user what type of water usage was happening in the house. Wristwatches, especially with GPS tracking data linked to individual devices, can be combined with external knowledge of what locations are and what people do at different times of day, to estimate what activities users are doing in their daily lives. An example of a context aware desk tool is an alarm clock that knows when the user usually needs to set alarms so that the clock can remind the user. This context aware alarm clock can also tell when the user is typically busy, perhaps in a meeting, and must be quiet.

It is important for the context aware alarm clock to have properly fitted and tested classifications because if the user is reliant on the clock to automatically set alarms for them, and the clock fails to do so, the user will face negative consequences and begin to mistrust the gadget. Similarly, if the alarm goes off when it is not supposed to, the user will start to hate the device and not want to use it. The difficulty of properly

training this machine learning model is that, if it is based on a decision tree, it is in best practices to not overly categorize the small edge case branches. However, the main cause of problems with a device like this happens when an unusual thing happens in the user's schedule, making what is normally a routine become a nuisance. These breaks in routine that the gadget ought to catch are exactly what the machine learning model is not supposed to take into consideration when making decisions.

2. Wieser and others discuss the vision of ubiquitous computing and why it hasn't been fully realized in the present day. Name a gadget that we discussed during lectures or demonstrated in class presentations and explain why it may not be easily adopted by users. Next, using sensors we've seen in class, design a simple modification that can improve this gadget's acceptance into the real world and explain why.

Plant-watering gadgets were common during class presentations. Most consisted of a soil moisture sensor and either a phone notification demanding manual watering or an automatic watering system with large tubes. However, these gadgets may find it difficult to become widely adopted by users because they are missing a few steps of convenience. First of all, a plant-watering gadget that only sends warnings of low soil moisture does not actually water the plant, so people who are already too busy to water their plants may ignore or miss the mobile notification and still not water their plants. If the gadget has an irrigation system, the piping may be too large, and it may need a water reservoir that still needs refilling, or an unwieldy connection to a water source in a building's wall.

I propose that the plant-watering gadget's physical footprint is shrunken down, and that plants can be purchased with these gadgets already installed in the pot's soil. The gadget can be in the shape of a small refillable bottle with a thin neck that is stuck into the soil. The soil moisture sensor will still remain here, but the bottle will be able to release water automatically without taking up a lot of space for tubing. The water can be released by a servo motor that rotates a valve for a brief period of time. The gadget will have a longer lifespan between maintenances, but still be portable and convenient. It can notify the user when the bottle is empty instead of when the pot is dry, perhaps using a float sensor inside the bottle. With these quality of life improvements and small size, the new plant-watering gadget is more likely to be used by plant owners.