Long Answer (2 questions)

1. **A.**
   Explain conceptually, for both the hardware and code, how you would go about setting up 4 LEDs to light up sequentially with an Arduino Uno *(no actual code needed)*.

Firstly, in the hardware setup, each LED is connected to a separate digital pin on the Arduino board through a current-limiting resistor to prevent excessive current flow. Additionally, each LED should also be connected to the ground (GND) pin on the Arduino, completing the circuit and allowing current to flow through the LED when it's turned on. This configuration ensures that the Arduino can individually control each LED. Secondly, in the programming aspect, a loop is utilized to iterate through each LED one by one. Within this loop, each LED is turned on for a specified duration using the delay() function to create a visible sequence. After lighting up one LED, it's turned off, and the loop proceeds to the next LED, creating the sequential lighting effect.

   B.
   Would you use analog or digital output for this circuit? Explain why.

To simply turn the LEDs on or off sequentially, digital output pins are sufficient and more straightforward to use. Each LED can be connected to a separate digital output pin, allowing independent control over each LED. Therefore, digital output pins are the appropriate choice for setting up 4 LED pins with an Arduino Uno.

   C.
   Now you want to increase the speed of the sequence each time it iterates through a loop until it gets to 5 times, then reset. Explain conceptually how you would do this in the code (*no actual code needed).*

To increase the speed of the LED sequence each time it iterates through a loop until it gets to 5 times, then reset, you can implement a variable to track the speed of the sequence. Initially, the speed variable is set to a base value. During each iteration of the loop, the delay between lighting up each LED can be decreased based on the current value of the speed variable, increasing the speed of the sequence. After each loop iteration, the speed variable is incremented until it reaches a maximum value, after which it resets to the base value. This process repeats for a total of 5 times before resetting the speed variable.

2. **A.**
   Meg, a student in Scott Hudson’s Gadgets course, is preparing her final project presentation. Unfortunately, while riding her electric unicycle to class, she falls and loses one of the resistors in her project and can't remember which resistor to

use. However, she remembers that she has an LED that requires 20 milliamperes (mA) of current. If she wants to connect the LED directly to the 5 volts output from an Arduino Uno, how can she calculate the value of the resistor she should use to limit the current flowing through the LED? Provide the formula and the steps to find the resistor value.

To calculate the value of the resistor Meg should use to limit the current flowing through the LED when connected directly to the 5 volts output from an Arduino Uno, she can use Ohm's Law.

R = V/I (or any other variant of this same formula e.g. V=IR)

R = 5/.02 = 250 ohms.

If Meg were to connect the LED directly to the 5 volts output from the Arduino Uno, she would need a 250 ohm resistor to limit the current to 20 milliamperes.

B.
While preparing her final project presentation, Meg hears from a classmate that she may not need a resistor when connecting an LED directly to the digital output pins of an Arduino Uno. Her classmate claims that since the digital output pins can supply sufficient current, using a resistor is unnecessary. Is Meg's classmate correct? Explain why or why not, considering the potential consequences of connecting an LED without a current-limiting resistor.

Using a resistor is still advisable for two main reasons. Firstly, without a current-limiting resistor, the LED may draw excessive current, leading to potential damage to both the LED and the Arduino. Secondly, using a resistor ensures that the LED operates within its specified current and voltage ratings, prolonging its lifespan. Therefore, while it's technically possible to connect an LED directly to a digital output pin without a resistor, it's not recommended due to the potential risks involved.

C.
In her final presentation, a student asks Meg if she considered using a potentiometer to control the brightness of her LED. She has not tried this before, but is curious and wants to set it up after class as an experiment. Explain conceptually how Meg can connect a potentiometer to this circuit with both the hardware and code *(no actual code needed)*.

To incorporate a potentiometer into her circuit for controlling the brightness of her LED, Meg connects one end of the potentiometer to the 5 volts output from the Arduino Uno, another end to ground, and the signal pin of the potentiometer to an analog input pin on the Arduino. This arrangement allows Meg to read the varying voltage levels using the analogRead() function in

her code. By turning the potentiometer knob, Meg adjusts the voltage level at the analog input pin, which corresponds to the desired brightness level of the LED. In her code, Meg maps the analog input values from the potentiometer (ranging from 0 to 1023) to a suitable range for controlling the LED brightness. For instance, when the potentiometer is at its minimum position, the LED emits minimal brightness, and when it's at the maximum position, the LED emits maximum brightness.

Multiple Choice (5 questions)

1. **When connecting an LED to an Arduino Uno, why is it important to use a current-limiting resistor?**
   A) To increase the brightness of the LED.
   B) To protect the LED from excessive current and potential damage.
   - *Not using a resistor can cause the LED to overdraw current and damage the LED.*

   C) To reduce the voltage across the LED.
   D) To decrease the resistance in the circuit.

2. **Using an LED that requires 33 milliamperes (mA) of current and an output pin of 5 volts, what resistor value should she use to limit the current flowing through the LED?**
   A) 250Ω
   B) 330Ω
   C) 220Ω
   D) 150Ω
   - *R = V/I. R = 5/.033 = 150 ohms.*

3. **What is the purpose of the void setup() function in an Arduino sketch?**
   A) To initialize variables used in the sketch.
   B) To declare pin modes and set initial conditions for the program.
   - *The void setup () function is where one can declare all the pins and conditions so that the code runs this first and sets everything up*

   C) To define the main loop of the program.
   D) To execute specific tasks once the program starts running.

4. **In an Arduino Uno, what does PWM stand for?**
   A) Pulse Width Modulator
   - *No explanation needed*

   B) Power Wave Modulation
   C) Periodic Wave Modulator
   D) Phase Width Modulation

5. **In an Arduino project, why might a capacitor be used in conjunction with a voltage regulator?**

A) To increase the output voltage of the regulator.
B) To reduce the input voltage to the regulator.
C) To stabilize the output voltage and reduce noise.
- *When a capacitor is used in conjunction with a voltage regulator in an Arduino circuit, its primary purpose is to stabilize the output voltage and reduce noise in the circuit.*

D) To provide additional current to the regulator.