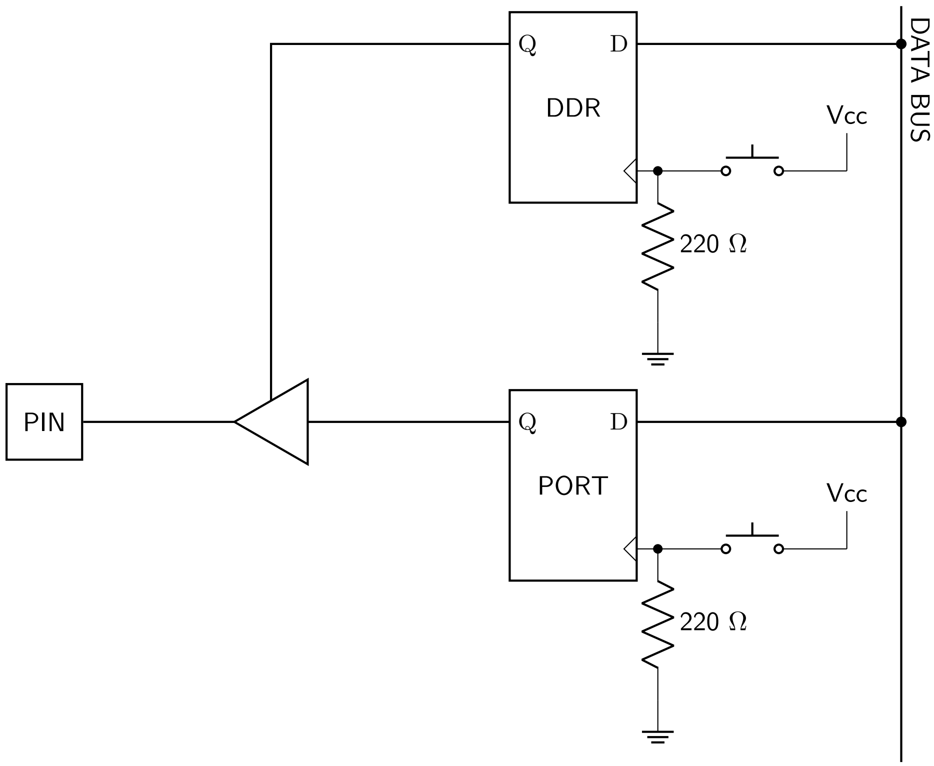
Name: ______________________

Activity 1: General Purpose I/O Hardware

Carefully read each question before answering. Refer to the lab manual, class textbook, ATmega328P datasheet, and any other relevant resources. Show all work or justify all of your answers to receive credit.

Build a 2-bit I/O port setup corresponding to the circuit diagram below. The thick lines represent 2-bit buses.



This will simulate the output functionality of the GPIO pins on the ATmega328P. Pushbuttons are used to transfer data from the data bus to either the data direction register (DDR) or port register. Connect LEDs to the data bus, and connect different color LEDs to the output pins. Demonstrate the functionality of your circuit to your instructor to receive a stamp.

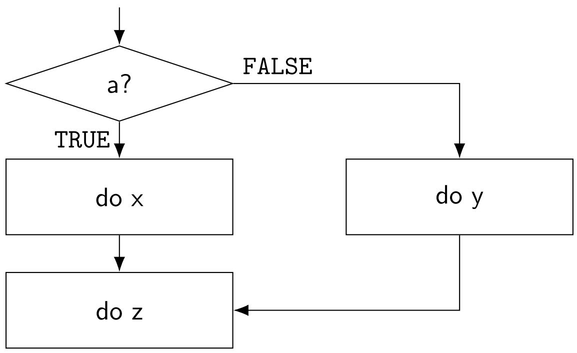
Instructor Stamp: ______

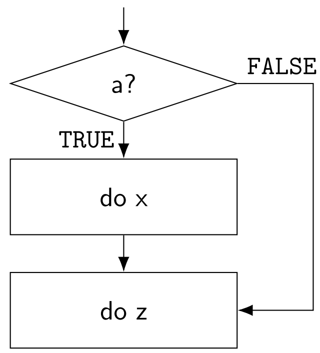
Name: ______________________________

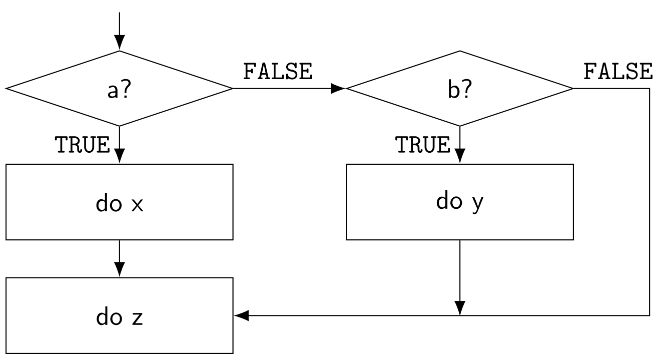
Activity 2: Control Flow

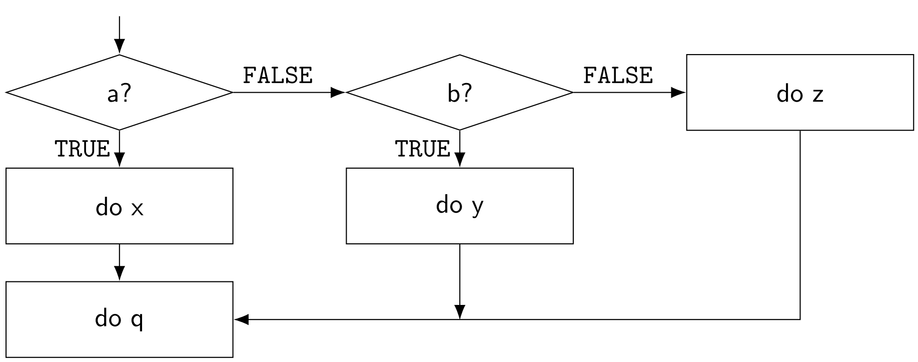
Carefully read each question before answering. Refer to the lab manual, class textbook, ATmega328P datasheet, and any other relevant resources. Show all work or justify all of your answers to receive credit.

Identify each of the following types of conditional control flow by analyzing the flowcharts.

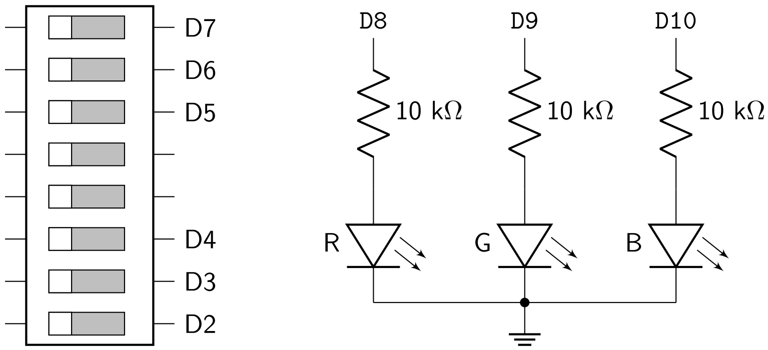








Circuit I: Use a DIP switch with **internal pull-up resistors** and an RGB LED with a current-limiting resistor on each anode (as shown in the following circuit diagrams) to perform the following tasks.



- The DIP switch inputs connected to pins `D7` (MSB), `D6`, and `D5` (LSB) comprise variable `a`.
- The DIP switch inputs connected to pins `D4` (MSB), `D3`, and `D2` (LSB) comprise variable `b`.
- If `a` > `b`, the RGB LED should be red.
- If `a` < `b`, the RGB LED should be green.
- If `a == b`, the RGB LED should be blue.

Before you begin, answer the following questions:

1. How will you mask and shift data from `PIND` to save as the variable `a`? (Your answer should be in the form of `unsigned char a = // something to do with PIND`. Consider how the use of internal pull-ups may affect this answer.)

2. How will you mask and shift data from `PIND` to save as the variable `b`? (Your answer should be in the form of `unsigned char b = // something to do with PIND`. Consider how the use of internal pull-ups may affect this answer.)

When the circuit is functioning properly, demonstrate it to your instructor to receive a stamp. Submit your software code and schematics as directed by your instructor.

Instructor Stamp: ______

Name: ____________________

Activity 3: ADC Configuration Registers

Carefully read each question before answering. Refer to the lab manual, class textbook, ATmega328P datasheet, and any other relevant resources. Show all work or justify all of your answers to receive credit.

Consider Lab 2 Circuit III. You will use the analog to digital converter (ADC) in full-precision free-running mode with auto triggering enabled, AVCC as the reference voltage, a prescaler of 128, and no interrupts. You must initialize the register to set the start conversion bit to trigger the first conversion cycle. **All reserved (unused) bits in each register should be assigned a value of 0.**

1. How will you configure `ADCSRA`?

7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
`ADEN`	`ADSC`	`ADATE`	`ADIF`	`ADIE`	`ADPS2`	`ADPS1`	`ADPS0`

   (a) What is the value of this register in hexadecimal?

2. How will you configure `ADCSRB`?

7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
–	`ACME`	–	–	–	`ADTS2`	`ADTS1`	`ADTS0`

   (a) What is the value of this register in hexadecimal?

3. Which ADC pin will you use for data input?

4. How will you configure `ADMUX`? You will use AVcc as the reference voltage.

7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
`REFS1`	`REFS0`	`ADLAR`	–	`MUX3`	`MUX2`	`MUX1`	`MUX0`

   (a) What is the value of this register in hexadecimal?

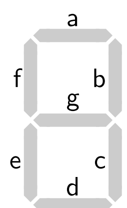
Name: ____________________

Activity 4: Arrays

Carefully read each question before answering. Refer to the lab manual, class textbook, ATmega328P datasheet, and any other relevant resources. Show all work or justify all of your answers to receive credit.

Decide if you'd like to use a common-cathode or common-anode display to display hexadecimal characters 0–F. Record your choice below.

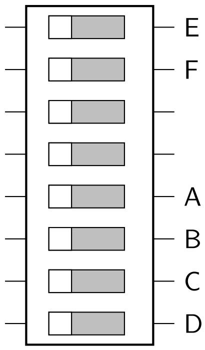
Each of the segments on the display is labeled as follows.



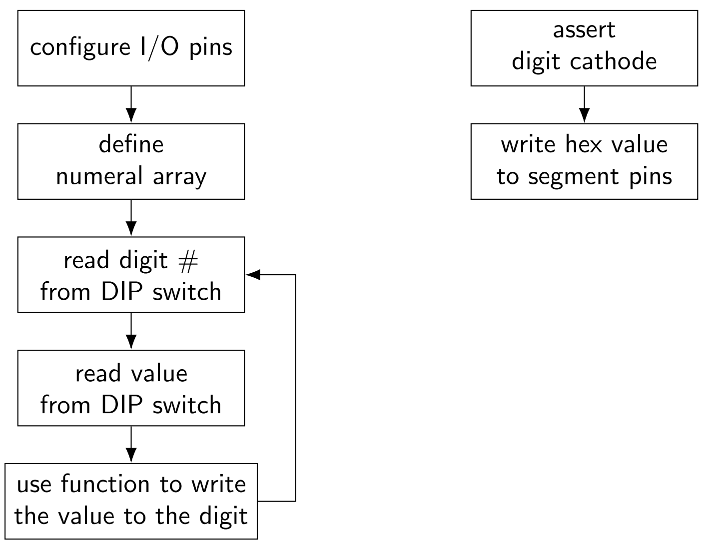
Determine if each segment should be ON or OFF for each character. Determine the values (use hexadecimal) that you would need to send to `PORTD` to accomplish this, if each segment of the display is connected to a pin on `PORTD`. Connect the display to an Arduino using current-limiting resistors between each segment and the corresponding Arduino pin to verify that your values are correct.

segment	a	b	c	d	e	f	g	hex value
pin								–
0								
1								
2								
3								
4								
5								
6								
7								
8								
9								
A								
b								
C								
d								
E								
F								

Circuit I: Use a DIP switch and a MUX 7-segment display to display a hexadecimal character defined by bits `ABCD` on the DIP switch on the digit defined by bits `EF` on the DIP switch. Use the numeral array you defined on the previous page to generate each hexadecimal character. A video of how this circuit functions is available online: `https://youtu.be/4VKFYXrp-nI`



Use the following flowchart to help you write your code. Note that the external function is not explicitly labeled but can be identified by a lack of arrows connecting it with the main program flow. Your external function should have a name that meaningfully identifies its functionality.



When the circuit is functioning properly, demonstrate it to your instructor to receive a stamp. Submit your software code and schematics as directed by your instructor.

Instructor Stamp: ______

Name: ______________________________

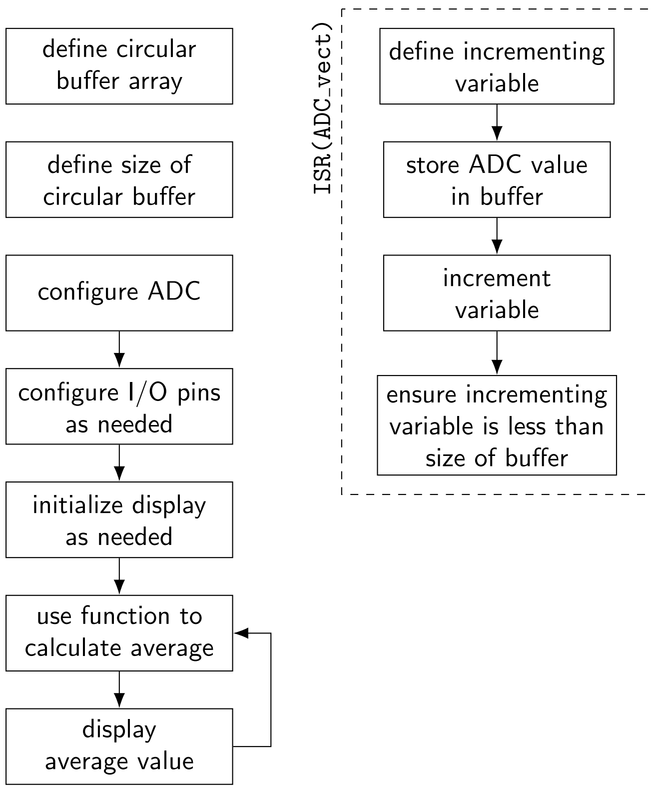
Activity 5: Averaging a Circular Buffer

Carefully read each question before answering. Refer to the lab manual, class textbook, ATmega328P datasheet, and any other relevant resources. Show all work or justify all of your answers to receive credit.

Circuit I: This circuit will create a foundation for the circuits in Lab 4. In this circuit, you will use the serial monitor, LCD screen, or MUX display to display the average of a circular buffer of data recorded from a potentiometer connected to the ADC. Use full-precision mode. You will be using the ADC ISR in Lab 4, so use it in this circuit as well.

Choose a value between 10–20 to use for the circular buffer. Use a variable to refer to this quantity in your software. It's important that this variable is easy to change if you want to modify it.

Use the flowchart provided below to assist in writing your code. The external function used to average the data is not shown in the flowchart. (Refer to Lab 4's flowchart if you need help writing this function.) **Do not use floating-point math.**



When the circuit is functioning properly, demonstrate it to your instructor to receive a stamp. Submit your software code and schematics as directed by your instructor.

Instructor Stamp: ______

This part of the activity is to familiarize you with deriving an equation for a sensor that is both accurate and that uses integer math. This activity will consider the SHT30 humidity sensor. This device outputs an analog voltage that scales with the relative humidity of the surrounding environment. Table 1 below is from the SHT30 datasheet, and can be used to determine how the voltage scales with humidity (consider that VDD would be equal to 5.0 V using our microcontroller). You can assume for the sake of this exercise that there is no offset (that is: the relative humidity would be 0 % if the output voltage of the sensor is 0 V).

1 Sensor Performance

Humidity Sensor Specification

Parameter	Conditions	Value	Units
SHT30 Accuracy tolerance[1]	Typ.	±3	%RH
	Max.	**Figure 2**	-
SHT31 Accuracy tolerance[1]	Typ.	±2	%RH
	Max.	**Figure 3**	-
Repeatability[2]		0.1	%RH
Resolution	Typ.	0.01	%RH
Integrated Non-Linearity[3]	Typ.	0.2	%RH
Hysteresis	at 25°C	±0.8	%RH
Specified range[4]	extended[5]	0 to 100	%RH
Response time[6]	$\tau_{63\%}$	8	s
Long-term drift	Typ.[7]	<0.25	%RH/yr
Sensitivity	V_{DD}=2.4 V	19.2	mV/%RH
	V_{DD}=3.3V	26.4	mV/%RH
	V_{DD}=5.0V	40.0	mV/%RH
	V_{DD}=5.5V	44.0	mV/%RH

Table 1 Humidity sensor specification

1. If the sensor can only measure humidity levels between 0 % and 100 %, what datatype should be used for the sensor value?

2. Derive an integer-math equation for the humidity of the sensor that is based on the value from the ADC. Assume that you are using the ADC in full-precision mode.

Name: ______________________________

Activity 6: External and Pin Change Interrupts

Carefully read each question before answering. Refer to the lab manual, class textbook, ATmega328P datasheet, and any other relevant resources. Show all work or justify all of your answers to receive credit.

Circuit I: Build a circuit that uses a pushbutton connected to pin D2 to trigger an external interrupt. When the button is pressed, an LED (connected to any other I/O pin) will turn on. When the button is not pressed, the LED will turn off.

1. What values do you need to save to `EICRA` to trigger an external interrupt on pin D2?

7	6	5	4	3	2	1	0
–	–	–	–	`ISC11`	`ISC10`	`ISC01`	`ISC00`

2. What values do you need to save to `EIMSK` to trigger an external interrupt on pin D2?

7	6	5	4	3	2	1	0
–	–	–	–	–	–	`INT1`	`INT0`

When the circuit is functioning properly, demonstrate it to your instructor to receive a stamp. Submit your software code and schematics as directed by your instructor.

Instructor Stamp: ______

Circuit II: Build a circuit with three pushbuttons (one for red, one for green, and one for blue) connected to pins D8, D9, and D10 and an RGB LED connected to three other pins of your choice. Pressing a pushbutton will turn on one color LED. When the pushbutton is not pressed, that color LED will turn off. Pressing multiple buttons will generate secondary colors as well as the color white.

1. What values do you need to save to `PCICR` to trigger pin change interrupts on pins D8, D9, and D10?

7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
–	–	–	–	–	`PCIE2`	`PCIE1`	`PCIE0`

2. What values do you need to save to `PCMSK0` to trigger pin change interrupts on pins D8, D9, and D10?

7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
`PCINT7`	`PCINT6`	`PCINT5`	`PCINT4`	`PCINT3`	`PCINT2`	`PCINT1`	`PCINT0`

When the circuit is functioning properly, demonstrate it to your instructor to receive a stamp. Submit your software code and schematics as directed by your instructor.

Instructor Stamp: ______

Name: ______________________________

Activity 7: Smart Car I/O Pins

This activity is intended to get you started thinking about how things will connect to your smart car.

Motors

The speed pins must be on PWM-enabled pins. Use the same timer/counter for each motor.

Description	Pin	Description	Pin
Left motor forward speed		Right motor forward speed	
Left motor reverse speed		Right motor reverse speed	
Left motor control		Right motor control	

Line Followers

The line followers output an analog voltage between 0–5 V.

Description	Pin		
Left sensor		Center sensor	
Right sensor			

Wheel Encoders

The wheel encoders output digital signals.

Description	Pin		
Left wheel encoder		Right wheel encoder	

For the barrier detection demo, you can opt to use the contact switches or ultrasonic sensors. Each has different I/O requirements.

Contact switches

The contact switches are essentially pushbuttons.

Description	Pin
Left switch	
Right switch	

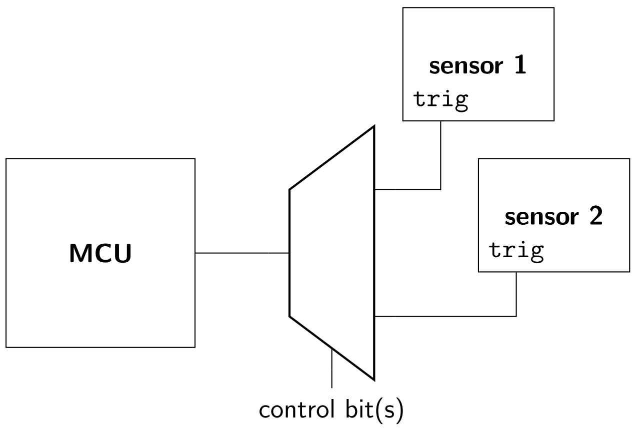
Ultrasonic sensor(s)

See note on next page for more information.

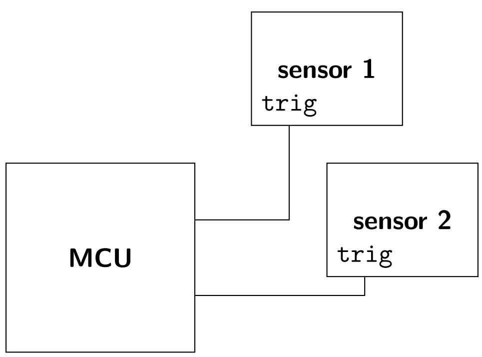
Description	Pin
Trigger pin(s)	
Echo pin	
MUX pin(s)	

Each ultrasonic sensor requires a digital signal sent to its trigger pin. If using more than one ultrasonic sensor, you can opt to use one pin on the MCU to send this signal and an external DEMUX to select which sensor's trigger pin to connect to. This will require the use of control bits, but you will already have these for the echo pin (keep reading). Alternatively, you can opt to use one individual MCU pin to connect directly to each sensor's trigger pin.

Shared trigger pin

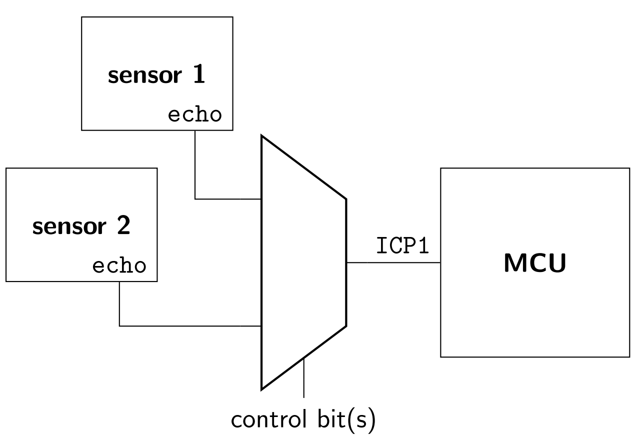


Individual trigger pins



The echo pin must connect to `ICP1`. If using two ultrasonic sensors, you must include one extra pin to use as a MUX control bit. If using three ultrasonic sensors, you must use two pins as MUX control bits.

Shared echo pin



Name: ______________________________

Activity 8: Timer/Counter LED Toggling

Carefully read each question before answering. Refer to the lab manual, class textbook, ATmega328P datasheet, and any other relevant resources. Show all work or justify all of your answers to receive credit.

In this activity, you will use a DIP switch to control the frequency of oscillation of an LED by toggling an output compare pin associated with one of the timer/counter output compare units. The range of frequencies should include frequencies that are slow enough to be visible to the human eye but not include any frequencies slower than approximately 1/3 Hz.

1. Which timer/counter(s) can you use to achieve this outcome?

2. Which prescaler will you use?

3. You will configure the output compare pin to toggle on a compare match. This means that it will take two compare match cycles to generate a complete oscillation of the LED. Based on this information, your selection of timer/counter, and prescaler, calculate..

   (a) ...the slowest period of oscillation of the LED (based on `OCRnx` = `MAX`).

   (b) ...the fastest period of oscillation of the LED (based on `OCRnx` = `BOTTOM`).

4. What values will you need to store in registers...

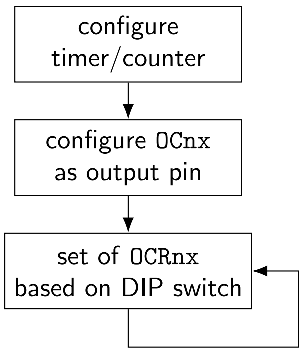
   (a) ...`TCCRnA`?

   (b) ...`TCCRnB`?

5. Before continuing with this activity, have this data stamped by your instructor to verify its accuracy.

Instructor Stamp: ______

Circuit I: Build a circuit that uses the 8-bit value of a DIP switch to control the blink frequency of an LED. This circuit will use a timer/counter in CTC mode where `OCRnx` will be scaled between `BOTTOM` (when the value on the DIP switch is 0) and `MAX` (when the value on the DIP switch is 255). Use the compare match output mode bits in `TCCRnA` to cause the LED (connected to the corresponding output compare pin) to toggle on each compare match. Use the following flowchart to assist as you write your code.



When the circuit is functioning properly, demonstrate it to your instructor to receive a stamp. Submit your software code and schematics as directed by your instructor.

Instructor Stamp: ______

Name: ______________________________

Activity 9: Lab 7 Super Pre-Lab

Carefully read each question before answering. Refer to the lab manual, class textbook, ATmega328P datasheet, and any other relevant resources. Show all work or justify all of your answers to receive credit.

The first part of this activity is to experience the glitch generated by fast PWM waveforms by using it to generate a 1 kHz signal sent to an LED with a duty cycle of 0 %. You should see that the LED never turns completely off when using fast PWM, but does turn completely off when using phase-correct PWM.

1. Using timer/counter 2 with fast PWM to control an LED with a frequency of approximately 1 kHz...
   (a) What is the smallest possible prescaler that can be used to accomplish this, when counting to `MAX`?

   (b) Use a duty cycle of 100 %, 50 %, and 0 % to see how the brightness of the LED changes. Simultaneously view the output signal on the oscilloscope. Note in particular the glitch that occurs in fast PWM with a duty cycle of 0 %. Display this condition to obtain a stamp.

Instructor Stamp: ______

Now you will derive values to use in lab. To avoid glitches, we will use phase-correct PWM. For each of the following, display the waveforms on an oscilloscope. Use a static duty cycle of 50 % for each signal to display on the oscilloscope.

2. In circuit 1, you will use timer/counter 2 with phase-correct PWM to control an LED with a frequency of approximately 1 kHz.
   (a) What is the smallest possible prescaler that can be used to accomplish this, when counting to `MAX`?

   (b) What is the actual frequency of operation in this condition?

   (c) Display the signal on the oscilloscope to obtain a stamp. (Use a duty cycle of 50 % to demonstrate the correct frequency, then use a duty cycle of 0 % to demonstrate that the LED is able to turn completely off.)

Instructor Stamp: ______

3. In circuit 2, you will use timer/counter 1 with phase-correct PWM to control a servomotor with a frequency of 50 Hz.
   (a) What is the smallest possible prescaler that can be used to accomplish this?
   (b) What is the corresponding value of `OCR1A` (round to the nearest integer)?
   (c) Display the signal on the oscilloscope to obtain a stamp.

Instructor Stamp: ______

4. What values of `OCR1B` are necessary to turn the servomotor to an angle of...
   (a) ...10 °, which requires a 0.6 ms value for T_{on}?
   (b) ...170 °, which requires a 2.4 ms value for T_{on}?
5. Write an equation for `OCR1B` as a function of the ADC value. Use bitshift operators so that you can decide what ADC resolution to use during lab. **Do not use floating-point math!**
6. In circuit 3, you will use timer/counter 1 with phase-correct PWM to control a DC motor with a frequency of 25,000 Hz.
   (a) What is the smallest possible prescaler that can be used to accomplish this?
   (b) What is the corresponding value of `OCR1A` (round to the nearest integer)?
   (c) Display the signal on the oscilloscope to obtain a stamp.

Instructor Stamp: ______

7. What value of `OCR1B` is necessary to obtain a duty cycle of 10 % (which corresponds to a mostly off functionality of the DC motor)?
8. Write an equation for `OCR1B` as a function of the ADC value. Use bitshift operators so that you can decide what ADC resolution to use during lab. **Do not use floating-point math!**

Name: ____________________________

Activity 10: Wheel Encoders

Carefully read each question before answering. Refer to the lab manual, class textbook, ATmega328P datasheet, and any other relevant resources. Show all work or justify all of your answers to receive credit.

The wheel encoders on the Smart Cars function to give us information about how many wheel rotations have occurred. The wheel encoders use a device known as a Hall sensor, which is able to detect a particular pole in a magnetic field.

- The magnet attached to the motor has 8 poles, which means the encoder will toggle its state (HIGH to LOW) 4 times per motor revolution.
- The motor and the wheel are geared with a 48:1 ratio. This means that the motor will turn 48 times for each wheel revolution.
- The wheel encoders provide a digital signal and must be connected with internal pull-up resistors enabled.
- The Smart Car wheel diameter is 65 mm.

1. Given the number of poles in the magnet, and the gear ratio between the magnet and the wheel, how many times will the encoder toggle its state per wheel revolution? Verify this number with your instructor before you continue this activity.

Instructor Stamp: ______

2. Decide which two pins you will use to connect to the wheel encoders. (Consult activity 7.)

3. Write the code required for enabling the internal pull-up resistors on these two pins.

4. Will you use external interrupts or pin-change interrupts to check for a toggle in pin state on these two pins? Explain your choice. (You may not have a lot of choice based on the pins that you are using for other peripherals. Consult activity 7.)

Circuit I: Write code that detects **falling edges** on the wheel encoder signals to increment a variable (one for each wheel). Calculate the average of the increments between both wheels.

Display the number of increments on each wheel as well as the average number of increments on either the serial monitor or LCD screen.

To test your code, rotate one of the wheels through one revolution. You should note that the variable corresponding to that particular wheel will increment a number of times equal to the number you calculated in Question 1. Repeat with the other wheel.

When the circuit is functioning properly, demonstrate it to your instructor to receive a stamp. You will **not** need to submit your software code for this circuit.

Instructor Stamp: ______

Circuit II: Edit your code from the previous question to calculate the distance that the wheels have travelled. Display this value (along with a proper metric unit) on the serial monitor or LCD screen.

When the circuit is functioning properly, demonstrate it to your instructor to receive a stamp. Submit your software code and schematics as directed by your instructor.

Instructor Stamp: ______

Name: ______________________________

Activity 11: H-Bridge Motor Driver

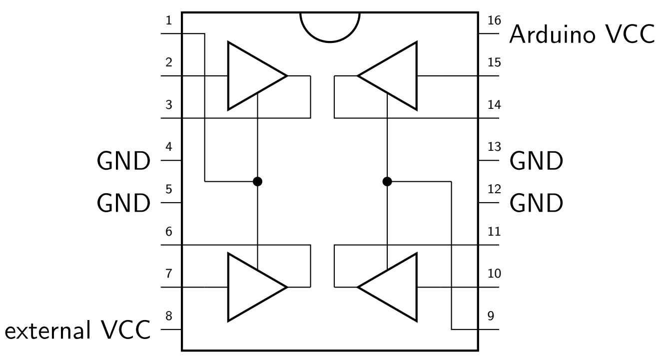
Carefully read each question before answering. Refer to the lab manual, class textbook, ATmega328P datasheet, and any other relevant resources. Show all work or justify all of your answers to receive credit.

Circuit I: Build a circuit that controls a single DC motor with the following functionality.

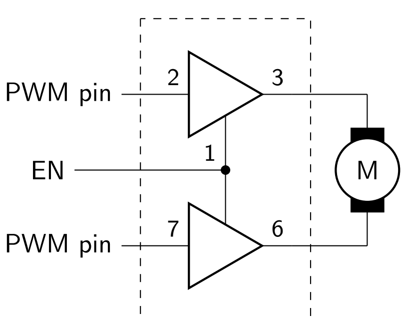
- Toggle switch – turns the motor on and off using the enable pin on the driver chip
- Potentiometer – controls the speed of the motor
- Toggle switch – controls the direction of the motor

It is **strongly recommended** that you use the `COMxn` bits on the timer/counter to control directionality of the motors by enabling the desired `OCNx` pin and disconnecting the unused `OCnx` pin.

To operate motors bidirectionally, use the 754410 H-bridge driver chip with an external power supply. This chip allows the motor to be driven in both clockwise and counter-clockwise directions. The tri-state buffers within the IC contain protective flyback diodes, so additional hardware is not necessary to prevent current spikes.



The numbers at each terminal in the circuit diagram below indicate the pins that should be used on the 754410 chip. Ensure that your Arduino and external power supply share a common ground. The dashed lines in the circuit diagram show the hardware that is internal to the 754410 chip.



When the circuit is functioning properly, demonstrate it to your instructor to receive a stamp. Submit your software code and schematics as directed by your instructor.

Instructor Stamp: ______

Name: ______________________________

Activity 12: SPI and USART Protocols

Carefully read each question before answering. Refer to the lab manual, class textbook, ATmega328P datasheet, and any other relevant resources. Show all work or justify all of your answers to receive credit.

1. Which I/O pins are used by the SPI and USART protocols?

SPI	I/O pin	USART	I/O pin
`MOSI`		`RXD`	
`MISO`		`TXD`	
`SCK`		`XCK`	
$\overline{\texttt{SS}}$			

2. Consider the SPI protocol.
   (a) Is this protocol simplex, full-duplex, or half-duplex?

   (b) Is this protocol synchronous, asynchronous, or configurable as either?

3. Consider the USART protocol.
   (a) Is this protocol simplex, full-duplex, or half-duplex?

   (b) Is this protocol synchronous, asynchronous, or configurable as either?

4. What value should be saved in `UBRR0` to obtain a baud rate of 9600?

5. Based on the information given in the circuit description below, what values should be stored in...
   (a) ...`UCSR0A`?

   (b) ...`UCSR0B`?

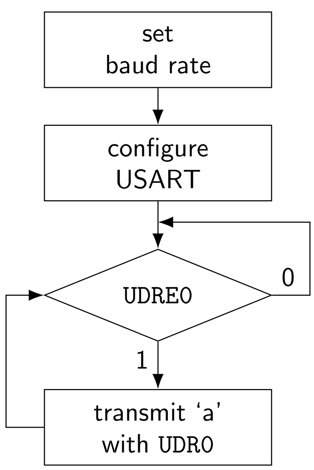
   (c) ...`UCSR0C`?

Circuit I: Program the USART to operate in asynchronous normal (not double-speed) mode with a baud rate of 9600. Only transmission will occur, and each frame will consist of 8 data bits and two `STOP` bits.

Transmit the 8-bit character 'a' to the `TXD` pin. There should be no delay in your repeating code. To confirm that this is working, you should be able to see the character 'a' printed in the serial monitor.

Before sending data through the transmit pin, you must ensure that the data register is empty. Remember that there is a flag (`UDRE0`) for this in register `UCSR0A`!

When the circuit is functioning properly, demonstrate it to your instructor to receive a stamp. Submit your software code and schematics as directed by your instructor.



Instructor Stamp: ______

Name: ______________________________

Activity 13: SPI with Multiple Secondary Devices

Carefully read each question before answering. Refer to the lab manual, class textbook, ATmega328P datasheet, and any other relevant resources. Show all work or justify all of your answers to receive credit.

Circuit I: Independent secondary configuration

Use a potentiometer as an input device that generates a number between 0–1023. Display that number on four 7-segment displays using SPI using the following configurations. A schematic diagram of each secondary configuration is provided in chapter 15 of the class textbook.

You will need to connect all 74595 VCC connections to an external 5 V power supply. The Arduino does not have sufficient current to source all of the LEDs on four 7-segment displays.

When the circuit is functioning properly, demonstrate it to your instructor to receive a stamp. Submit your software code and schematics as directed by your instructor.

Instructor Stamp: ______

Circuit II: Daisy-chained secondary configuration

Use a potentiometer as an input device that generates a number between 0–1023. Display that number on four 7-segment displays using SPI using the following configurations. A schematic diagram of each secondary configuration is provided in chapter 15 of the class textbook.

You will need to connect all 74595 VCC connections to an external 5 V power supply. The Arduino does not have sufficient current to source all of the LEDs on four 7-segment displays.

When the circuit is functioning properly, demonstrate it to your instructor to receive a stamp. Submit your software code and schematics as directed by your instructor.

Instructor Stamp: ______

Name: ____________________________

Activity 14: ATmega328P Fuses

Carefully read each question before answering. Refer to the lab manual, class textbook, ATmega328P datasheet, and any other relevant resources. Show all work or justify all of your answers to receive credit.

1. For each of the following fuse bits, list what fuse byte it is located on and explain (in your own words) what the bit does if it is programmed.
   (a) ...`CKDIV8`
   (b) ...`CKOUT`
   (c) ...`WDTON`
   (d) ...`RSTDISBL`
2. For each of the following fuse bits, list what fuse byte it is located on and explain (in your own words) what the fuse bits control.
   (a) ...`CKSEL[3:0]`
   (b) ...`SUT[1:0]`
3. What fuse value indicates that a bit is...
   (a) ...programmed?
   (b) ...unprogrammed?

4. What are the **factory default** values for each fuse on an ATmega328P? (All unused bits are unprogrammed by default.)

   (a) Low Fuse

7	6	5	4	3	2	1	0
CKDIV8	CKOUT	SUT1	SUT0	CKSEL3	CKSEL2	CKSEL1	CKSEL0

   (b) High Fuse

7	6	5	4	3	2	1	0
RSTDISBL	DWEN	SPIEN	WDTON	EESAVE	BOOTSZ1	BOOTSZ0	BOOTRST

   (c) Extended Fuse

7	6	5	4	3	2	1	0
–	–	–	–	–	BODLEVEL[2:0]		

5. What are the values the **Arduino Uno** uses for each fuse? (All unused bits are unprogrammed by default.)

   (a) Low Fuse

7	6	5	4	3	2	1	0
CKDIV8	CKOUT	SUT1	SUT0	CKSEL3	CKSEL2	CKSEL1	CKSEL0

   (b) High Fuse

7	6	5	4	3	2	1	0
RSTDISBL	DWEN	SPIEN	WDTON	EESAVE	BOOTSZ1	BOOTSZ0	BOOTRST

   (c) Extended Fuse

7	6	5	4	3	2	1	0
–	–	–	–	–	BODLEVEL[2:0]		

Name: ______________________________

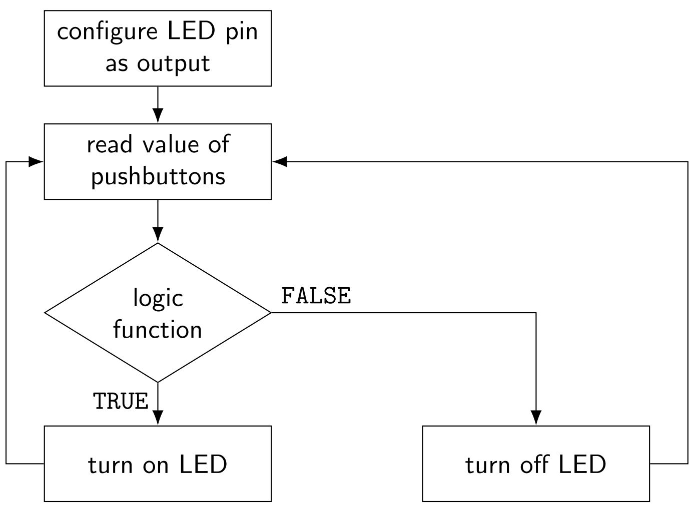
Activity 15: Assembly

Carefully read each question before answering. Refer to the lab manual, class textbook, ATmega328P datasheet, and any other relevant resources. Show all work or justify all of your answers to receive credit.

Refer to the AVR Instruction Set Manual for details on each of the available machine instructions. You may use Atmel Studio in debug mode to test all of these answers before loading code onto the ATmega328P microcontroller.

Circuit I: Create a programmable logic gate, choosing one of the following Boolean algebra functions (AND, OR, NAND, NOR). Record the Boolean algebra function that you have chosen.

Connect two pushbuttons to the Arduino and implement the logic gate, using the flowchart below as a reference.

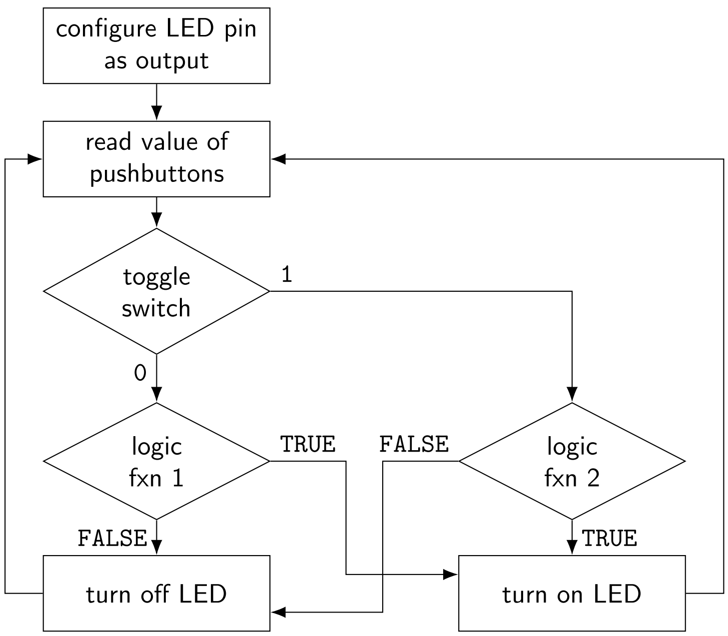


When the circuit is functioning properly, demonstrate it to your instructor to receive a stamp. Submit your software code and schematics as directed by your instructor.

Instructor Stamp: ______

Circuit II: Add a toggle switch in your design to include a second logic gate, creating a programmable logic gate. The second function should be either XOR or XNOR. Record the Boolean algebra function that you have chosen.

Use the flowchart below for your reference.



When the circuit is functioning properly, demonstrate it to your instructor to receive a stamp. Submit your software code and schematics as directed by your instructor.

Instructor Stamp: ______