LAB 6 - LIGHT-CONTROLLED SERVO (H)

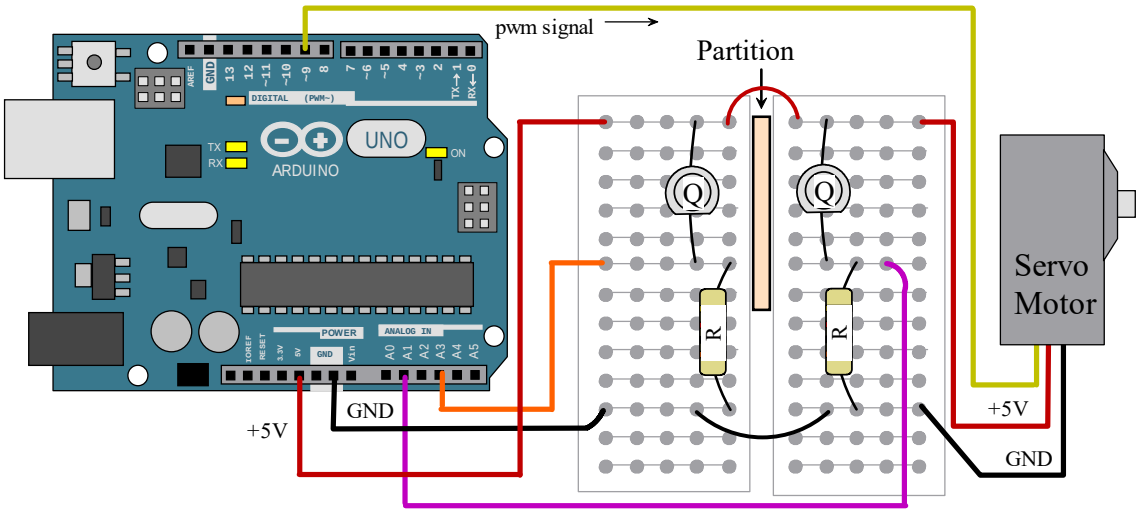
ITEM LIST

(1) Arduino, USB cable, computer
(1) Micro servo motor (e.g., SG 90, Hitech HS-422, etc.)
(2) Phototransistor
(2) Resistors (2 kΩ)
(1) Breadboard, jumper/hook up wire
(1) Flashlight
(1) Partition

EXERCISE

We learned how to control a servo motor and how to obtain data from a light detector in separate exercises. Now we will combine these tasks so that the light data controls the servo-motor. Then we will drive the servo based on the DIFFERENCES in light detected on 2 different light detector circuits (an important step to making a solar tracker). Finally we will use filters to SMOOTH the signals (and/or motor command) to move the motor more smoothly. These are the important small steps needed to make our solar tracker.

6.1 SERVO & LIGHT-BASED ANALOG VOLTAGE



EXERCISE

Here we will drive a servo motor based on sensor data from a SINGLE light detector circuit. We have 2 light detector circuits from the last lab exercise, but here we will only use one. Do not disassemble the other light circuit. You will use it later.

CONNECTIONS

We must add the servo motor connections to the set up of the previous exercise. +5V and GND must be wired to both the light detector circuit and the servo (split them on the breadboard). The diagram shows 2 light detector circuits. These are from a previous lab. In this particular exercise we will only use one of the light circuits, but don't disassemble the other one. We'll need it later. A small servo motor may work okay using power from Arduino but the motor must not have resistance (or be bound).

CODE

Our program must obtain light detector data AND use that data to control the servo.

```
//servolite1_voltage.ino -----------------------
// drive servo using analog voltage output of one light detector circuit
// servo moves to ~0 deg w/ no light and to 180 deg with full light

#include <Servo.h>
Servo myservo;

int servoPin = 9;          //pwm pin - must match physical circuit
int sensorPin = A3;        //analog in pin - receives sensor voltage

void setup()
{
   Serial.begin(9600);                  //Set baud rate for serial monitor
   myservo.attach(servoPin);            //attach servo
}

void loop()                                  // Main loop auto-repeats
{
   int sensorVal, servoAngle;
```

```
  sensorVal = analogRead(sensorPin);        //read sensor voltage
  servoAngle = map(sensorVal, 0, 1023, 0, 180);   //map voltages to servo angle

  myservo.write(servoAngle);
  delay(80);
}
```

HOW IT WORKS & OUTPUT

This exercise incorporates both the servo motor and the analog voltage light detector circuit. The light circuit outputs 0V with no light and up to 5V with bright light. This analog voltage is passed to an analog input pin on Arduino. The program then takes that value and causes the motor to turn to a certain angle based on that voltage reading. This is done with the **`map()`** function which takes a range of values and linearly interpolates those values into another set of values.

The motor may have a "twitchy" or vibrating movement. This is often due to NOISE that comes from the sensor (light) circuit. All sensors have unwanted noise. Noise appears as random jagged ups and downs in the input voltage signal. If noise appears in the sensor signal, and we use the sensor data to drive the motor, the motor's movement will reflect this noise. If we don't want the motor to twitch we will need to figure out how to reduce the noise. We will address this in a future exercise.

6.2 SERVO DRIVEN BY DIFFERENCE OF 2 LIGHT DETECTORS

EXERCISE

Now we will drive a servo motor's position based on the signal differences between 2 light detector circuits. There is no change in the circuits, only a change in code. Once done, move a flashlight back and forth across the partition and the motor should turn based on the movement of the flashlight.

CONNECTIONS

See connections from last exercise, but this time we will use both light circuits.

CODE

Our program must incorporate data from 2 light detector circuits, compute the difference, then MAP the difference to a range of 0 to 180 (shaft angle of the motor).

```
//servolite2_diff.ino ----------------------
// drive servo based on difference in analog output of 2 light detectors

#include <Servo.h>
Servo myservo;

int servoPin = 9;          //pwm pin - must match physical circuit
int sensorPin1 = A1;
int sensorPin2 = A3;
```

```
void setup()
{
  Serial.begin(9600);                 //Set baud rate for serial monitor
  myservo.attach(servoPin);           //attach servo
}

void loop()                                  // Main loop auto-repeats
{
  int light1, light2, servoAngle;
  light1 = analogRead(sensorPin1);           //read sensor 1
  light2 = analogRead(sensorPin2);           //read sensor 2
  int diff = light2 - light1;

  servoAngle = map(diff, -1023, 1023, 0, 180);    //map voltages to servo angle

  myservo.write(servoAngle);
  delay(80);
}
```

HOW IT WORKS & OUTPUT

The program receives data from two light detector circuits, computes the difference (which can range from –1023 to +1023), and then maps that to a range of values of 0 to 180 (the motor angle). You should see the motor turn over a range of (roughly) 0 to 180 degrees as you move the light across the partition. You may find the motor twitching and vibrating quite a bit (not desirable).

6.3 SERVO DRIVEN BY DIFFERENCES IN LIGHT, SMOOTHED

EXERCISE

Now we will try to remove some of the motor twitching and vibrating. We do this by running the difference data through a smoothing filter. There is no change in the circuits, only a change in code.

BACKGROUND

Here we will filter the "raw" difference data with an EXPONENTIAL FILTER (see prior "Light Detector" lab). Exponential filters works with both the raw data (unfiltered) and the filtered data. A single weight variable w (ranging from 0 to 100%) weights how much raw vs. filtered data is used. Higher w weights the raw data more, making the result fast but less smooth. Lower w weights filtered data more, making the result smoother but less responsive.

CONNECTIONS

Same as prior exercise.

CODE

```
// servolite3_smoothed.ino --------------------
```

```
// drive servo based on smoothed diff in light signal (analog V)
// smooth with expon filter (both diff and servoAngle)

#include <Servo.h>
Servo myservo;

int servoPin = 9;
int sensorPin1 = A1;
int sensorPin2 = A3;

void setup() // ----------------------------------------
{
  Serial.begin(9600);
  myservo.attach(servoPin);
}


void loop() // ----------------------------------------
{
  int servoAngle;

  int light1 = analogRead(sensorPin1);
  int light2 = analogRead(sensorPin2);
  int diff = light2 - light1;
  int diffexpon = exponFilter(diff);
  int servoAngleFiltered;

  servoAngle = map(diffexpon, -1023, 1023, 0, 180);
  //servoAngle = map(diff, -1023, 1023, 0, 180);              //TRY THIS TOO!
  servoAngleFiltered = exponFilter(servoAngle);

  myservo.write(servoAngle);
  //myservo.write(servoAngleFiltered);

  Serial.print(servoAngle);
  //Serial.print(diff);
  Serial.print("  ");
  Serial.println(servoAngleFiltered);

  delay(40);
}

int exponFilter(int lightData) //-------------------------------------
{
  static int lastFilteredData;
  float w = .30;
  int y;
  y = w * lightData + (1 - w) * lastFilteredData;
  lastFilteredData = y;
  return y;
}

//end ---------------------------------------------------------------------
```

OUTPUT

The servo should turn to a shaft angle that is related to the difference in light data. The motor should be at center (0 degrees) roughly when light is equally applied to both light circuits. The servo should turn to one extreme with light only on detector A, and then turn to the other extreme with light on only detector B.

Try changing the code so servoAngle is mapped from "diff" instead of "diffexpon". See if the servo is more twitchy without the filter.

LAB SIGN-OFF FORM
(for students to print out)

Student Name: _____
Student Name: _____

1. _____	Servo with analog voltage	drive servo based on 1 analog voltage from light detector
2. _____	Servo diff	drive servo based on diff of 2 light detectors (no smoothing)
3. _____	Servo, diff, smoothed	drive servo based on diff in 2 light detectors (smoothed)

SUBMISSION:

Students will demonstrate their completed exercises to the instructor in class.

A possible option is uploading videos to Canvas.
The instructor will let you know which is acceptable.
See the rules for file uploads to Canvas.