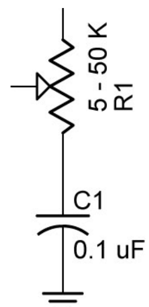
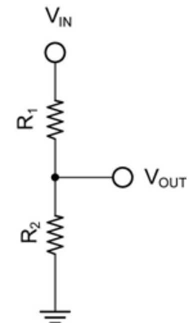
Electronics and Robotics I Week 25
Resistive Sensors

- **Administration:**
  - Prayer
- **PicBasic Pro Programs Used in This Lesson:**
  - General PicBasic Pro Program Listing: http://www.cornerstonerobotics.org/picbasic.php
  - Lab 1 adc1 as a .pdf file: http://www.cornerstonerobotics.org/code/adc1.pdf
  - Lab 1 adc2 as a .pdf file: http://www.cornerstonerobotics.org/code/adc2.pdf
  - Lab 1 adc3 as a .pdf file: http://www.cornerstonerobotics.org/code/adc3.pdf
  - Lab 2 braitenberg1 as a .pdf file: http://www.cornerstonerobotics.org/code/braitenberg1.pdf
  - Lab 3 bend_sensor1.pbp as a .pdf file: http://www.cornerstonerobotics.org/code/bend_sensor1.pdf
- **Resistive Sensors:**
  - **PicBasic Pro POT vs. ADCIN Commands:**
    - Depending upon the circuit conditions, resistive sensors may be read using the POT or ADCIN commands.
    - POT Command:
      - Resistive device normally within the 5 – 50 K ohm range.
      - The POT command measures the time it takes to charge a capacitor in a resistor/capacitor series circuit. Knowing the value of the capacitor and the charging time, the PIC converts the time value into an 8-bit resistance value of 0 - 255.
      - There is no voltage source when using the POT command therefore it does not measure a voltage drop. See the schematic comparison below.
      - Restricted to an 8-bit variable, giving outputs from 0 – 255.
      - See the following website for further discussion: http://books.google.com/books?id=XYwuCq5u2oEC&pg=PA189&lpg=PA189&dq=resistive+sensors+picbasic+pro&source=web&ots=d9Vra7g0Z2&sig=dZ5Ml3R4vSSOCE9aeaxEronc8gw

- ADCIN Command:
  - ADCIN, which reads an A/D converter (analog to digital converter), measures a voltage drop across a resistor.
  - There is a voltage source when using the A/D command ADCIN.
  - Variables may be 8, 10, or 12-bit, generating outputs of 0 – 255, 0 – 1024, or 0 – 4096 respectfully. The ADCIN command is more accurate than the POT command.

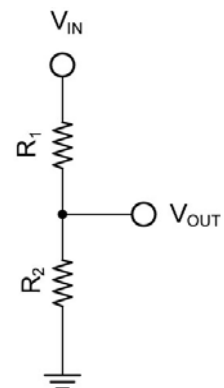




POT Uses No Voltage Source **ADCIN Has a Voltage Source, V_{IN}**

  - This lesson will focus on the ADCIN command.

- **Voltage Divider Review:**
  - Voltage at Point A, V_A:



  - Current through the series resistors:

    $V_{IN} = I\ R_{TOTAL}$, since $R_{TOTAL} = R_1 + R_2$,

    $V_{IN} = I\ (R_1 + R_2)$

    Solving for I,

    $I = V_{IN} / (R_1 + R_2)$

- V_{OUT}:

  $V_{OUT} = I R_2$, since the current, I, was solved above,

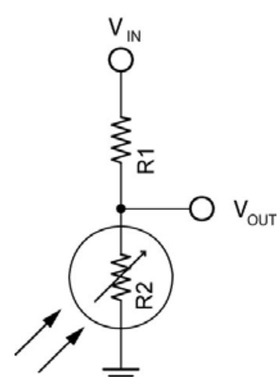
  $V_{OUT} = [V_{IN} / (R_1 + R_2)] \times R_2$, and

  $V_{OUT} = V_{IN} \times R_2 / (R_1 + R_2)$

- Cases:
  - When R_2 equals R_1, then V_A equals ½ V_{IN}.
  - When R_2 is smaller than R_1, then V_{OUT} will be closer to 0 volts or ground; conversely, when R_2 is larger than R_1, then V_{OUT} will be closer to V_{IN}.
- In our application, V_{IN} = +5V, so V_{OUT} varies from near 0 V to near +5 V.

▪ Perform Resistive Sensors LAB 1 – Reading a Potentiometer

- **Photoresistor Sensors (Cadmium Sulfide, CdS, Photo Sensor):**
  - Cadmium sulfide changes in resistance when exposed to varying degrees of light. The resistance of a CdS photoresistor or photocell decreases as it receives more light (an inverse relationship).
  - Photocells have a relatively slow response to changes in light. The characteristic blinking of overhead fluorescent lamps, which turn on and off at the 60 Hertz line frequency, is not detected by photocells.
  - Demonstrate 60 Hz frequency using a photocell and phototransistor circuits and a frequency counter and oscilloscope. Video?
  - If a photoresistor is substituted for R_2 in the voltage divider above and it is illuminated brightly, its resistance will be low and V_A will be near 0V.
  - In contrast, if the same photoresistor is shielded from light, its resistance will be high and V_A will be near +5V.
  - Photoresistors normally require shielding because they are sensitive to ambient or surrounding light.
  - Use the photoresistor as R_2 in the voltage divider. See below:



CdS Photocell in Voltage Divider

- Use the following formula to calculate the value for R_1:

$$R_1 = SQRT(CdS_{DARK} * CdS_{BRIGHT})$$

Where:

R_1 = Resistance of Resistor 1,

Cds_{DARK} = Resistance of the CdS photocell in the darkest condition the photocell will operate,

CdS_{BRIGHT} = Resistance of the CdS photocell in the brightest condition the photocell will operate

- Source and derivation of the equation: http://www.societyofrobots.com/schematics_photoresistor.shtml

  - Complete Resistive Sensors LAB 2 – CdS Photoresistors

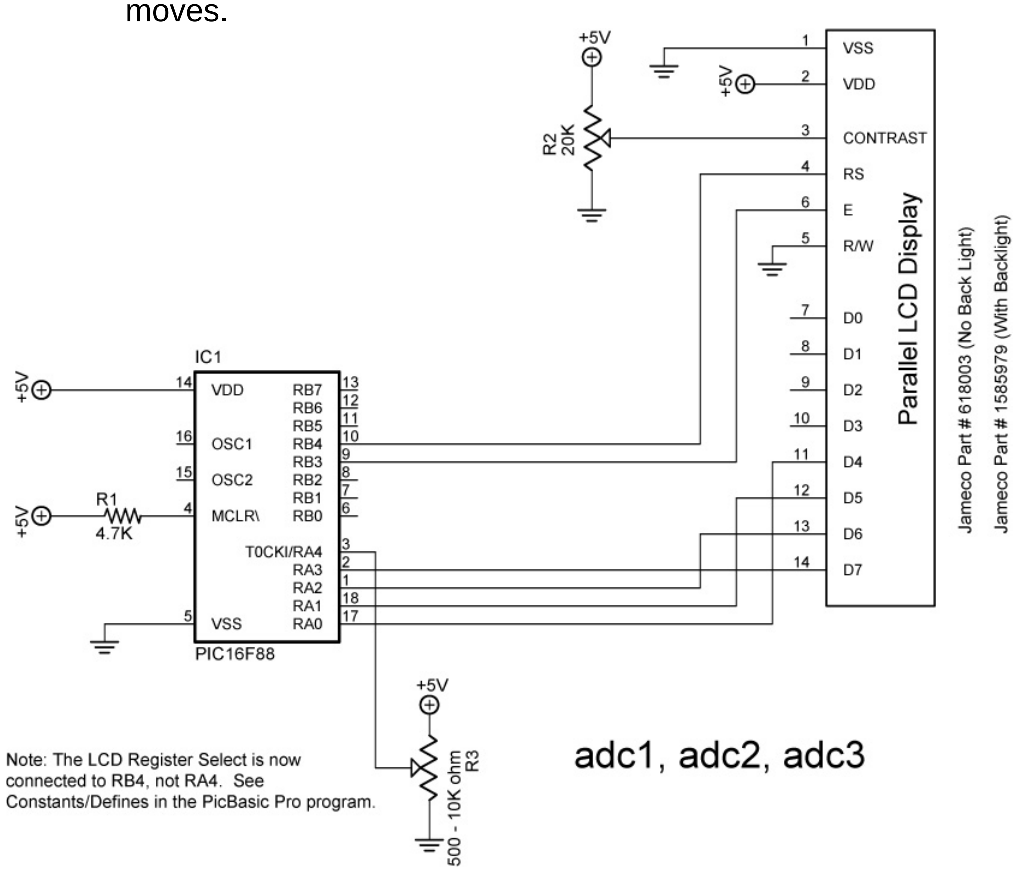
- **Other Resistive Sensors:**
  - Bend Sensors:
    - The resistance of the sensor increases in proportion to the degree of bending or flexing. For the Jameco #150551, 0 degrees is about 10K ohms and 90 degrees is 30K – 40K ohms.
    - Perform Resistive Sensors Lab 3 – Bend Sensors
    - Source for bend sensors: http://www.robotshop.ca/home/products/robot-parts/sensors/stretch-bend-sensors/

Electronics and Robotics I Week 25
Resistive Sensors LAB 1 – Reading a Potentiometer

- **Purpose:** The purpose of this lab is to teach the student how to wire a PIC18F88 for analog/digital conversion, to expose the student to the PicBasic Pro command ADCIN, and to introduce the linear slide sensor.
- **Apparatus and Materials:**
    - 1 – Breadboard with +5V supply or an Analog/Digital Trainer
    - 1 – PIC 16F88 Microcontroller
    - 1 – 10 K Tripot
    - 1 – Phidgets Slide Sensor, Product # RB-Phi-20 from:

http://www.robotshop.ca/home/products/robot-parts/sensors/linear-rotary-resistors/index.html

- **Procedure:**
    - Wire the circuit below. Use a 10K tripot for R3. Make sure to read the note in the schematic.
    - Program the PIC16F88 with **adc1.pbp**, **adc2.pbp**, and then **adc3.pbp**. Adjust R3 and note the values on the LCD screen for each program.
    - Now substitute the slide sensor for the 10K tripot. Note the changes in the LCD value as the linear position of the slide sensor moves.



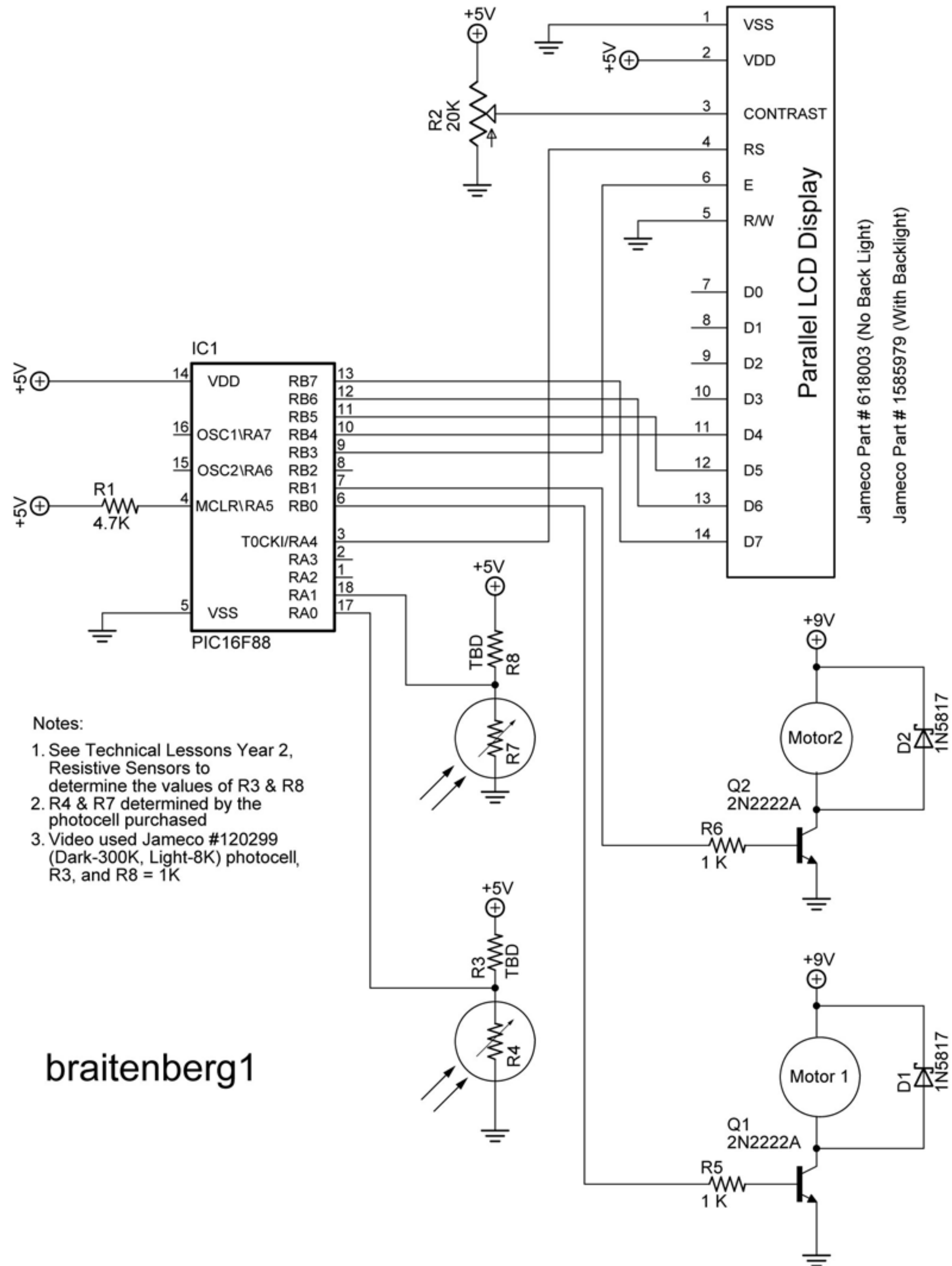
Electronics and Robotics I Week 25
Resistive Sensors LAB 2 – CdS Photoresistors

- **Purpose:** The purpose of this lab is to acquaint the student with the use of a CdS photocell as a resistive sensor.

- **Apparatus and Materials:**

    - 1 – Robotic Car Platform
    - 1 – PIC 16F88 – I/P Microcontroller
    - 1 – LCD Screen, Jameco #618003
    - 1 – 20 K Ohm Potentiometer
    - 2 – CdS Photoresistors, Jameco #120299 (300K-Dark, 8K-Light)
    - 1 – 4.7K Resistor
    - 4 – 1K Resistor, Includes R3 and R8
    - 2 – 2N2222A NPN Transistors

- **Procedure:**
    - Wire the following circuit.
    - Program the PIC16F88 with **braitenberg1.pbp**.
    - Adjust the CdS photocells for the car to be attracted to the light. See: http://www.youtube.com/watch?v=N_X4_VVxOrE
- **Challenges:**
    - **Line-follower:** Mount CdS sensors on your robotic car for the car to follow a taped line. See: http://www.youtube.com/watch?v=ut0iTLZykog
    - **Light-Steering:** Use one photocell to activate steering or forward motion for the robotic car. Use a second photocell to turn the robotic car off. The car must begin in the starting box and come to a complete stop in the finish box.
    - **CdS switch:** Wire a circuit and program a PIC16F88 to serve as a light activated switch which turns on and off an LED.

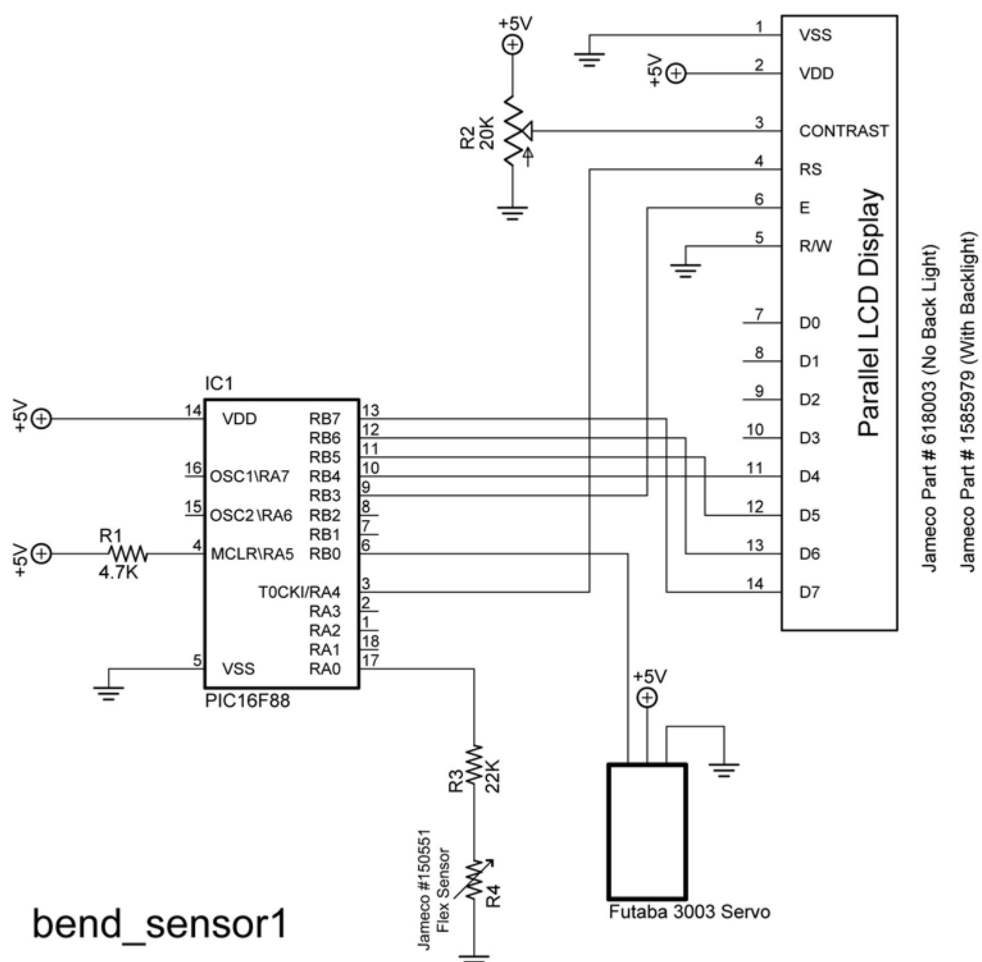

+5V
R2
20K
1 VSS
+5V
2 VDD
3 CONTRAST
4 RS
6 E
5 R/W
7 D0
8 D1
9 D2
10 D3
11 D4
12 D5
13 D6
14 D7
Parallel LCD Display
Jameco Part # 618003 (No Back Light)
Jameco Part # 1585979 (With Backlight)
IC1
+5V
14 VDD
16 OSC1\RA7
15 OSC2\RA6
R1
4.7K
4 MCLR\RA5
T0CKI/RA4
5 VSS
PIC16F88
RB7 13
RB6 12
RB5 11
RB4 10
RB3 9
RB2 8
RB1 7
RB0 6
RA4 3
RA3 2
RA2 1
RA1 18
RA0 17
+5V
TBD
R8
R7
+9V
Motor2
D2
1N5817
Q2
2N2222A
R6
1 K
Notes:
1. See Technical Lessons Year 2, Resistive Sensors to determine the values of R3 & R8
2. R4 & R7 determined by the photocell purchased
3. Video used Jameco #120299 (Dark-300K, Light-8K) photocell, R3, and R8 = 1K
+5V
R3
TBD
R4
+9V
Motor 1
D1
1N5817
Q1
2N2222A
R5
1 K
braitenberg1

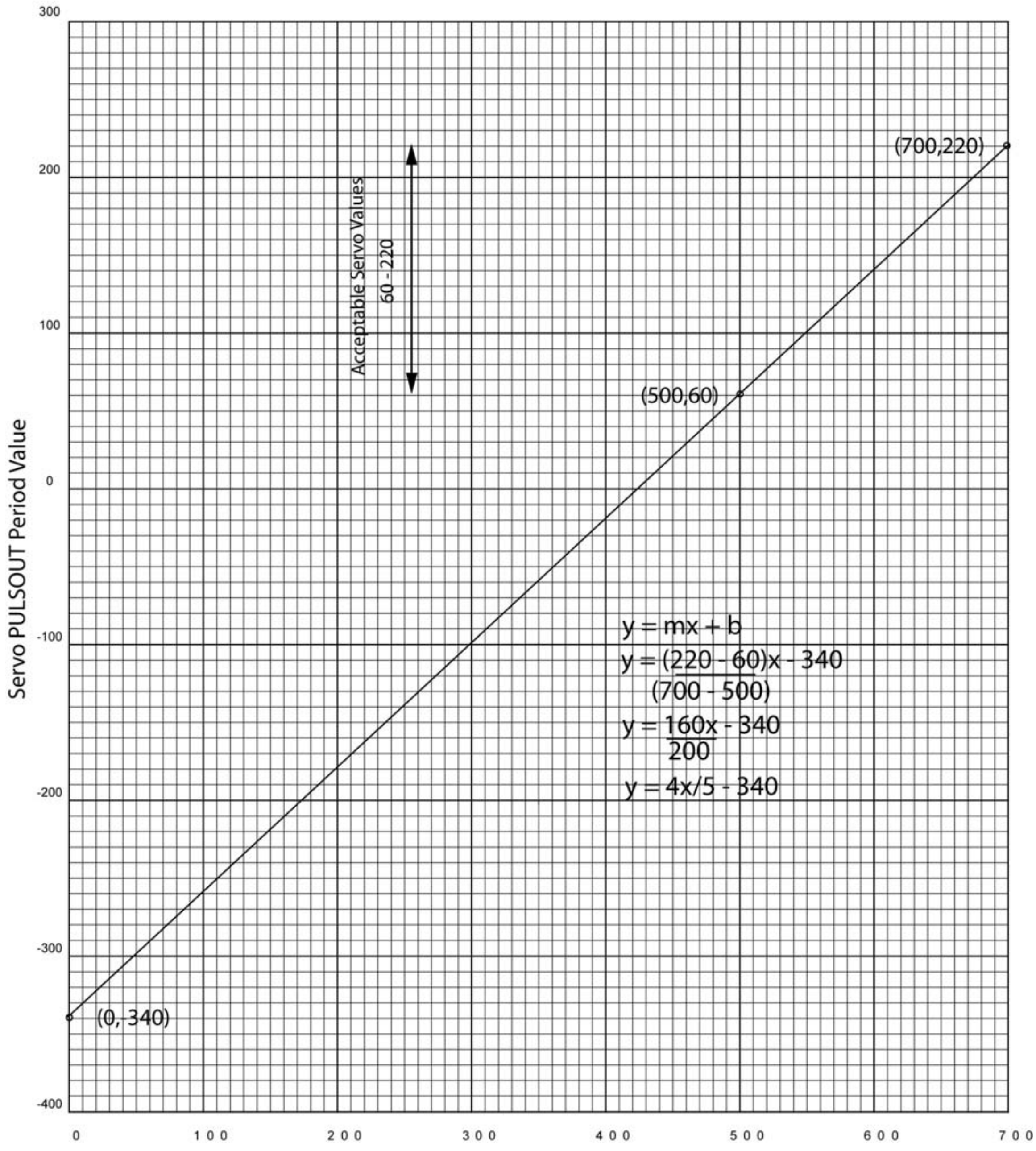
Electronics and Robotics I Week 25
Resistive Sensors LAB 3 – Bend Sensors

- **Purpose:** The purpose of this lab is to acquaint the student with the function of a bend sensor.

- **Apparatus and Materials:**
  - 1 – Breadboard
  - 1 – PIC 16F88 Microcontroller
  - 1 – 4.7K Ohm Resistor
  - 1 – 22K Resistor
  - 1 – 20K Tripot
  - 1 – Bend Sensor, Jameco #150551
  - 1 – LCD Screen, Jameco # 618003
  - 1 – Futaba 3003 Hobby Servo

- **Procedure:**
  - o Wire the circuit bend_sensor1.
  - o Program the PIC16F88 with **bend_sensor1.pbp**
  - o Bend flex sensor and note servo movement.
  - o Review the derivation of the equation in the graph below.





Derivation of Formula Used in bend_sensor1.pbp