On 20th April, Edward Shen, Ian Li, Stanford Xue, and I conducted our first experiment in the course Mechatronics, from which we have explored angular displacement measurements using a potentiometer and an incremental encoder.

For the first part - angular displacement measurements using a potentiometer, we understand the voltage dividing properties of the potentiometer. From Table 1, we can obtain the calibration equation for that potentiometer, which is shown in Equation 1. After fitting the curve, which is automatically done by LabVIEW, we can get that the sensitivity of the sensor is equal to .

For the second part - angular displacement measurements using an incremental encoder, we have observed the behavior of signal and using different types of encoding and concluded into following items.

* Compare the behavior of signal and .   
  An incremental encoder employs a quadrature encoder to generate its A and B output signals. The pulses emitted from the A and B outputs are quadrature-encoded, meaning that when the incremental encoder is moving at a constant velocity and there is a 90-degree phase difference between A and B.   
  At any particular time, the phase difference between the A and B signals will be positive or negative depending on the encoder's direction of movement. In the case of a rotary encoder, the phase difference is for clockwise rotation and for counter-clockwise rotation, or vice versa, depending on the device design. This can be confirmed by observing the diagram of X4 encoding when we rotate the encoder in the clockwise direction, which **match**es the **state machine diagram** for X4 decoding algorithm.   
  The frequency of the pulses on the A or B output is directly proportional to the encoder's velocity (rate of position change); higher frequencies indicate rapid movement, whereas lower frequencies indicate slower speeds. Static, unchanging signals are output on A and B when the encoder is motionless. In the case of a rotary encoder, the frequency indicates the speed of the encoder's shaft rotation.
* Compare the difference for three types of encoding.   
  With quadrature output, three types of encoding can be used: X1, X2, or X4. The difference between these encoding types is simply which edges of which channel are counted during movement, but their **influence on encoder resolution** is significant. Although the pulses per revolution (PPR) of the encoder is fixed, which is pulses per revolution, different types of encoding can provide us with more choices of the need for resolution.   
  With X1 encoding, either the rising or the falling edge of channel A is counted. If channel A leads channel B, the rising edge is counted, and the movement is forward, or clockwise. Conversely, if channel B leads channel A, the falling edge is counted, and the movement is backwards, or counterclockwise. When X2 encoding is used, both the rising and falling edges of channel A are counted. This doubles the number of pulses that are counted for each rotation or linear distance, which in turn **double**s the encoder’s **resolution**. X4 encoding goes one step further, to count both the rising and falling edges of both channels A and B, which quadruples the number of pulses and **increases resolution by four times**.  
  All of above conclusions are obtained from the data in Table 2, which is the experimental data. And it matches the theoretical resolution calculated in equation 1.