# ECE 162 Week 4 – The DC Motor

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## Purpose

The purpose of this lab is to study the relationship between current, torque and rotational speed of a DC motor.

## Theory

This lab deals primarily with the properties of a standard DC motor. For this particular lab, we will be keeping voltage constant to keep it relatively simple. The voltage used for this lab will be Vs, measured in (V). In this lab, we compare the current (A), torque (N\*m), and rotational speed (ω) of a provided DC motor. The relationship between torque and rotational speed is proposed to be linear.

Two important properties of DC motors are as follows; k is the motor constant, which depends on the number of magnetic poles used, and is the total flux passing through the motor. The product of these two is constant for all ω for a particular motor. Since these are constants for all ω, they are useful for comparing torque and current. The relation is shown below in equation 1:

Where T is torque in (N\*m), and I is current in (A).

Another useful property for DC motors is the armature resistance (Ra), which is measured in (Ω). This is found by stalling the motor and measuring voltage and current. This property is used in equation 3, and is calculated using equation 2 as follows:

Using Ra it is possible to compare current and angular speed. This relation is shown below in equation 3:

## Experimental Method

* Measure the source voltage (Vs). In the lab description, it is recommended that we use a 4V source. Because of the limitations of the breadboard given to us, we were unable to vary the voltage, and had to use the given 5.9V source.
* Measure the moment arm of the DC motor using a ruler. This is the distance from the center of the motor to the end of the motor arm.
* Apply Vs across the motor. Stall the motor by attaching the scale to the end of the moment arm. With this we have enough information to calculate the maximum torque of the motor. Measure the current drawn at this point.
* Detach the scale from the motor and allow it to spin at max speed for this voltage. Measure the current.
* Using one finger, slow the motor slightly. Measure the current at this speed.

## Diagram

For measuring the voltage across the DC motor we want to take readings on either side of the motor. The voltage source should be placed in parallel with the DC motor in order to force current through it. A diagram of how to take this measurement is shown below in figure 1.

Figure 1

The other physical quantity we want to measure in this experiment is the current going through the motor. This is done by putting the current reader in series with the motor, and attaching the voltage source to force current through both the motor and the multimeter. The current through the motor will be the same as the current through the multimeter because they are in series. This is shown below in figure 2.

Figure 2

## Results

The first thing done in this experiment is finding the source voltage (Vs). This was measured to be 5.9V, and this is included in Table 1 shown near the end of this section.

Next we used a ruler to measure the moment arm of the DC motor. This was measured to be 3.3 cm, or .033 meters. The moment arm is also the variable (r) in equation 4 below. Next the motor was stalled by connecting a scale and measuring the force applied by the stalled motor. This was measured to be .275 Newtons. Using these two values, we are able to calculate torque at the stall point (T) using equation 4 below:

Also measured was the current at the stall point. The value was .67 A, and this value is repeated in table 1 near the end of this section. Using this value and equation 1, we are able to calculate for this particular motor. The value for was calculated to be .0136, and has units of (N\*m/A).

Another important constant for analyzing DC motors is the armature resistance (Ra). This was calculated using equation 2, and the value was found to be 8.87 Ω.

Now that we have found all of the important constants concerning this particular DC motor, we are able to find the rotational speed (ω) and the torque (T) for all mechanical loads. Table 1 is shown below:

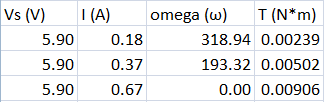


Table 1

A plot of this table is shown below. In the beginning of this report, it was mentioned that the relationship between T and ω was going to be linear, and it seems that the data found in this lab was accurate, as the plot shows a linear relationship.

## Discussion

Because of the limitations of the breadboard that we were using, we were unable to create a variable voltage source. We had to use the given voltage by the breadboard, which happened to be 5.9. This is a 1.9V difference, and a 32.2% difference.

In terms of analyzing the data, the relation between T and ω, plotting it using the experimental procedure suggested gives a perfectly linear relationship. This is incredibly boring as a means for discussion, because it gives us a 0% error, and no way to brainstorm possible abnormalities. This is because of the way that the data was generated. For the stall case, current and torque were measured, ω was inferred to be 0, and a constant () was calculated. For both other cases only current was measured, then T and ω were calculated using a linear relationship. The only result of this experimental method is a linear relationship, which makes discussion difficult.

Much more interesting to the discussion of this lab would be to introduce other data points. For example, a maximum torque for the DC motor could be given, and this could be compared to the value found experimentally. Similarly, for the case where the motor is free to move on its own (max ω) a tachometer could be given to each group to measure the real angular velocity of the motor, and this value could be compared to the calculated angular velocity. Both these would produce % error calculations, and incite discussion on possible sources of error.

## Conclusion

This lab was highly educational in the behavior of DC motors. It included measurement of key properties such as , as well as Ra which are important for characterizing DC motors. It also showed the linear relationship between torque and angular momentum for a constant voltage source, which is a key concept to design with DC motors, because you need to figure out the maximum requirements for each, and supply a voltage source which meets both of those requirements.