ME1010: Testing Your Motor for Torque-Speed Performance
Assignment #7
Due Friday October 3, 2014

To determine optimal power of your dc motor, you must determine the torque-speed (T-ω) curve, because the motor power is the product of torque and rotational speed, as shown in Equation 1, where P=power (W), T=torque (N-m), ω is rotation speed (radians/s).

$$P = T * \omega \qquad\qquad (1)$$

You are trying to optimize power (find the maximum power), which means finding the maximum product of torque and rotational speed. Thus, knowing how torque varies as a function of rotational speed is necessary. A plot, such as Figure 1, is important to this analysis.
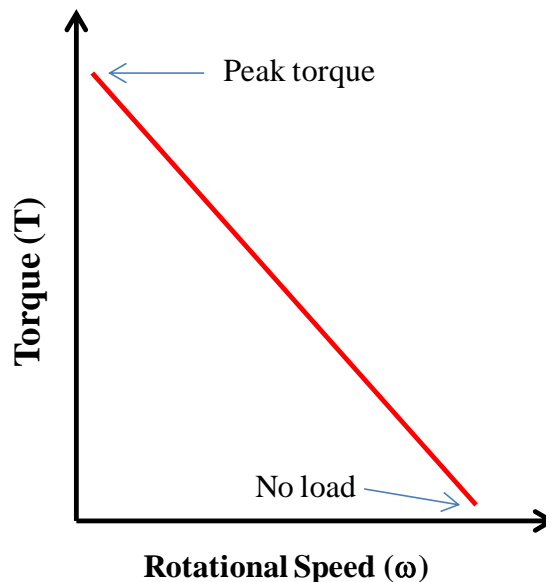

Figure 1. Torque vs. Rotational Speed Sample Graph

There are many ways to determine this relationship. The most rigorous way is to actually have the motor lift various weights, determine the moment arm (and thus torque), while measuring the rotational speed for each load. This is complex and hard to do with a small motor. So we will apply loads with attached discs and calculate the torque knowing the voltage, current, and rotational speed

To perform the testing, you will need the following equipment:

(a) Direct current (dc) power supply
(b) Voltmeter (to measure dc voltage)
(c) Ammeter (to measure dc current)
(d) Tachometer (for rotational speed)
(e) Your motor
(f) A weight, in the form of a disk, to attach to the motor shaft

Note that to read voltage, the voltmeter must be in parallel with the motor (from the power supply) and the ammeter must be in series. If you are having trouble getting readings, you probably do not have the ammeter in series (if you have it in parallel, it bypasses the motor circuit because it has a lower resistance to electron flow.)
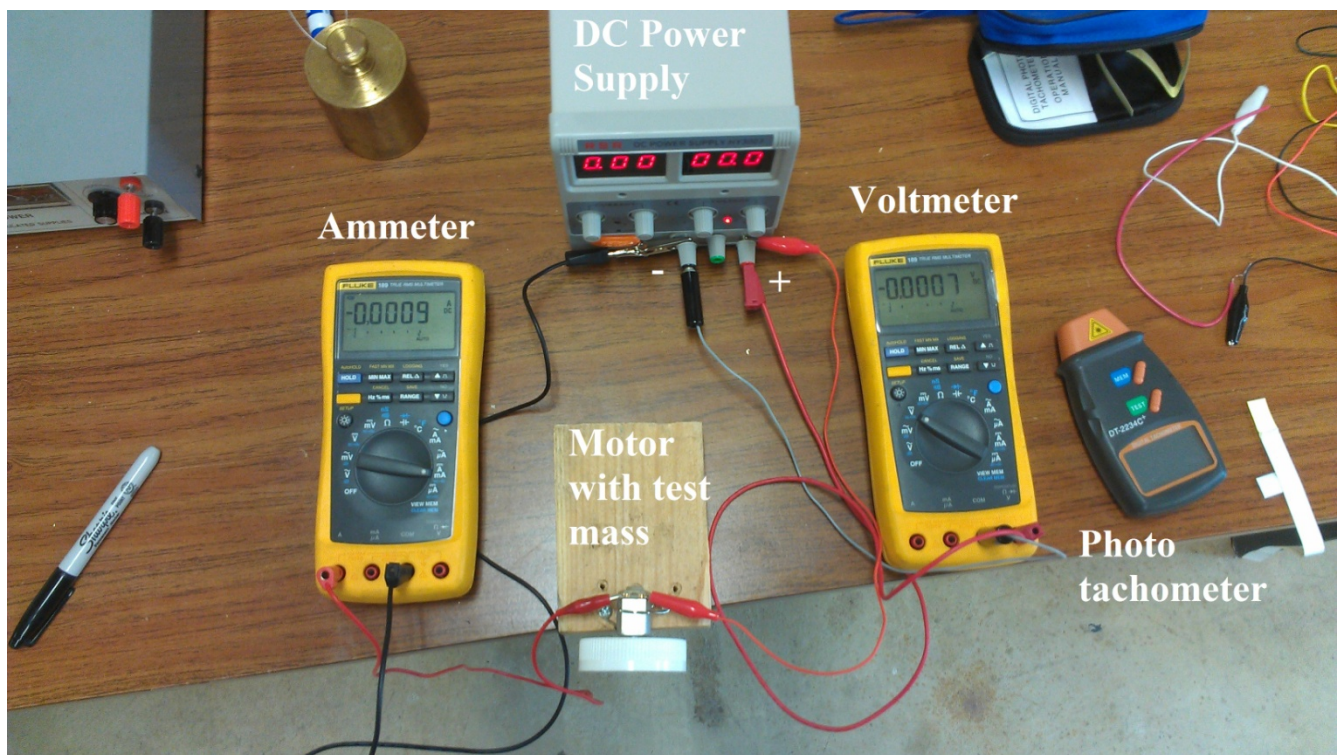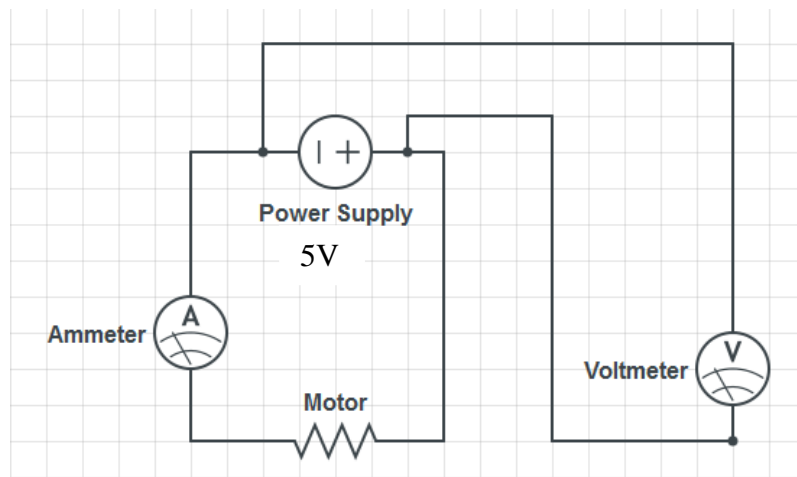
The tachometer is needed to measure the rotational speed.

You will measure voltage, current, and rotational speed. You will be able to determine the torque from these data using Equation 1, 2, 3 and 4. Remember, Equation 1 relates Power and Torque. Therefore, Equation 1 can be rewritten as Equation 2

$$T = P/\omega \tag{2}$$

Power can be found as the product of voltage and current (since it is direct current)

$$P = V * I \tag{3}$$

where V is voltage (in volts) and I is current (in amps). Therefore, T is found in Equation 4

$$T = V * I /\omega \tag{4}$$

To convert the rpms read from the phototachometer to radians per second, use Equation 5

$$\omega \text{ (rad/s)} = \frac{2 * \pi * rpm}{60} \tag{5}$$

Experimental Procedure

Step 1. Set the unloaded (disconnected) voltage from the power supply to about 3.75V (3.73-3.77 is okay). Turn up the "coarse" current to about $1/3^{rd}$ full scale so current will be flowing. Use the voltmeter in parallel to get an accurate reading of the voltage, but do not record it. It is the upper limit you could achieve, so think of it as a safety measure.

Step 2. Attach your weight to the shaft of the motor. You will need to create a contrast so the rotation is picked up by the photo tachometer. Darken the wheel (maybe a Sharpie). Then paint a white line along a narrow the radius of the wheel (I have put a bottle of Whiteout on the bench for you). You need contrast! Remember, the photo-tachometer counts reflected light waves.

Step 3. Using loads of (around) 10g, 50g, 100g, 150g, and 200g, attach the weight to the motor with the power supply off (but the voltage dials still at the 3.75V position). Once connected, turn the current dial to 0 and turn the power supply on. Then increase the current until the weight is spinning. Record the voltage, current and rotational speed.

Step 4. With the same weight attached, take the current up to 1.5-2.0 amps (if it will get that high) and measure the current, voltage, and rotational speed. (Remember, rotational speed will have converted from rpms to radians per second). The rotational speed must be measured using the photo-tachometer.

Step 5. Repeat steps 3 and 4 for all weights.

Step 6. Analyze the data by plotting torque vs rotational speed and power vs. rotational speed. Analyze for peak power as you did in Assignment #6.