

Prelab √+ √ √- 0	Participation √+ √ √- 0	Lab √+ √ √- 0
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# 1 Lab: Motor Spin Down Test

## 1.1 Introduction to Dynamic Systems lab

Each laboratory experiment consists of a PreLab, Inlab, and Postlab.

- The PreLab is to be done individually **before** coming to lab. The PreLab is checked for completion by your TA **immediately upon your arrival** at your lab section.
- The InLab is held in Peterson 108. Experiments are done in small groups during your regularly scheduled lab section.
- The Postlab is due at the same time as the homework. Submit the PostLab (lab handout and graphs) **separately** from the homework.

## 1.2 PreLab: Motor spin-down (analytical and Working Model)

1. Do the following two homework problems (from the book):  
System identification for a 1<sup>st</sup>-order dynamic system (Coulomb friction).  
System identification for a 1<sup>st</sup>-order dynamic system (viscous damping).
2. Download and install Working Model (demo version) from the class website:  
<http://www.stanford.edu/class/me161>  
Go through the Working Model tutorial.
  - Start Menu→Programs→Working Model→WMIntroduction
  - Double click the WMInstructoryTutorial.pdf file
  - Become comfortable with Working Model as you will use it in several labs.
3. Download the following Working Model simulations from the class website:  
MotorSpinDownTest.wm2d  
MotorSpinDownTestGuess.wm2d
4. Run the Working Model simulations.  
Record results on the Working Model1 PreLab (see back of the book).

## 1.3 Experiment: Motor spin down

This section acquaints you with lab hardware and real motors. By measuring the angular speed of a freely spinning motor you will be able to determine numerical values for the viscous damping and/or Coulomb friction in the motors.

Each lab station has the following equipment:

DC motor	Wooden rod	HEDS 9100 encoder
Stopwatch	Variable voltage supply	ATMEL ATmega168 microprocessor
Oscilloscope		DS275 RS-232 Transceiver Chip

### 1.3.1 Estimation without an Encoder

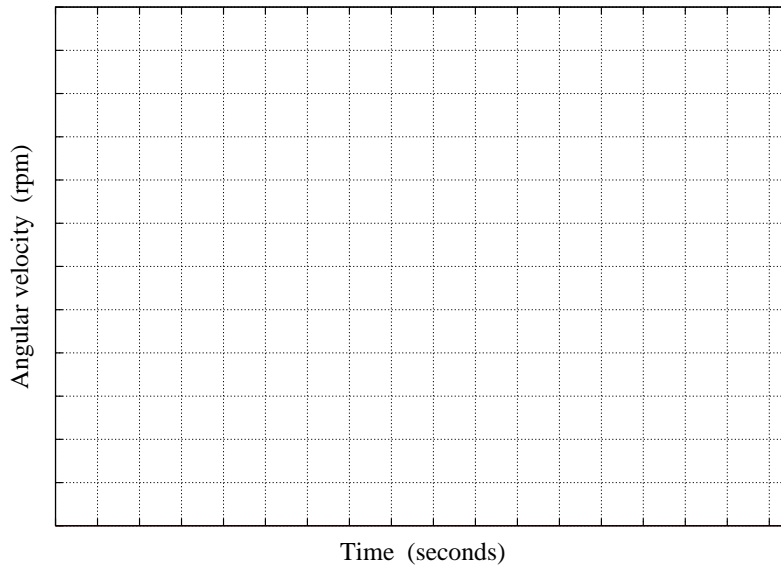
The purpose of this section is to use a stop-watch and variable power supply to estimate the shape of the spin-down angular speed for a DC motor with a wooden rod attached to the shaft. Note: The motor's no-load speed is 5984 rpm at 24 volts and the no-load speed is **directly proportional** to the input voltage (assume the rod does not contribute a significant load).

Complete the graph of the time-history of motor angular speed (below).

**Please label the scale on your axes!**

- Turn on the variable power-supply and pick a voltage between 3 volts and 8 volts
- Wait for the motor to spin-up to full speed
- Disconnect one of the alligator clips that supply power to the motor and simultaneously start the stop-watch
- Stop timing when the motor stops spinning

How many data points do you need to determine if the motor's speed decreases linearly or exponentially? .



### 1.3.2 Estimation with an Encoder

We use several pieces of equipment to measure and record the motor's angular speed, namely, we use an encoder, a microprocessor, a transceiver, and a computer.<sup>1</sup> This equipment is described below (if you fully understand it, you are a superstar).

- **Encoder:**

Our optical quadrature encoder determines our motor's rotational speed by detecting alternating light and dark patterns on a disk. For example, the encoder on the right shows 8 transitions (from light to dark or vice-versa). A quadrature encoder has the ability to detect both angular speed **and** direction. Our encoder has 1000 transitions (500 black sections and 500 white sections) and counts  $1000 \frac{\text{tics}}{\text{rev}}$ .



- **AVR ATmega168 microprocessor:**

The microprocessor receives a digital signal from the encoder (i.e., bits of one and zero) and counts the number of times the encoder changes from light to dark in a 2 ms interval.

- **DS275 transceiver:**

The transceiver receives bits (ones and zeros) from the microprocessor and translates it to the standard RS-232 serial port communications protocol. This transceiver is somewhat specific to the microprocessor, the serial port, and the communications protocol. For practical purposes, information received by the transceiver is instantaneously translated to the serial port.

- **Computer:**

The computer receives bits from its serial port and uses the software program Teraterm to translate the bits to integer numbers which are then printed to the screen. The numbers displayed on the computer screen are in units of  $\frac{\text{tics}}{2 \text{ ms}}$ .

Complete the following equation which converts from the units displayed on the computer screen to the motor's angular speed in RPM. (Note: This is important for determining x-axis tic-mark values for your graph).

$$\frac{1 \text{ [ ]}}{1 \text{ [ ]}} * \frac{1 \text{ interval}}{2 \text{ ms}} * \frac{1000 \text{ ms}}{1 \text{ second}} * \frac{60 \text{ sec}}{1 \text{ minute}} * \frac{1 \text{ rev}}{\text{[ ] tics}} = \frac{30 \text{ rev}}{1 \text{ minute}}$$

You will collect data twice. The first time, collect data without attaching the rod to the end of the motor. The second time, collect data with the rod attached. Ensure there are no wires or hands in the way of the spinning rod!

To collect data using the computer setup:

1. Login to the computer. Username: me161student. Password: 1euler1
2. Make sure domain says ENGR
3. Create a folder on the desktop for your lab group (put all your files in it every week)
4. From the desktop, open TeraTerm Pro (ttermpro)

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<sup>1</sup>Most motors do not come attached to a rotary encoder and assembled with a encoder, microprocessor, transceiver, and computer. It is still possible (without an encoder, etc.) to make rough estimates of the viscous damping or Coulomb friction in a motor.

5. Click the button for serial connection Com1
6. Go to File→Log and make a new log file in your group folder
7. Turn on the power supply. Make sure the variable power is at a low voltage.
8. On the terminal screen a menu should appear.  
Choose the “encoder data dump” option. (Press “1”).
9. Disconnect one of the alligator clips supplying power to the motor.
10. Press the space bar to stop recording data after the motor has stopped.
11. Plot the data (e.g., using Microsoft Excel, Matlab, or **MGPlot**):
  - Close TeraTerm Pro
  - Navigate to your folder on the desktop
  - Right click on the file you just created, select “Open With”, and choose Excel.
  - Delete the menu (first couple of lines at the top).
  - Think about how to convert the encoder data (counts) into rpm and what to use for the time scale.
12. Email the data files and/or graphs to yourself and your group members.
13. For each set of data, print out a graph of angular speed (rpm) vs. time (s) of the motor to hand in with your lab handout. Label the axes and title the graphs!
14. Ensure the power to the board is off and the setup is neat for the next lab section.

### 1.3.3 Questions

For the no-load condition **without** the rod:

The motor’s speed appears to decrease **linearly/exponentially** (circle one)

It behaves like this because **Coulomb friction/viscous damping in the motor/air-resistance** (circle one) dominates the response

Determine the value of the quantity that dominates the motor spin-down, i.e., the **either** Coulomb friction constant **or** the time constant  $\tau$  .

Now **add the rod** to the motor shaft and take another set of data.<sup>2</sup>

The motor’s speed appears to decrease **linearly/exponentially** (circle one)

It behaves like this because **Coulomb friction/viscous damping in the motor/air-resistance** (circle one) dominates the response

Determine the value of the quantity that dominates the motor spin-down, i.e., the **either** Coulomb friction constant **or** the time constant  $\tau$  .

#### † (**Challenge question**)

If you had data from a motor that decayed purely exponentially, and you could calculate the value of  $\tau$ , How would you find the damping constant ( $b$ ) and the inertia ( $I$ )? Although  $b$  is an unknown, but you may assume that  $b$  is a constant.

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<sup>2</sup>The rod’s moment of inertia can be estimated as  $I_{rod} = \frac{1}{12} m L^2$