MEE210 ELECTRICAL MACHINES – Experiment #5

LABORATORY CONTENT: DC motor control using relay, switches, buttons and motor parameter determination
**EQUIPMENT REQUIRED: (students should bring electronic components)**

Qty	Description
1	Voltage supply (will be ready at lab.)
1	Breadboard
1	Multimeter
1	DC motor (**!!critical warning:** You should know the speed of your motor at rated voltages, ex. 1500rpm @6V)
1	Shaft load (details are mentioned in Preliminary-4)
2	Switches (at least 2, or it depends on your design)
4	Buttons (at least 4, or it depends on your design)
1	5V relay
1	2N2222 (npn type) (these components may fail during application, advised to bring extra for backup)
1	2N2907 (pnp type) (these components may fail during application, advised to bring extra for backup)
1	100 Ω resistor
-	Wiring equipments (jumper cables, **crocodiles**, etc.)

Introduction:
DC motors are electromechanical devices that includes electrical and mechanical dynamic equations. Talking about a permanent magnet motor, the electrical and the mechanical dynamic equations are given.

$$V_{in} - i_a R_a - L_a \frac{di_a}{dt} - K_v \omega_a = 0$$

$$K_t i_a - J \frac{d\omega_a}{dt} - B\omega_a - T_L = 0$$
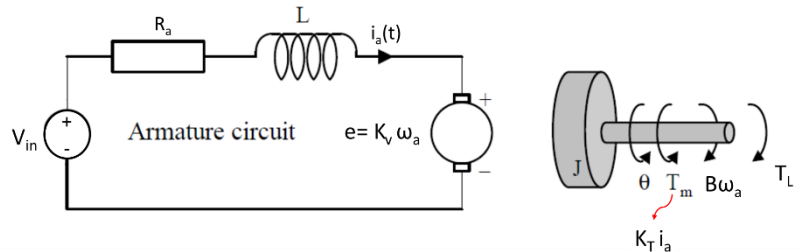
To find the constants depending on both equations, two experiments can be applied: no-load test and blocked rotor test. The principle underlying is that equation components are eliminated by applying known values or cancelling by making it zero.

- In no-load test, no load is applied to the shaft, V_{in} is increased to the rated voltage, the speed and the current is constant and known, and the resistance of the armature is measurable by the multimeter. In the first equation, since all the parameters and the variables are known and measured, then K_v can be determined.
- In blocked rotor test, the rotor is blocked by a mechanism (ex, spring-based to measure the applied torque), and the input voltage is increased to the value that the rated current flows through. In the second equation, since the angular velocity is zero and the applied torque is known, K_t can be determined.

PRELIMINARY QUESTIONS:
These preliminary steps consist of the methods that will be used in the experiment. Some of the methods are expected to be searched by you and not be given to you directly (which means that the required components may change depending on your designs).

1) Using a relay, build up two circuits to drive a DC motor by ON/OFF control mode. To drive the relay, use a transistor-based circuit with a button/switch. This transistor-based circuit should be built up using pnp-type BJT in one circuit and npn-type BJT in the other one. Explain your designs.

2) Using just switches and buttons, build up another circuit to control the motor in both rotating directions. Explain your design.

3) Fill Table 1 with your motor specifications.

Table 1. Motor specifications

Rated voltage	Rated current	No-load angular speed

4) For the block-rotor test, as the required blocking mechanism does not exist, an approximate experiment is held. For this reason, you should prepare a load to attached to the shaft. The design should be in a manner that the torque effect can be calculated. Some of the primitive design advices are given below. Calculate the affecting torque to the rod with your load design when the angular velocity is zero.
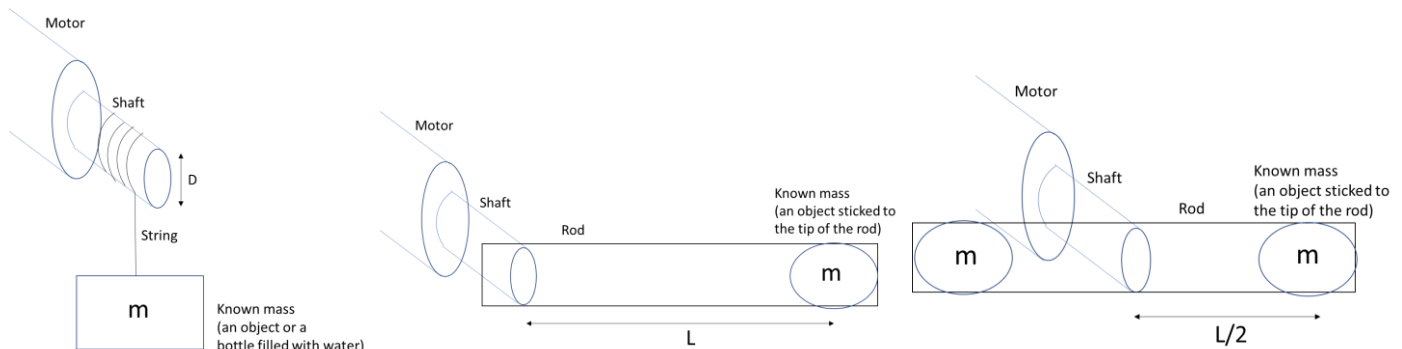

Figure 1. Block rotor test load advices.

EXERCISE STEPS:

1) Demonstrate your working circuits mentioned in Preliminary 1-2.

2) Fill Table 2 with your motor specifications with your measurements.

Table 2. Motor specification measurements

Armature resistance	No-load current

3) Apply no-load test as described in Introduction part.

4) Apply block rotor test as described in Introduction part. Increase the input voltage from zero with tiny steps while observing the flowing current value. As the rotor starts the motion (the load torque is equal to the motor torque), note the input voltage and current values.

POSTLIMINARY QUESTIONS:

1) Describe your no-load and block rotor test results with equations.

1) Comment about relays (advantages, disadvantages, etc., hint: mostly focus on its electromechanical properties).

2) What is the difference between relays and contactors?

3) Give some daily life and industrial application examples using the control methods learned in this experiment (it doesn't have to be motor control applications).

 IMPORTANT NOTE: For the next experiment, you need to build up some contents. So, the ones who are not prepared for the experiment will not be allowed to participate.