Practical Task Description:

Name	Natalie Kehoe	**Group Number**	5B
Student Number	n11031808	**Signature**	
Practical Number	Practical Lab 6 (Week 7)		
Task name	Torque and Speed Characteristics of a DC Motor		
Learning Objectives	In this lab, you will be learning to: • Experimentally determine the torque/speed curve for the motor • Analyse the torque/speed/power characteristics of a real DC motor • Select a motor for a given load		
Apparatus	• 1x motor/encoder/pulley assembly • 1x power supply • A set of weights • A ruler • A stopwatch/timer		

Preface

Torque/speed curves describe the practical behaviour of the motor, allowing you to detail its torque capacity, peak power load and peak efficiency load and speed. Using these curves, we can select the right motor for the job. However, motors and gearboxes (the gearbox is often integrated with the motor) often do not come with torque speed specifications, and you may need to determine them experimentally. In this lab, you will use the same setup as last week to determine a motor + gearbox torque/speed curve.

Your tasks

Measurement of forces and accelerations during lifting of a mass

We will now set a fixed voltage and vary the load. You will conduct 6 lifts with different loads to explore the motor behaviour.

1. Note the value of the shunt resistor in your system, this should be between 1-3 Ohms. Write this value in the Your Measurements section. Remove all masses from and the hook from the motor string
2. Using the middle pulley, place a 100 g mass (this should be the mass hook) on the string loop and position so it is approximately 1 cm off the ground. Set the voltage on the power supply to 5V.
3. Set up the voltmeter as per Figure 1. The black lead in the COM Port and the red lead in the VΩmA Port, set the dial to 20 V DC. Note that you will be measuring the voltage across the resistor on the side of the control box

Voltmeter Set Up

Where to measure the voltage

Figure 1: Voltmeter Setup and Measurement Location

1. Flip the switch to raise the mass, lift the mass for approximately 5 seconds, with the specific lifting time measured with stop watch. After 5 seconds return the switch to its original position to cut the power to the motor and stop the timer. During the lift have one person note the voltage across the resistor, write the voltage across the resistor in the Your Measurements section for Exercise 2.
2. Using the tape measure accurately measure the distance lifted, using this distance and the time taken for the lift to calculate the velocity of this lift in m/s.
3. Attach a **100 g** mass. Ensure it is free hanging 1 cm off the ground. Repeat steps 3 and 4. **For all tests ensure that that mass is approximately 1 cm off the ground at the beginning of the test**
4. Attach an **additional 100 g** mass. Repeat steps 3 and 4
5. Add another **100 g**. Repeat steps 3 and 4
6. Add another **100 g**. Repeat steps 3 and 4
7. Add another **200 g**. Repeat steps 3 and 4
8. **Remove all masses. They are heavy and can bend the motor shaft if left on!**

Calculations of Motor Properties

Now we will use your measurements to calculate the mechanical power, electrical power, efficiency, angular velocity and torque of the motor under the conditions tested. To do this you will need to do the following:

9. Convert the linear velocity to an angular velocity
10. Calculate the mechanical power for linear motion
11. Calculate the torque
12. Calculate the electrical power
13. Calculate the efficiency

Some potentially helpful equations:

Linear to Angular Velocity Conversion: $\omega = v/r$

Torque: $T = F \times r$

Newton's Second Law: $F = ma$

Mechanical power for linear motion: $P = Fv$

Efficiency: $\eta = \frac{P_{out}}{P_{in}}$

Ohm's Law: $V = IR = voltage = current \times resistance$

Electrical power: $P = IV = current \times voltage = \ (V_{supply} - V_{shunt}) \times I_{shunt}$

Power Max: P_{max} @ $0.5\omega_{no-load}$

Your measurements

Fill in the following based on your analysis. All quantities below are ***steady-state*!**

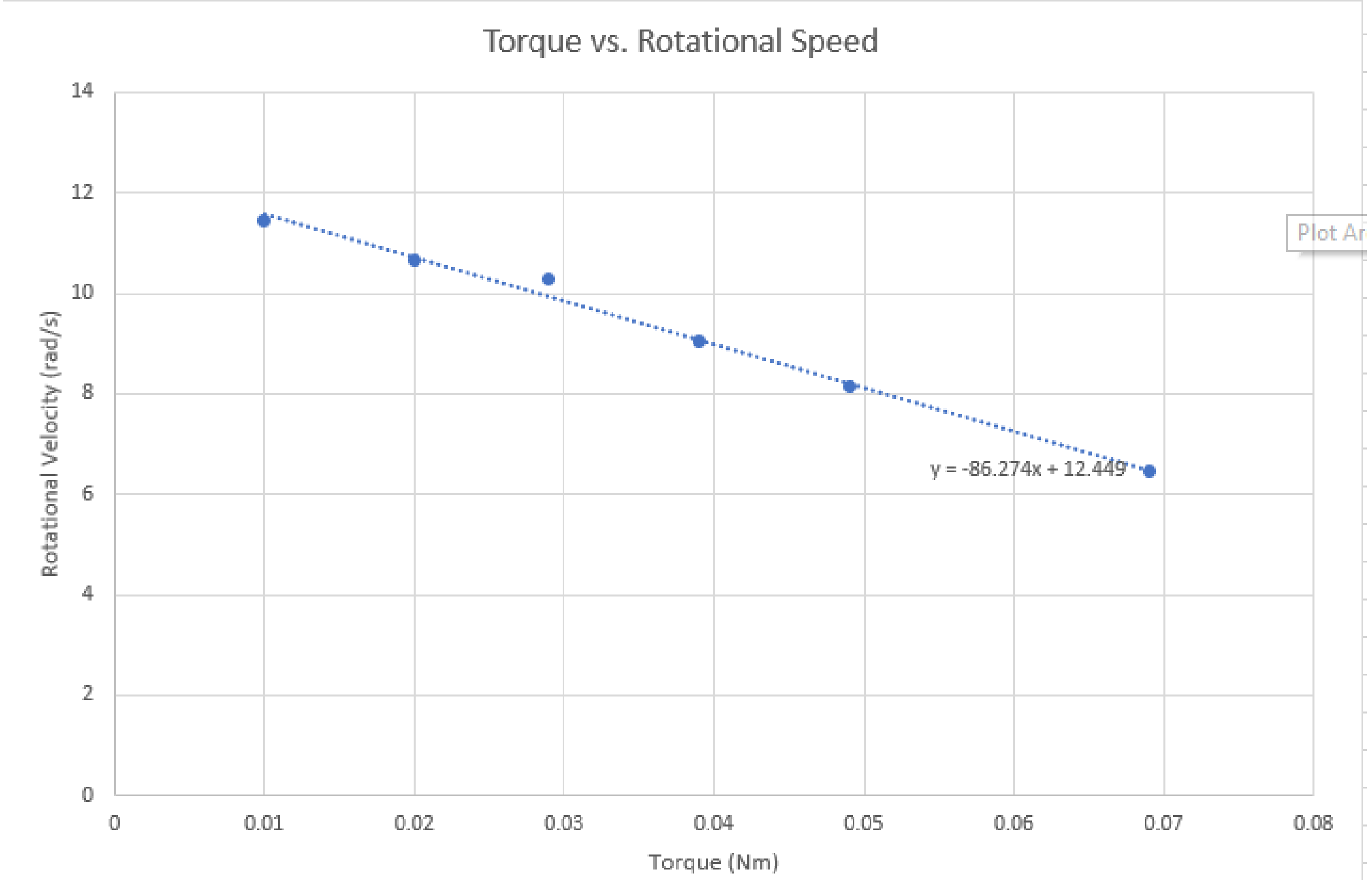
Value of Shunt Resistor: 1.5

Pulley radius: 1 cm

Load mass (kg)	Load Force (N)	Linear Velocity (m/s)	Rotational Velocity (rad/s)	Torque (N.m)	Mechanical Power (W)	Voltage Across Shunt (V)	Current Through Shunt Resistor (A)	Electrical Power (W)	Efficiency
0.1	0.980	0.105	11.451	0.010	0.112	0.130	0.087	0.422	0.266
0.2	1.960	0.106	10.648	0.020	0.209	0.160	0.107	0.516	0.404
0.3	2.940	0.103	10.296	0.029	0.303	0.210	0.140	0.671	0.451
0.4	3.920	0.091	9.067	0.039	0.355	0.260	0.173	0.822	0.433
0.5	4.900	0.081	8.134	0.049	0.399	0.310	0.207	0.969	0.411
0.7	6.860	0.065	6.463	0.069	0.443	0.430	0.287	1.310	0.338

Your reflection

Using the graph below, plot torque vs. rotational speed. Please use units of N · m for the torque and rad/s for the rotational speed.



Draw an approximate line of best fit through your measurements. Predict the no-load speed and the stall torque.

No-load speed:
let Torque = 0
$\therefore$ = 12.45 rad/s

Stall torque:
let rot. velocity = 0
$\therefore T = \frac{12.449}{86.274} \approx 0.141$ Nm

For the no-load speed determined previously, what is the speed and torque combination that would give you peak power?

No load speed = 12.45 rad/s

$\omega_{peak} = \frac{\omega_{NL}}{2}$

≈ 6.5 rad/s

According to equation line of best fit, as outlined in graph: $\omega = -86.274\tau + 12.449$

$\therefore 6.5 = -86.274\tau + 12.449$

$\tau = \frac{6.5-12.449}{-86.274}$

$\tau_{peak} \approx 0.0690$ Nm

Given you measurements, what is the approximate peak efficiency of this motor? What is the speed and torque combination that achieves this efficiency?

Peak Efficiency: 45.1 %

Speed: 10.3 rad/s

Torque: 0.029 Nm

Given your response above, if you are to lift a 500g mass, what pulley radius should you use to achieve near-peak efficiency? Select the pulley radius that is closest to the value you calculate and repeat step 9 and fill in the table below. Comment on the agreement!

$F = 9.8 \times 0.5 = 4.9N$

Since Torque = $F \times r$:

$r = \frac{\tau}{F}$

$= \frac{0.029}{4.9}$

≈ 0.00591

Closest pulley radius = 0.5cm

Pully Diameter 1cm

Linear Velocity (m/s)	Rotational Velocity (rad/s)	Torque (N.m)	Mechanical Power (W)	Electrical Power (W)	Efficiency
5.15	10.3	0.029	0.3	0.66	45.1%