Department of Robotics and Mechatronics Engineering

University of Dhaka

Lab Report

Course Name: Advance Robotics Lab

Course Code: RME 4111

Experiment no : 06

Experiment Name : Determining linear equivalent friction coefficient and maximum power required for moving a robot.

Group No : 2

Group Members :

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Objectives:

1. Measure the linear equivalent friction coefficient and analyze its impact on robot movement efficiency.
2. Determine the maximum power required for smooth and efficient robot motion by studying the relationship between applied force and movement.
3. Experimentally find the optimal force or torque to overcome frictional resistance for precise robot movements.
4. Investigate the influence of different surface conditions on friction coefficient and power requirements during robot motion.
5. Provide practical insights for enhancing robot design, energy efficiency, and overall performance by optimizing friction coefficient and power consumption.

Theory :

In this experiment, we aim to determine the linear equivalent friction coefficient and maximum power required for the movement of a robot. Understanding these factors is crucial for optimizing the efficiency and performance of robotic locomotion.

1. **Linear Equivalent Friction Coefficient:** The linear equivalent friction coefficient, denoted as μ, represents the resistance encountered by the robot while moving on a surface. It quantifies the frictional force between the robot and the surface. The formula to calculate the frictional force is:

$$\text{Frictional force (F)} = \mu \times \text{Normal force (N)}$$

Where N is the normal force exerted on the robot due to its weight or external loads.

2. **Maximum Power Required:** The maximum power required for moving the robot corresponds to the highest power consumption during its locomotion. Power (P) is defined as the rate at which work is done or energy is transferred. For a robot moving at a constant velocity, the power can be calculated using the following equation:

Power (P) = Force (F) × Velocity (V)

Where F is the force exerted by the robot, and V is its velocity.

Apparatus :

1. A Robot
2. Some mass
3. Stopwatch
4. Protactor
5. Calculator
6. Ruler

Working procedure :

Firstly, the path for the robot was prepared with a slight slope. To determine the slope angle, the perpendicular height from the ground and the horizontal distance of the slope were measured. The angle was then calculated using the inverse tangent function.

As , $$\theta = \tan^{-1}\frac{height}{horizontal\ distance}$$

1. After that , we also needed to measure the path distance. So, we measured the path distance of the robot has to covered .

It was 2.315 m . So,

$$s = 2.315 \text{ m}$$

2. Then, we measure the weight of the without mass. It was .612 kg. Then, we run the robot without mass and checked the time for it to reach the destination. We took that measure for 3 times and average the value of t.

$t = 2.81$ s

3. After that, we added few mass in the robot and again measured the time for it to reach there for 3 times. For that case,

Average t was 3.08s .

4. After taking these measures in 2 different condition of without mass and with mass, we needed to do the calculation for the experiment. So, we calculated our desired parameters.

Result :

For without mass,

Acceleration $a = \frac{2s}{t2} = 0.54 \text{ ms}^{-2}$ so , Force F = ma

$= 0.612 \times 0.54$

$= 0.3305$ N

And for with mass,

Acceleration $a = \frac{2s}{t2} = 0.45\ ms^{-2}$ so , Force F = ma

$= 1.224 \times 0.45$

$= 0.5508$ N

So, $B = \frac{\nabla F}{mg} = \frac{0.5508 - 0.3305}{0.612\ x\ 9.8} = 0.037$

Now, V_{max} for both condtion is,

For without mass,

$V_{max} = a \times t = 1.5174\ ms^{-1}$

For with mass,

$V_{max} = a \times t = 1.386\ ms^{-1}$

Then , calculating total force for this ,

$F = F_a + F_b + F_g = 1.428$ N

Now, $P = S_f \times F \times V_{max}$ S_f = safety factor , $S_f = 1.8$

So, P = 3.90W

Conclusion : In conclusion, the experiment aimed to determine the linear equivalent friction coefficient and maximum power required for the movement of a robot. By measuring the slope angle, path distance, and recording the times for the robot to reach its destination with and without added mass, valuable data was obtained. These findings provide insights for optimizing robot design, energy efficiency, and overall performance during locomotion.

Experiment no- 06

Experiment ~~number~~ name- Determining linear equivalent friction coefficient and maximum power required for moving a robot.

Group no- 02

Group members - 1) Rabeya Akter (SK-092-015)
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16.03.2023

$\alpha = 7.96^\circ$

$s = 213.5\ cm = 2.135\ m$

without mass

$m = 0.612\ kg$

$t_1 = 2.79\ s$

$t_2 = 2.81\ s$

$t_3 = 2.84\ s$

$$t = \frac{t_1 + t_2 + t_3}{3}$$

$= 2.81\ s$

$$a = \frac{2s}{t^2}$$

$= 0.54\ m/s^2$

$F = ma = 0.3305\ N$

With mass

$m = 1.224\ kg$

$t_1 = 3.11\ s$

$t_2 = 3.06\ s$

$t_3 = 3.08\ s$

$$t = \frac{t_1 + t_2 + t_3}{3}$$

$= 3.08\ s$

$$a' = \frac{2s}{t^2}$$

$= 0.45\ m/s^2$

$F = ma = 0.5508\ N$

$$B = \frac{\Delta F}{mg} = \frac{0.5508 - 0.3305}{0.612 \times 9.8} = 0.037$$

$$v_{max} = a k = 0.54 \times 2.81 = 1.5174 \ ms^{-1}$$

$$v = a k = 0.45 \times 3.08 = 1.386 \ ms^{-1}$$

$$f_a = ma = \overset{1.224}{\cancel{0.612}} \times 0.45 = \cancel{0.33} \ 0.55 \ N$$

$$f_b = Bv = 0.037 \times 1.386 = 0.051 \ N$$

$$f_g = mg \sin\alpha = 0.612 \times 9.8 \times \sin 7.96^\circ$$

$$= 0.827 \ N$$

$$f = f_a + f_b + f_g$$

$$= 1.428 \ N$$

Safety factor, $SF = 1.8$

$$P = SF \times F \times V_{max}$$

$$= (1.8 \times 1.428 \times 1.5174) \text{ watt}$$

$$= 3.90 \text{ watt}$$