Department of Robotics & Mechatronics Engineering
University of Dhaka

Course code : RME 4111
Course name : Advanced Robotics Lab

Experiment no : 08
Experiment name : Friction measurement in a linear system.

Group no : 02
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Objective:

- To measure and quantify the frictional forces present in a linear system, providing valuable insights into the system's performance and efficiency

Theory:

When an object moves in relation to another, there is resistance known as friction. The force that acts between two surfaces to keep them from gliding or slipping against one another is called static friction, or Fs. Our planted foot can grab the ground and push backward, forcing the ground to push us ahead as we run. This frictional force allows us to accelerate forward. Static friction is the name given to this form of friction, which resists slippage.

Without static friction, we would simply jog in place when jogging, which would be analogous to the experience of running on very slick ice. It can be difficult to measure friction parameters, though. It is difficult to determine the overall friction coefficient using values from datasheets. Furthermore, when considering friction, several friction coefficients enter the picture, including those for gear trains, motor bearings, commutators, and wheel bearings, among others.

Even without taking into account static friction, it is significant to recognise that friction is a very nonlinear process. When there is static friction, the item must first be propelled into motion by an initial force that overcomes the resistance.

In the following, we will show a simple setup to devise friction of sliding objects belonging to a linear system. In this arrangement, the robot is allowed to slide down from the top to the lower end of the platform and we measure the time taken. Assume that the distance traveled is X meters along with the platform, and the time taken by the robot to travel is T seconds.

$$Mgsin(q) = M\frac{d^2x}{dt} + B\frac{dx}{dt}$$

where x is the distance measured from the starting point. By assuming that all the initial conditions are zero and taking the Laplace to transform, we get,

$$\frac{Mgsin(q)}{S} = [Ms^{2} + Bs]\,X(s)$$

Substituting β = (B/M), which is the corner frequency of the system response, and taking the inverse Laplace to transform, we obtain,

$$x(t) = \frac{gsin(q)}{b}\left(1 - \frac{(1-e^{-bt})}{b}\right)$$

As mentioned, assume that t = T, x(t) = X are obtained by conducting the above experiment. Hence, we obtain

$$b = \sqrt{\frac{gsin(q)}{X}\,[bT - (1 - e^{-bt})]}$$

Where b is the linear friction coefficient.

Equipment:

- Remote control car
- Stop watch
- MATLAB Software

Procedure:

- First we run the remote control car with a specific angular displacement and measure the time using a stopwatch to record the time it takes to cross the specified distance and average the time.
- Then measure the distance crossed by the car and the weight of the car.
- Then all the values are inserted into the MATLAB code to calculate the desired values. The following scripts is used for this:

```
%Matlab script for calculating beta value

beta=3.0;  % initial guess for beta value

g=9.81;    % acceleration due to gravity

M=2.2;     % mass

T=3.2;     % time taken to descend

X=2.13;    % distance traveled

theta=5.173*3.14/180; % slope in radians

%iterate about 100 times to check convergence

%once converge beta value will repeat at later iterations

for i=1:100

beta= sqrt(g*sin(theta)*(T*beta-1+exp(-T*beta))/X)

end;

B=beta*M
```

Code:

```
clc; clear all;
beta = 3.0;
g = 9.8;
M = 2.2;
T = 2.673;
X = 1.035;
theta = 10 * 3.14/180; %according to our roll
for i = 1:100
beta = sqrt(g*sin(theta)*(T*beta - 1+exp(-T*beta))/X);
end;
B = beta *M;
```

Result:

The values used:

Theta = 10 degree
t1 = 2.69 s
t2 = 2.77
t3 = 2.56 s
T = (t1+t2+t3)/3 =
X = 103.5 cm = 1.035 m

Finally we get:

beta = 3.9872
B = 2.4242

Discussion:

The acquired results for beta and B in the linear system's friction measurement offer crucial details on the system's frictional behavior.

The coefficient of static friction is represented by beta, with a value of 3.9872. It shows the amount of resistance that must be overcome before the linear system may start moving. A higher beta value indicates that more force is needed to overcome static friction and get the system moving. This discovery is essential for comprehending the system's behavior at startup and ensuring that enough force is delivered to go over the early resistance.

The coefficient of kinetic friction is represented by the value of B, calculated as 2.4242. It displays how much resistance the system encounters when moving. Greater friction is implied by a larger value of B, which also suggests that more force is required to maintain or modify the system's velocity. For assessing the system's effectiveness and energy usage during continuous motion, understanding the coefficient of kinetic friction is crucial.

These findings demonstrate how crucial friction is to the efficiency of the linear system. A greater value of B denotes increased resistance during motion, whereas a higher value of beta signifies a stickier or more resistive interface between the surfaces in contact. These results have consequences for the design of systems because they shed light on the choice of suitable materials, lubricants, or surface treatments to reduce frictional losses and increase the overall effectiveness of the linear system.

It is important to keep in mind that the precise values of beta and B could be affected by a number of variables, including surface roughness, lubricant quality, and environmental circumstances. To gain a deeper knowledge of the frictional behavior and potential optimization techniques for the linear system, additional research may study the sensitivity of these parameters to various operating situations.

Generally, the results of beta and B in the linear system's friction measurement help us better understand the system's frictional characteristics and offer important information for enhancing its functionality, energy efficiency, and general dependability.

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Group no-0

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$\theta = 10^\circ$

$t_1 = 2.69$ s

$t_2 = 2.77$ s

$t_3 = 2.56$ s

$x = 103.5$ cm

$= 1.035$ m

$t_{avg} = T = 2.673$ s

beta = 3.9872

B ~~beta~~ ~~B~~ = 2.4242