**PHYS 201L TORQUE**Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Partner(s):\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Purpose: To investigate torque by doing the following activities:
 a. Finding the center of gravity of a meter stick
 b. Measuring an unknown mass
 c. Measuring the mass of a meter stick
 d. Calculating clockwise and counter-clockwise torques

Apparatus: Meter stick, unknown mass, knife edge clamp, knife edge support, mass-hanger, mass set, lab jack, electronic balance, and string loops.

Theory: Introduction to torque

Think about the everyday activity of opening a door, top view is shown below, and entering a room, just for a moment.

|  |  |
| --- | --- |
|  | Q: What do you think you do to the door when you open it? A: You apply a torque. |

Torque = Lever-arm X Force; Torque is a vector. Torque comes in clockwise and counter clockwise directions. Clockwise direction is the direction in which a mechanical clock turns. The opposite direction is called counter clockwise.

The door knob is kept away from the hinge in order to have a greater lever-arm. Imagine how hard it will be to open if the knob is kept closer to the hinge. Give another example where a greater lever-arm makes it easy to rotate something.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Lever-arm is the perpendicular distance between the line of action of the force and axis of rotation. Line of action of the force is a line along the force, forward and backward. A force, F is applied with different directions to a door below. Show the line of action and lever arm for each of the following cases, and rank the torques in descending order.


a. Center of gravity of a meter stick:

Mass of the knife-edge clamp = \_\_\_\_\_\_\_\_\_\_ Mass of the meter stick = \_\_\_\_\_\_\_\_\_\_

1. Support the meter stick with a knife-edge clamp and obtain balance as shown below.



1. Read the center of gravity to the tenth of a centimeter.


Location of the center of gravity (C.G) = \_\_\_\_\_\_\_\_ cm

b. Measuring an unknown mass (Meter stick is supported at the center of gravity)



Unknown mass will try to rotate the meter stick counter
clockwise and known mass will try to rotate the meter
stick clockwise. Draw a free-body diagram for the meter stick.



For balance, counterclockwise torque = clockwise torque.
Unknown mass can be determined using the above equation.
For convenience, we will use mass in grams as the force, since
the gravity is the same for all the masses.

DATA for Unknown Mass
Mass of the knife-edge clamp = \_\_\_\_\_\_\_\_ Mass of the meter stick =\_\_\_\_\_\_\_\_\_

Location of the center of gravity (C.G) = \_\_\_\_\_\_\_\_ cm

Location of the unknown mass          = \_\_\_\_\_\_\_\_\_ cm    \_\_\_\_\_\_\_\_\_cm    \_\_\_\_\_\_\_\_\_\_cm

Location of the known mass              = \_\_\_\_\_\_\_\_\_ cm    \_\_\_\_\_\_\_\_\_cm    \_\_\_\_\_\_\_\_\_\_cm

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Known mass, m(g) | Lever-arm for known mass, l (cm) | Lever-arm for unknown mass, L (cm) | Unknown mass, M (g) | Normal force at the support point (g)  |
| 200 |  |  |  |  |
| 250 |  |  |  |  |
| 300 |  |  |  |  |
| Average of the unknown mass, M |  |  |
| Unknown mass measured using electronic balance |  |
| % Difference ($\% Difference= \frac{Difference}{Average}x100$) |  |

c. Measuring the mass of a meter stick (M)

Now you need to move the support point away from the center of gravity (C.G). This way you get the rotation effect of M, mass of the meter stick. Draw a free-body diagram for the meter stick.




DATA for Mass of Meter Stick

Mass of the knife-edge clamp = \_\_\_\_\_\_\_\_

Mass of the meter stick =\_\_\_\_\_\_\_\_\_

Location of the center of gravity (C.G) = \_\_\_\_\_\_\_\_ cm.

Location of the support (pivot) point   = \_\_\_\_\_\_\_\_ cm    \_\_\_\_\_\_\_\_\_\_cm    \_\_\_\_\_\_\_\_\_cm

Location of the known mass                = \_\_\_\_\_\_\_\_ cm    \_\_\_\_\_\_\_\_\_\_cm    \_\_\_\_\_\_\_\_\_cm

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Known mass, m (g) | Lever-arm for known mass, l (cm) | Lever-arm for mass of meter stick, L (cm) | Mass of meter stick, M (g) | Normal force at the support point (g) |
| 50 |  |  |  |  |
| 100 |  |  |  |  |
| 150 |  |  |  |  |
| Average of the mass of meter stick, M |  |  |
| Mass of meter stick measured using electronic balance |  |
| % Difference ($\% Difference= \frac{Difference}{Average}x100$) |  |

d) Torques

1. With the meter stick on the support stand at X0 (center of gravity) suspend a 150-g mass at the 10 cm mark and a 200-g mass at 90 cm mark. Hang a 100-g and adjust its position to obtain static equilibrium.



2. Record the location of the 100-g mass.

3. Draw a free-body diagram for the meter stick and identify all the forces acting on it. Use masses as force.

|  |
| --- |
|  |

4. What is the normal force at the support (pivot) point?\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5. Write an equation by balancing the torques about the support (pivot) point.

|  |
| --- |
|  |

6. Calculate the location for the 100-g mass, using the above equation, and compare it with the experimental value.

7. Use the experimental value of the location for the 100-g mass to calculate the counterclockwise and clockwise torques about X0 and complete the data below.

DATA for Torques (Include units):

    Experimental value of the location for the 100-g mass = \_\_\_\_\_\_\_\_\_\_\_

    Calculated value of the location for the 100-g mass    = \_\_\_\_\_\_\_\_\_\_\_

                                                    % Difference                = \_\_\_\_\_\_\_\_\_\_\_

    Counterclockwise torque about X0 = \_\_\_\_\_\_\_\_\_

    Clockwise torque about X0           = \_\_\_\_\_\_\_\_\_\_

                                    % difference = \_\_\_\_\_\_\_\_\_

Conclusion: