**Unit 3 – Moments (Instructor Narrative)**

Engineering Statics in Physics Project

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**3.1 Tendencies of forces to rotate a body constrained to pivot about a point**

A “moment apparatus” (an L-shaped structure that pivots about a rod) will be used to practice quantifying the tendency of forces to rotate a body about a point. **The moment due to a force about a point is the tendency of the force to cause a body to rotate about that point.** Students will examine three experimental configurations: (i) with the applied force perpendicular to the arm attached to the pivot, (ii) with the applied force parallel to the arm, and (iii) with the applied force at an angle with respect to the arm.

LEARNING OBJECTIVE: Students will be able to measure the force which causes a body to rotate about a given point and the moment arm associated with that force. They will be able to use these values, the force and moment arm, to compute the moment (sometimes called torque) due to the force.

Apply a force with the spring scale to each of the different hooks on the “L” of the moment apparatus. In response to the applied force, the “L” rotates. Try to pull hard enough so that the L lies perpendicular to the base and the two lines marked on the apparatus are aligned.

 

When you pull the L with the spring scale, notice that two forces exert opposing tendencies to rotate the L about the pivot rod: that due to the spring scale and that due to a counter spring in the apparatus itself. If the L is always rotated to the same location, the tension exerted by the counter spring in the apparatus always has the same magnitude. Thus the counter-spring, stretched by the same amount and having the same orientation and attachment point in each trial, provides the same tendency to rotate the L.

When you apply a force with the spring scale and hold the L in a fixed position, it is in equilibrium. So, your spring scale force produces a tendency to rotate exactly opposite to that of the counter spring. It is like two people pushing on opposite faces of a door and the door not rotating.

**(i) with the applied force perpendicular with the arm attached to the pivot:** For each of the hooks shown, measure the force needed to make the arm attached to the pivot rotate so it is perpendicular to the base. Measure the perpendicular distance for each force and compute the moment due to each force about the rod (force times perpendicular distance).

A

B

C

D

E

F

|  |  |  |  |
| --- | --- | --- | --- |
| **Hook** | **Force** | **Perpendicular distance** | **Moment** |
| **A** |  |  |  |
| **B** |  |  |  |
| **C** |  |  |  |
| **D** |  |  |  |
| **E** |  |  |  |
| **F** |  |  |  |

**(ii) with the applied force parallel to the arm attached to pivot arm:** Measure the force needed to make the L perpendicular to the base when applied to each of the hooks as shown. Measure the perpendicular distance for each force and compute the moment due to each force about the rod (force times perpendicular distance).

E

F

|  |  |  |  |
| --- | --- | --- | --- |
| **Hook** | **Force** | **Perpendicular distance** | **Moment** |
| **E** |  |  |  |
| **F** |  |  |  |

**(iii) with the applied force at an angle with respect to the arm**: In this experiment, the force is applied, to hook F, at an angle θ with respect to the horizontal. Measure the force needed to make the L perpendicular to the base when the angle is 30°, 45°, and 60°.

For each angle, measure the perpendicular distance. This is the distance from the pivot rod to the line through the force - it may be challenging to measure this distance accurately. Then, compute the moment due to the force about the rod (force times perpendicular distance).

Next, for each angle, resolve the applied force into its horizontal and vertical components. Measure the perpendicular distance associated with each component and compute the moment contributed by each component. Sum the two moments and compare this result with the moment determined by the unresolved force.



F

|  |  |  |  |
| --- | --- | --- | --- |
| **Angle** | **Force** | **Perpendicular distance** | **Moment** |
| **30°** |  |  |  |
|  | **Force Comp** | **Perpendicular distance** | **Moment of Force Comp** |
| **30°** |  |  |  |
| **30°** |  |  |  |
|  |  |  | **Total Moment** |
| **30°** |  |  |  |
|  |  |  |  |
|  | **Force** | **Perpendicular distance** | **Moment** |
| **45°** |   |  |  |
|  | **Force Comp** | **Perpendicular distance** | **Moment of Force Comp** |
| **45°** |  |  |  |
| **45°** |  |  |  |
|  |  |  | **Total Moment** |
| **45°** |  |  |  |
|  |  |  |  |
|  | **Force** | **Perpendicular distance** | **Moment** |
| **60°** |  |  |  |
|  | **Force Comp** | **Perpendicular distance** | **Moment of Force Comp** |
| **60°** |  |  |  |
| **60°** |  |  |  |
|  |  |  | **Total Moment** |
| **60°** |  |  |  |

**3.2 Direction of rotation produced by a force**

Students will examine the tendency of an applied force to cause rotational motion for a body pivoted about a point. Students will observe the sense of rotation that results, as the direction of the force is varied.

LEARNING OBJECTIVE: Students will be able to explain how the direction of the rotation of an applied force affects the direction of rotation about a pivot point.

Place an L-shaped body so rests freely on a horizontal surface such as a table or the floor. While pressing with a finger on one corner (the pivot), loop a piece of string to the far hook. When the direction of the applied force is varied, observe the resulting sense of rotation: clockwise or counterclockwise. Find the angle of the force that produces no rotation.

Press down lightly with finger here to allow pivoting about this point