Experiment 3

Torque and Equilibrium

Time for activity 40-60 minutes

Resources

The Virtual Lab https://phet.colorado.edu/sims/html/balancing-act/latest/balancing-act_en.html

Paper. Pencil, Calculator

Software Requirements

The new HTML5 sims can run on iPads and Chromebooks, as well as PC, Mac, and Linux systems.

iPad:
iOS 11+ Safari
iPad compatible sims

Android:
Not officially supported. If you are using the HTML5 sims on Android, we recommend using the latest version of Google Chrome.

Chromebook:
Latest version of Google Chrome
The HTML5 and Flash PhET sims are supported on all Chromebooks.
Chromebook compatible sims

Windows Systems:
Microsoft Edge and Internet Explorer 11, latest version of Firefox, latest version of Google Chrome.

Macintosh Systems:
macOS 10.9.5+, Safari 9+, latest version of Chrome.

Linux Systems:
Not officially supported. Please contact phethelp@colorado.edu with troubleshooting issues.

Background

A body is truly in equilibrium when it has no tendency to turn or move. This means no translation and no rotation.

There are two conditions of equilibrium

1. Net Force = 0 $\sum_i F_i = 0$

   Sum of forces on left = sum of forces on right

   Sum of forces upwards = sum of forces downwards

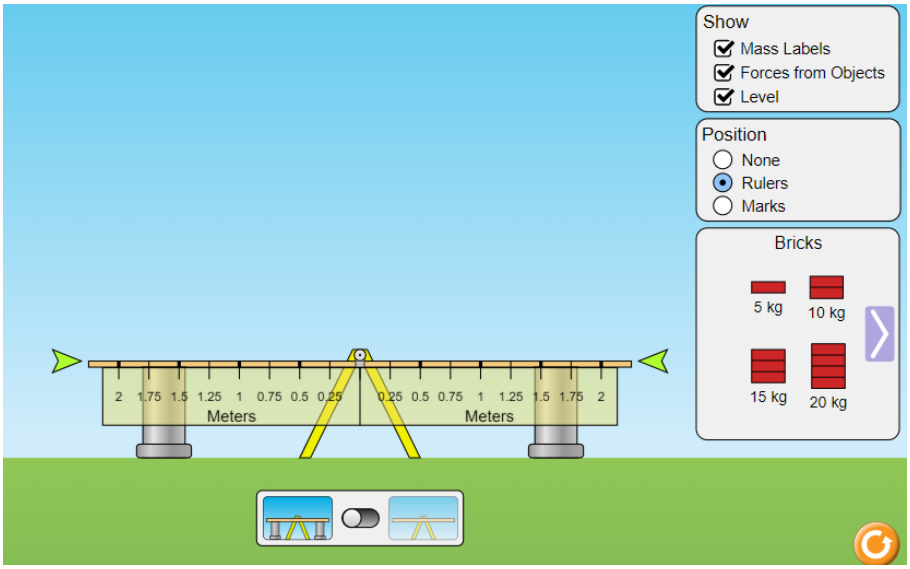
2. Net Torque = 0 $\sum_i \tau_i = 0$

   Sum of clockwise torques = sum of counterclockwise torques

The Lab Environment

Spend a few minutes to understand/ explore the functionalities of the different tabs/components.

Instructions



1. Hold and drag the two masses on the lever such that the level is in equilibrium state.
2. To adjust the lever in equilibrium state, drag the masses on the lever left or right. Make sure that the option Level is checked. It will help you to level the lever.
3. You can put more than two masses (one on each side/ two on one side and one on the other/ two or more on both sides etc.) make sure the lever stands in equilibrium state.
4. Once the level is in equilibrium, note down the masses that you kept on both the sides of the lever. Record the values in the Table 1. Let these values are $m_1, m_2, \ldots$.
5. In the next column, multiply the masses by "g = 9.81 m/sec^2, (the acceleration due to gravity) to find the forces $F_1, F_2, \ldots$.
6. Find the total sum of all the forces. According to first condition of equilibrium, the total sum of the forces acting downwards must be equal to total forces acting vertically upwards. In this case the force acting vertically upwards is the normal reaction at the fulcrum. Find the normal reaction and record the result at the end of the table below.
7. the forces acting on the right side. Find the total sum of the forces acting on the left side. If the sum if equal, then the
8. Note down the distance of these forces from the center of rotation. Let these are $d_1, d_2, \ldots$. Record these values in the next column.
9. Calculate the moments by multiplying the forces with their respective distances. For example, multiply F_1 with d_1. This will be the torque due to the force F_1, given by $\tau_1 = F_1 d_1$.
10. Compute total torque both clockwise and counterclockwise separately. Add negative sign with clockwise torque and positive sign with counterclockwise torques.
11. Note that in case the observations were taken carefully, both the clockwise and the counterclockwise torques will be equal.

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Torque and Equilibrium

Student's Name_____ **Grade** ___

Observations and calculations

Sr No	Mass m (kg)	Force $F = mg$ (N)	Distance from fulcrum d (m)	Torque $\tau = Fd$	cw/ ccw
1					
2					
3					
4					
5					
6					

Sum of the forces $\sum F =$ _____

The normal reaction at the fulcrum $R = \sum F =$ _____

Sum of Clockwise Torque $\sum \tau_{cw} =$ _____

Sum of Counter-Clockwise Torque $\sum \tau_{ccw} =$ _____