Objectives

- Observe the conditions of equilibrium
- Apply the conditions of equilibrium to make predictions

Apparatus

Open the PhET simulation here and click on the **Balance Lab** icon. Check the **Mass Labels**, **Forces from Objects**, **Level** and **Rulers** boxes. A wood platform, about 4 meters in length, is shown to be balanced on a yellow stand that can pivot. The position of the stand is at the center of mass of the platform.

Click on the slider below the stand to remove the supporting structures underneath it. **Explain how the platform remains balanced.**

The platform remains balanced because it has equal mass on both sides, and is thus is equilibrium.

Position a 5 kg brick 0.75 m and a 10 kg brick 1.5 m to the right of the center of mass of the wood platform. **Determine experimentally the location where a 15 kg brick should be placed to balance the platform.**

5*0.75*9.8+10*1.5*9.8 = 15*9.8*d d=**1.25m**

The force due to gravity acting on each brick is indicated in the simulation by the white arrows pointing downward. **Calculate the force acting on the platform by each of the bricks. How does the weight of the brick on the left compare to the weight of the bricks on the right?**

5kg = 5*9.8 = **49 N**
10kg = 10*9.8 = **98 N**
15kg = 15*9.8 = **147 N**
147N of weight on the right and **147N** of weight on the left.

The center of mass of the platform is the same as its axis of rotation. **What is the direction of the torque that each force provides on the platform relative to its axis of rotation?**

Torque is negative (clockwise) on the right side of the platform and positive(counterclockwise) on the left side.

Calculate the clockwise and counter-clockwise torques and add them together to determine the net torque acting on the platform.

5kg = 5*9.8 = 49 N with a torque of 49N*-0.75m = **-36.75Nm**
10kg = 10*9.8 = 98 N with a torque of 98N*-1.5m= **-147Nm**
36.75Nm + 147Nm = **-183.75Nm (clockwise)**
15kg = 15*9.8 = 147 N with a torque of 147N*1.25m= **183.75Nm (counterclockwise)**

Position a 15 kg brick 1.5 m to the right of the center of mass of the platform. **Determine experimentally the locations where a 20 kg brick and a 10 kg brick should be placed to balance the platform.**

Calculate the force acting on the platform by each of the bricks. How does the weight of the brick on the right compare to the weight of the bricks on the left?

15kg * 9.8 = **147 N**
20kg * 9.8 = **196 N**
10kg * 9.8 = **98 N**

Weight of bricks on right is **147N** and left is (196+98=294N) **294N**.

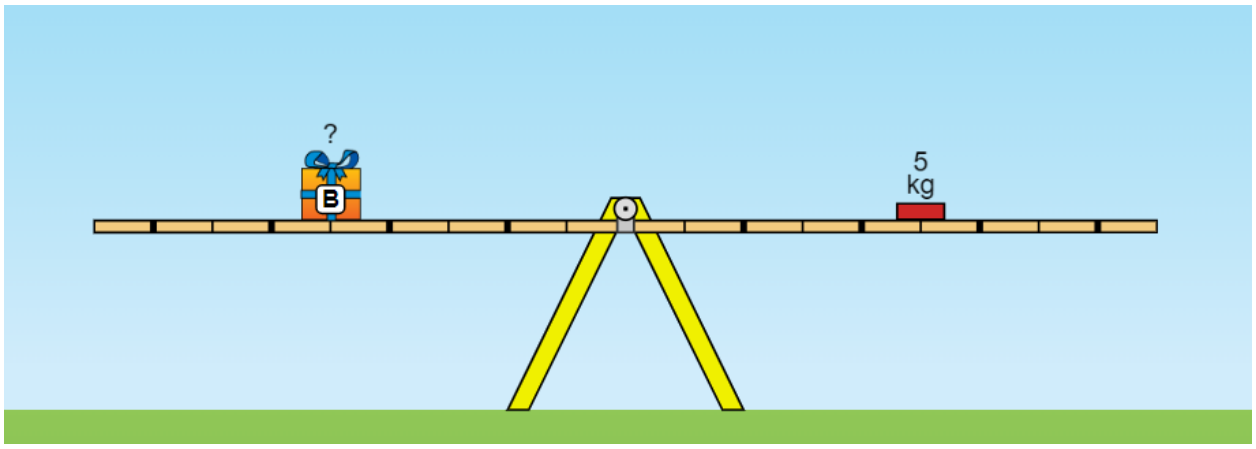
What is the direction of the torque that each force provides relative to the axis of rotation of the platform?

Torque is negative (clockwise) on the right side of the platform and positive(counterclockwise) on the left side.

Calculate the clockwise and counter-clockwise torques and add them together to determine the net torque acting on the platform.

15kg = 15*9.8 = 147 N with a torque of 147N*-1.5m = **-220.5Nm (clockwise)**
10kg = 10*9.8 = 98 N with a torque of 98N*1.25m= **122.5Nm**
20kg = 20*9.8 = 196 N with a torque of 196N*0.5m= **98Nm**
122.5Nm+98Nm=**220.5Nm (counterclockwise)**
220.5Nm-220.5Nm= **0Nm Net Torque**

Click on the arrow pointing to the right below **Bricks** and navigate to **Mystery Objects**. Position mystery object **B** 1.25 m to the left of the center of mass of the platform. Using only 5 kg, 10 kg and 15 kg mass bricks, try to balance the platform. **Include a snapshot of the balanced platform.**



Identify which forces provide clockwise and counter-clockwise torques.
The force from the brick (5*9.8=49N) provides clockwise torque and B provides the counter-clockwise torque with force of the same magnitude.

Calculate the mass of the mystery object? Show your work.

Brick	**Mystery Object B**
5kg * 9.8m/s^2 * -1.25m = -61.25Nm	61.25Nm = 9.8m/s^2 * 5kg * mass mass = **5kg**

Replace the mystery object with an object of the mass you calculated. **Does the platform remain balanced?**

Yes.

Why do you not include the force applied by the pivot in your calculation of the mass of the mystery object?

Any force applied at the pivot has a moment of F * 0m = **0Nm** and hence is not affecting the balance of the platform.