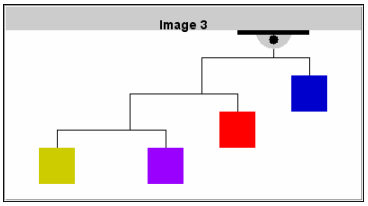
Worksheet for Exploration 13.1: Balance a Mobile



The center of gravity is at the same location as the center of mass for systems where the acceleration due to gravity is virtually equal for all points in the system. Therefore, in this Exploration we will talk about and calculate the center of mass. Restart.

The goal when making a mobile is for the center of mass to be below the string attached to the ceiling. Otherwise, there will be a net torque on the mobile about its center of mass until this condition is met. Consider a mobile made of two blocks as shown in the animation. The mass of the blue block is 0.050 kg. Assume that the rods and string connecting the blocks are light enough to be neglected **(position is given in meters)**. The goal when making a mobile is for the center of mass to be below the string attached to the ceiling. Otherwise, there will be a net torque on the mobile about its center of mass until this condition is met. Consider a mobile made of two blocks as shown in the animation. The mass of the blue block is 0.050 kg. Assume that the rods and string connecting the blocks are light enough to be neglected **(position is given in meters)**.

a. What is the mass of the green block in order for the mobile to be balanced in Animation 1?

To answer this question, consider the conditions of equilibrium. The net torque on the horizontal rod about the point where it is attached to the string connected to the ceiling must equal zero. Therefore, the magnitude of the torque on the rod due to the tension in the right string must be equal to the magnitude of the torque on the rod due to the tension in the left string.

b. Suppose you want to replace the green block with another two-block system just like the first one, but with less massive blocks as shown in Animation 2. What are the masses of the red and orange blocks?

This is very similar to the previous question, except that you are applying the conditions of equilibrium to the rod connecting the red and orange blocks. However, when you solve the equation, net torque = 0, you have a problem. The masses of BOTH the red and orange blocks are unknown. Before, for the green and blue blocks, you knew the mass of the blue block and could solve for the mass of the green.

c. You need another relationship between the red and orange blocks to help you out. Since we replaced the green block with the red and orange ones, how are the masses of these three blocks related?

d. Ok, this is getting fun. Suppose that you now replace the orange block with another identical two-block system as shown in Animation 3. What are the masses of the yellow and purple blocks?

e. Where is the center of mass of the system of four blocks?

Since you know the masses of the blocks, measure the x, y coordinates of each block and calculate the coordinates of the center of mass.

f. Now click on the animation to locate the point that you just calculated. Is it directly beneath the string that connects the mobile to the ceiling? It should be!

Note that adding a new system of blocks to the left end each time did not change the x coordinate of the center of mass; however, it did cause the y coordinate to decrease since each system of blocks hung lower and lower. However, shifting the y coordinate of the center of mass did not change the equilibrium status of the mobile.