Key Concepts

Chapter 2

Rotational equilibrium

Torque

Takeaways

Rotational equilibrium indicates a net torque of zero.

Rotational equilibrium problems are always solved with the same process: (1) draw a diagram, (2) write an expression for the net torque, and (3) set the net torque equal to zero and solve.

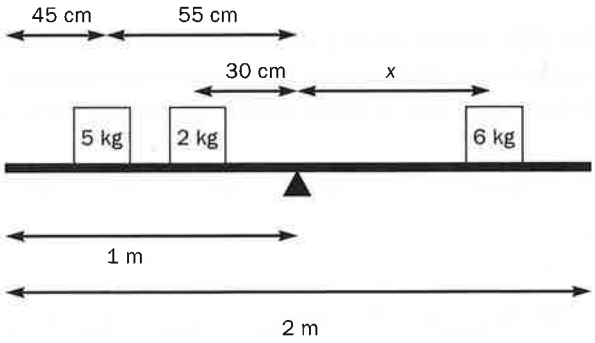
Things to Watch Out For

The most confusing aspect of these problems is often the wording of the question. Read carefully and draw a diagram of the system to sort things out. A common variation is to ask for the location of the fulcrum.

Rotational Equilibrium

Three masses are sitting on a 2 m beam of wood, which rests on a fulcrum. The first mass is 2 kg and rests 30 cm to the left of the fulcrum. The second mass is 5 kg and sits 45 cm from the left side of the beam. The fulcrum is located at the middle of the beam. The third mass is 6 kg. If the system is in rotational equilibrium, where is the third mass located?

1) Draw a diagram of the system.



Always draw a sketch of the system in these problems. Because mass 1 and mass 2 are both on the left side of the fulcrum, mass 3 must be on the right side to balance them out. Label the distance from the fulcrum to mass 3 as x.

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2) Write an equation for the total torque of the system.

torque = force × distance

torque = $5g(55) + 2g(30) - 6g(x)$

Write an equation for the torque about the fulcrum. Torque equals force times the distance to the axis of rotation. For each mass, the force is the weight of the mass, mg. Make a torque causing a counterclockwise rotation positive and a clockwise rotation negative.

Remember: *You can use cm as units for distance as long as you are consistent throughout the problem.*

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3) Set the torque equal to zero and solve.

The system is in rotational equilibrium. This means that the net torque on the system is zero. Set the equation for step 2 equal to 0 and solve for x. (Another way to solve this problem would be to say that the magnitude of the torque due to mass 3 must be equal to the sum of the magnitudes of the torques for mass 1 and 2, because these must balance out to stop the beam from rotating.)

torque = $0 = 5g(55) + 2g(30) - 6g(x)$
$5(55) + 2(30) = 6(x)$
$335 = 6x$
$x = 55.8$ cm

Similar Questions

1) Block A has 2.5 times the mass of block B. They are located 55 cm apart on a beam. Where should the fulcrum be placed relative to block B so that the beam does not rotate?
2) Three equal masses, each of 40 kg, are placed on a 5 m iron beam. They are placed 1.5 meters apart, with one on the far right end of the beam. Where should a fulcrum be placed so that the system is in rotational equilibrium?
3) Mass 1 is located at the far left end of a 90 cm beam. Mass 2 is located at the center of the beam, and mass 3 is located 30 cm from the center on the left side. Mass 3 and mass 1 are the same. If the fulcrum is located 10 cm to the left of the center of the beam, what is the mass of mass 2 if the beam does not rotate?