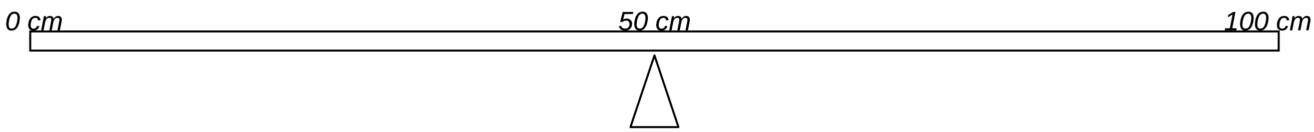
Torque and Balance

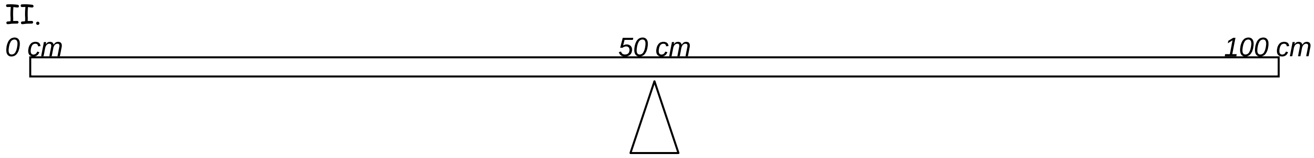
Many people incorrectly think that an object is balanced whenever one side has the same amount of weight on it as the other side. If that is true, then it should be impossible for you to balance a meter stick by supporting it at the 50 cm mark (approximately), and then place a 100 g mass on one side and a 200 g mass on the other side and maintain its balance. **Try it and see. Show the locations of the two masses on the diagram below.**

I.

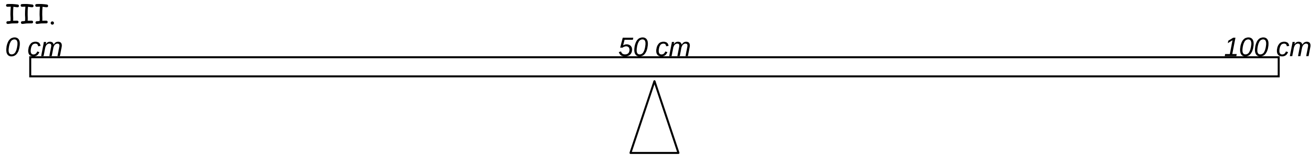


Now see if you can find 2 other places where the same masses may be balanced. Show their locations on the diagrams below.

II.



III.

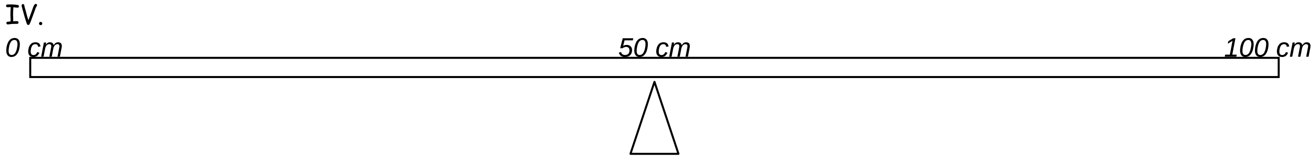


What can you say about the relative distances of each mass from the pivot point?

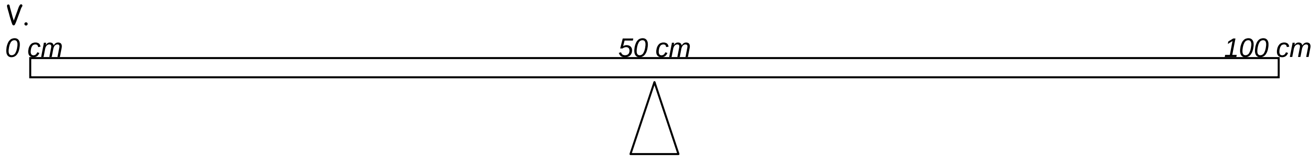
Make a prediction of the relative distances from the pivot point that 50 g and 200 g masses would need to be placed in order to keep the meter stick balanced at the 50 cm mark.

Test your prediction. Show balancing locations on the diagrams below.

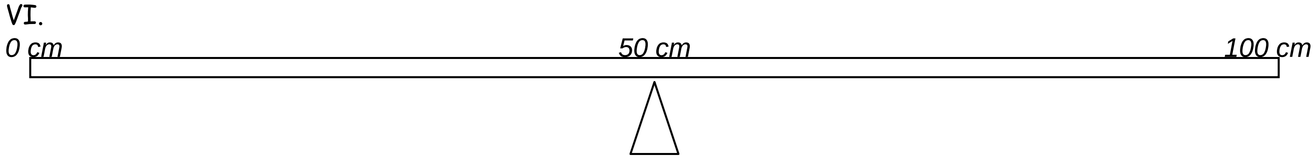
IV.



V.



VI.



Complete the following table for these previous 6 trials.

Trial	Mass, g	Weight, N	Dist. from Pivot Point, cm	Torque, N•cm	Direction, cw or ccw	$\Sigma\tau_{cw}$	$\Sigma\tau_{ccw}$
I	100						
	200						
II	100						
	200						
III	100						
	200						
IV	50						
	200						
V	50						
	200						
VI	50						
	200						

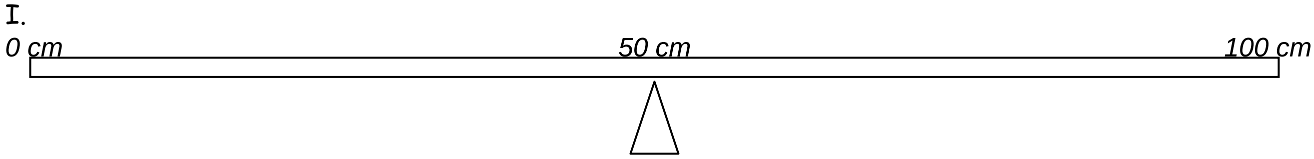
What do you notice about each trial's torques?

Repeat this process for 6 more trials using 50, 100, and 200 g masses.

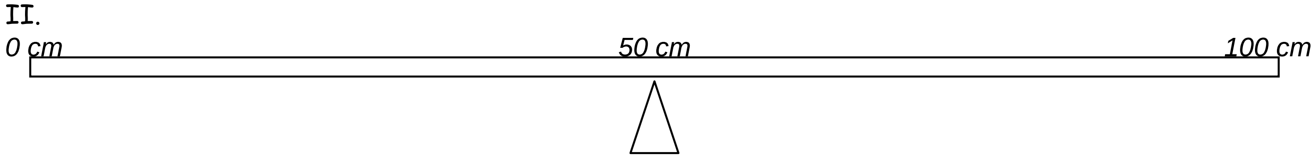
- For Trials 1 & 2, place the 50 and 100 g masses on the same side.
- For Trials 3 & 4, place the 50 and 200 g masses on the same side.
- For Trials 5 & 6, place the 100 and 200 g masses on the same side.

Show the locations of each mass on the diagrams and complete the table as before.

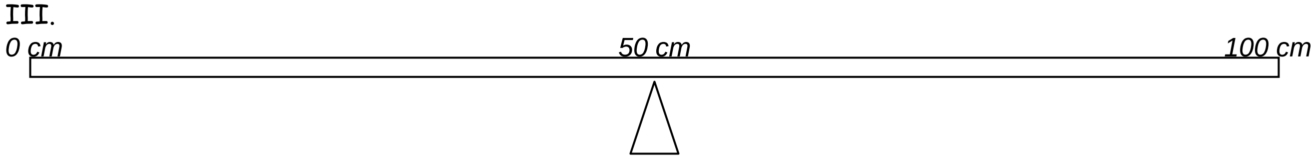
I.



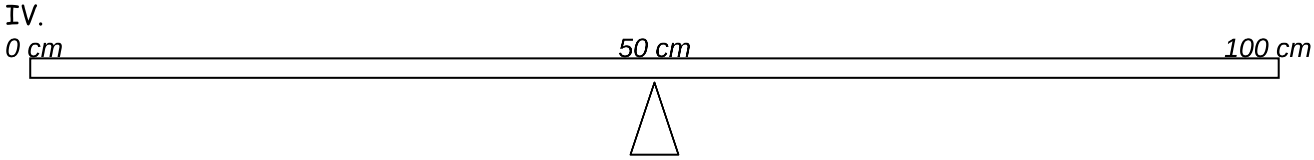
II.



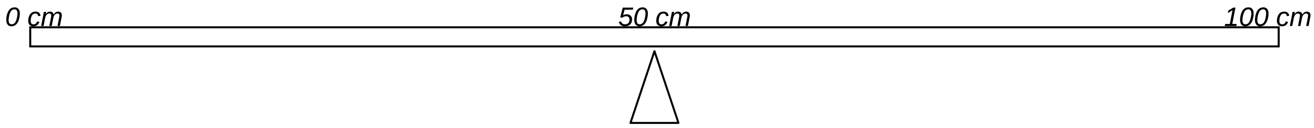
III.



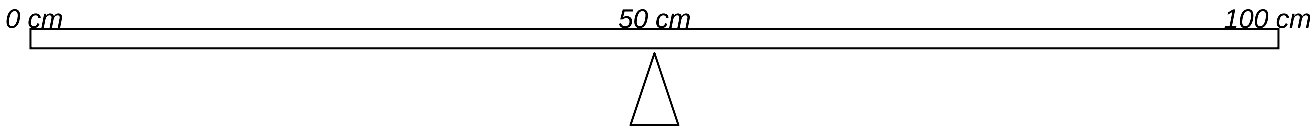
IV.



V.



VI.



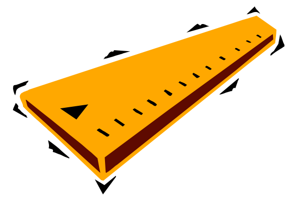
Trial	**Mass, g**	**Weight, N**	**Dist. from Pivot Point, cm**	**Torque, N•cm**	**Direction, cw or ccw**	$\Sigma\tau_{cw}$	$\Sigma\tau_{ccw}$
	50						
I	100						
	200						
	50						
II	100						
	200						
	50						
III	100						
	200						
	50						
IV	100						
	200						
	50						
V	100						
	200						
	50						
VI	100						
	200						

Complete this statement:

Objects are balanced when…

Torque and Rotational Equilibrium

In this part of the lab, you will pull on a meter stick at various locations until the meter stick is "at rest" (neither translating nor rotating, which is a state of equilibrium). You will then verify the **two conditions for equilibrium** by examining the total amounts of upward and downward force and the total amounts of clockwise and counterclockwise torques.



1. Place the scales at the locations indicated. Scales A and C should pull in the same direction, with scale B (and D if given) pulling in the opposite direction. Place arrows on the meter stick diagram in order to show the location of each force.
2. Record the readings on each scale when equilibrium is achieved.
3. Use the "zero" end of the meter stick as your pivot point and calculate your torques (in this procedure, "torque = force x location" since the location is the distance from the zero end).
4. Sum the forces and torques. Look at each of these values to see how well each trial verified the conditions for equilibrium.

I.

Scale	Location, cm	Force, N	Up or Down?	Torque, N•cm	cw or ccw?
A	20				
B	50				
C	80				

0 cm 100 cm

ΣF_{up}	ΣF_{down}	$\Sigma \tau_{cw}$	$\Sigma \tau_{ccw}$

II.

Scale	Location, cm	Force, N	Up or Down?	Torque, N•cm	cw or ccw?
A	30				
B	60				
C	90				

0 cm 100 cm

ΣF_{up}	ΣF_{down}	$\Sigma \tau_{cw}$	$\Sigma \tau_{ccw}$

III.

Scale	Location, cm	Force, N	Up or Down?	Torque, N•cm	cw or ccw?
A	10				
B	70				
C	90				

0 cm 100 cm

ΣF_{up}	ΣF_{down}	$\Sigma \tau_{cw}$	$\Sigma \tau_{ccw}$

IV.

Scale	Location, cm	Force, N	Up or Down?	Torque, N•cm	cw or ccw?
A	25				
B	40				
C	70				
D	80				

0 cm 100 cm

ΣF_{up}	ΣF_{down}	$\Sigma \tau_{cw}$	$\Sigma \tau_{ccw}$

V.

Scale	Location, cm	Force, N	Up or Down?	Torque, N•cm	cw or ccw?
A	5				
B	50				
C	70				
D	85				

0 cm 100 cm

ΣF_{up}	ΣF_{down}	$\Sigma \tau_{cw}$	$\Sigma \tau_{ccw}$