

Beam Forces, Moments and Reactions



https://en.wikipedia.org/wiki/Beam_bridge#/media/File:SteamAcrossIowaRiver.JPG

Objectives:

To understand how loads and moments – and their locations – affect the support forces (reactions) associated with simply-supported beams.

To collect quantitative data for a subsequent assignment in which beam reactions will be calculated.

To collect the data and images or videos needed to generate the deliverable (report, photo essay or video, as assigned) associated with this activity.

To understand how contracts can improve teamwork.

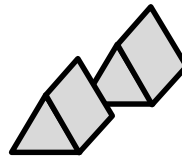
Apparatus:

Layout the following items from a “Beam Reactions” kit:

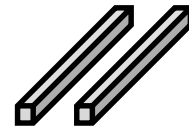
Quantity	Item(s)
2	Digital pocket scales
2	Triangular plastic fulcrums
2	Large matchsticks
1	Torque tool
1	Laser-etched beam
1	Rectangular wooden weight
2	Triangular wooden weights



Digital Pocket Scales



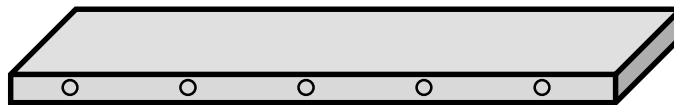
Triangular Plastic Fulcrums



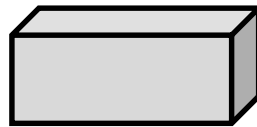
Large Matchsticks



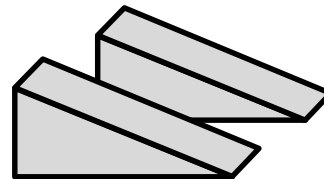
Torque Tool



Beam



Rectangular Wooden Weight



Triangular Wooden Weights

Recommended Procedure:

Steps marked with an asterisk () are elective, and should be skipped if you are short of time.
For this Activity (only), write your answers in the spaces provided.*

Step (A) sets the scene for a successful group effort.

- A) All group members should complete a “Beam Activity Contract” (Chapter 7) in advance of the activity work period.

1.1.1 Getting Started

This section will familiarize you with how to operate the Digital Pocket Scales.

- B) Open each Digital Pocket Scale by depressing the small button on its side. Hinge the cover open 180 degrees so it is fully open. Lay the scales out on your table as shown below.



- C) Press the ON/OFF buttons on each scale. If the scale does not turn on, you may need to move the batteries in the back of the scale from the storage section (which has no electrical connections) to the working section. If the scale still does not indicate 0.0g shortly after you turn it on, speak to the instructor or a TA.

A small “g” should appear in the upper right corner of the display, indicating that the scale is reading in grams. If not, hit the MODE switch multiple times, as needed, until the unit’s display cycles through to “g”.

If the load on a scale does not change within any given 50-second period, the scale assumes that that necessary readings have been taken, and it shuts off automatically to conserve the battery.

1.1.2 Measuring Object Weights

In this section you will make a few simple measurements using the scales.

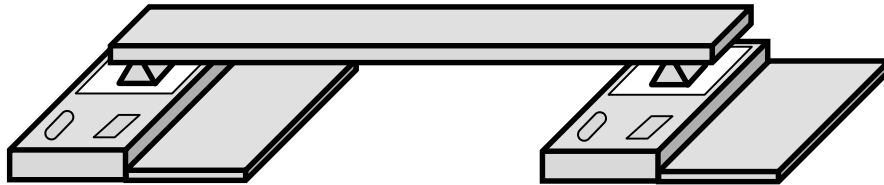
- D) Weigh the beam, the rectangular weight and both of the triangular weights, in turn, and record your measurements.

DO NOT ALLOW THE SCALE FORCE TO EXCEED 800g, AS DAMAGE CAN RESULT.

Item	Weight (g)
Beam	
Rectangular weight	
Triangular weight #1	
Triangular weight #2	

- E) If you measure a particular object multiple times, are your readings exactly the same? What happens if you weigh the same object on both scales? Comment on your observations.

- F) With both scales turned on, arrange the fulcrums and beam as shown below. A beam of this design is called “simply-supported.” The tops of the fulcrums should rest inside the grooves that run across the underside of the beam at ruler markings 0 and 24. Record the scale readings.



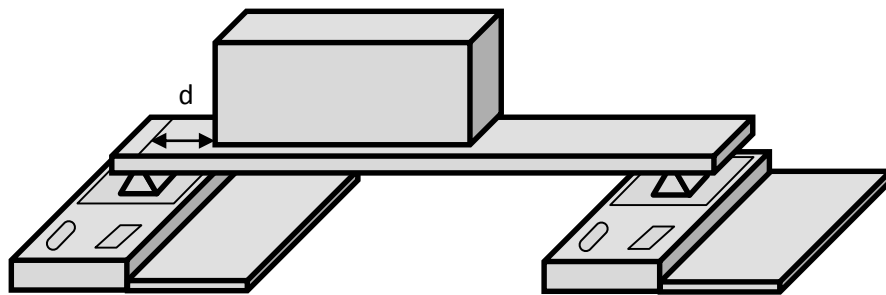
Left scale reading (g)	Right scale reading (g)

- G) What is the relationship of the scale readings to the beam weight measured in Step (D)? Are the readings of the left and right scales the same? Discuss what you see, and offer possible explanations for any unexpected readings.

1.1.3 Vertical Loads and Support Reactions

In this section you will explore how the position of a force (weight) affects the support forces.

- H) *Hold one end of the beam on the upturned fingers of your one hand and the other end on the upturned fingers of the other hand. Close your eyes. Have your partner position the rectangular weight at different locations from one end of the beam to the other. Can you feel how the reactions (forces on your two hands) change with block position? Change roles and repeat this step.
- I) Press the TARE buttons on both scales. The readings should change to 0.0. The weight of the fulcrums and the beam itself will now be “ignored.”
- J) With the scales on and showing a reading of 0.0, place a rectangular weight a small distance, $0 < d < 5\text{cm}$ (as indicated by the printed scale), from the left of the beam.

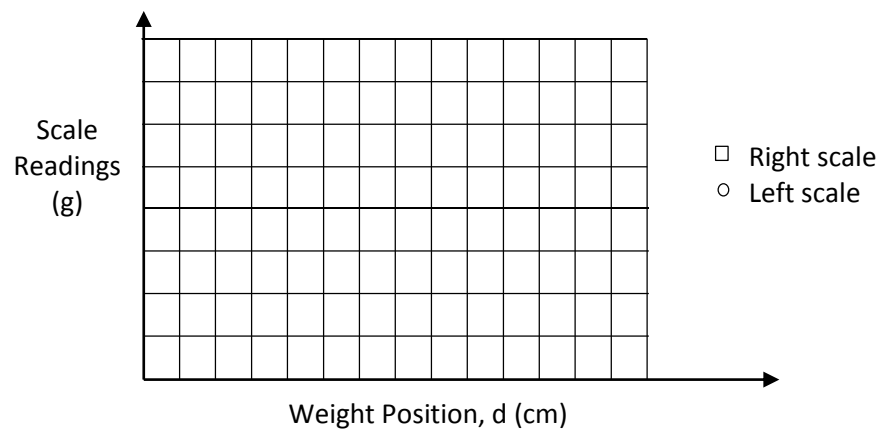


- K) Record the position of the left end of the weight (i.e., the distance d , as indicated by the built in ruler scale) and the weight scale readings in the row marked Test Number 1 in the Table below. If the scales should shut off, remove the weight, tare the scale, and resume your tests.

Test number	Weight position, d (cm)	Left scale reading (g)	Right scale reading (g)
1			
2			
3			
4			

L) Move the weight 4 to 6 cm further toward the right end of the beam, and again record the beam position and scale readings. * Repeat a third and fourth time. Do the scale readings depend on where the weight is applied? Do these findings concur with the findings of Step H?

M) * On the axes shown below, plot a graph of the left scale reading versus weight position. On that same graph, plot the right scale reading versus weight position. What do you notice about the shapes of these graphs?

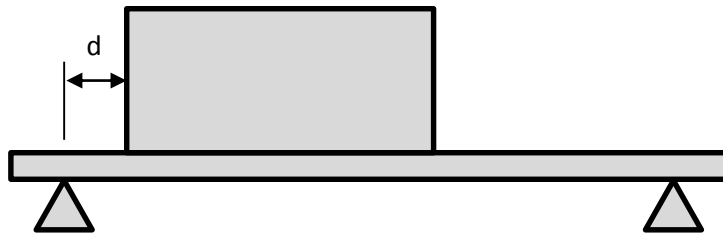


N) * By eye, choose and sketch appropriate mathematical functions for the data from left scale and then for the data from the right scale. Based on your graph, for what weight position would you expect the scale on the left to read zero? Place a weight at your predicted location and record the scale readings. Adjust the weight position so the scale actually reads zero and report its new position. Can you identify a physical significance for this weight position?

1.1.4 Equivalent Loads

In this section, you will see how distributed loads can be replaced with equivalent point loads.

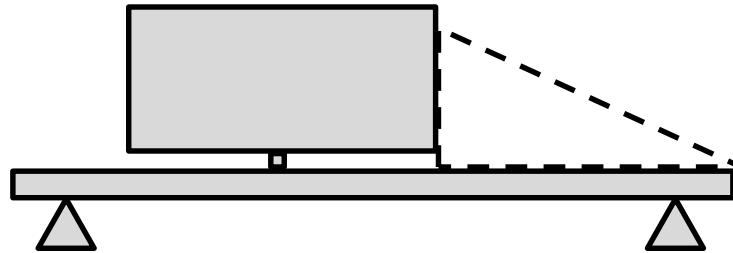
O) Consider a beam that supports a rectangular block as shown below.



P) Place the rectangular block at a position of your choice, measure d and the reaction forces when the block rests directly on the beam. Complete the first working row of the table below.

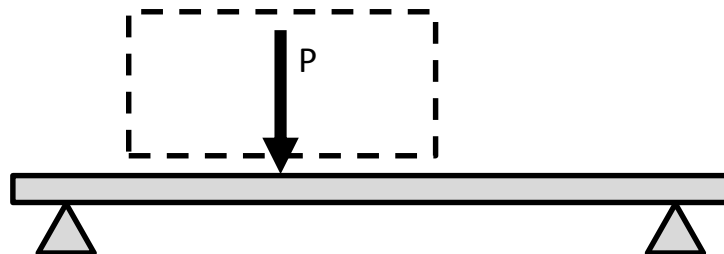
Test number	Weight position, d (cm)	Left reaction (g)	Right reaction (g)
Block resting directly on beam			
Block balanced on matchstick			

- Q) Then, while being careful to not change the horizontal position of the block, carefully slide a matchstick under the block and move the matchstick until the block balances on it. It may be best for two people to do this task together, and you might find one of the triangular blocks useful for maintaining the horizontal position of the rectangular weight, as suggested by the dashed outlines. Ensure that the matchstick is not skew to the beam, but rather runs directly across its width.



Where does the matchstick need to be placed relative to the block for it to balance? Does that position make sense? Why or why not?

- R) Now, all of the block weight passes through a single point (if viewed from the side). One could imagine replacing the distributed forces from the block with a point load P (see figure below). How large would P need to be?



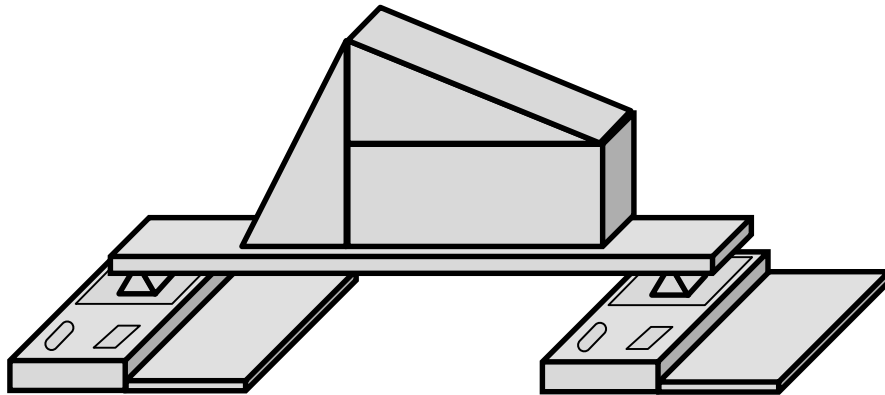
Measure the new reaction forces and record them in the second working line of the table in Step (O) on the previous page. Do the reactions change when the distributed load is replaced by a point load at the balance point? What do you learn from this exercise?

- S) *If you have time, you can repeat Steps N to Q, or some of them, for a triangular load.

1.1.5 Composite Loads

In this section, you investigate the effect of a composite load.

- T) Apply the three weights in a configuration of your choice (but so they all lie in common vertical plane along the length of the beam). One possible configuration is shown below.



- U) Record the scale readings. Make a sketch showing the exact position of each weight and take one or more photographs from which the overall geometry and exact weight positions can be confirmed at a later date. You will be given an assignment question based on this Step.

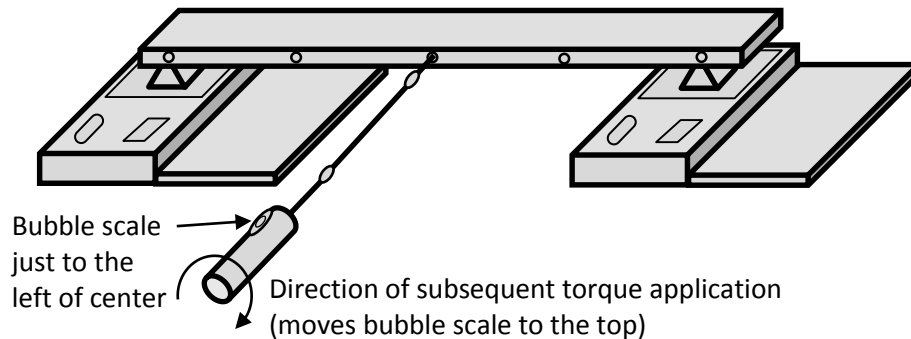
- V) Remove all weights and place them in their original positions in the storage container.

1.1.6 Torque and Support Reactions

In this section, you will learn about torque (moment) and the reactions it produces.

- W) Line up the parts of the torque tool so that they lie as closely as possible along a straight horizontal line that runs directly away from the side of the beam (see figure below). Rotate the torque tool handle along that axis until the bubble level is just slightly to the left of center. Then attach the torque tool at the center of the beam by inserting the x-shaped axle as far as it will go into the bushing on the edge of the beam near its center. You may need to adjust the tool angle slightly in order to get it to fit into the side of the beam.

APPLY ONLY THE TORQUE INDICATED IN STEP X, OR DAMAGE MAY RESULT.



- X) Tare the scales. Then rotate the tool as if you were tightening a screw (in the direction indicated by the curved arrow above) until the bubble level rotates just to the top of the handle – and no more. The axle will twist slightly as you apply this torque. For accuracy, do not touch the axle segment between the two universal joints while taking your readings.

When the bubble is in the center of the ring, record the scale readings (see Table below). If you followed the protocol carefully, you will have applied a pure moment of a pre-set magnitude.

Test number	Torque position (cm)	Left scale reading (g)	Right scale reading (g)
1 (Step W)			
2 (Step X)			
3 (optional)			
4 (optional)			

- Y) Now attach the tool to one of the other bushings and repeat the steps in (BB). Record you scale readings in the Table in Step (EE). Do the scale readings depend on where the torque is applied?

Are you surprised at this finding?

* If you want, you can try the tool at one of the other attachment points (Record your readings as Tests 3 and 4 in the Step (EE) Table).

- Z) *Hold one end of the beam on the upturned fingers of your one hand and the other end on the upturned fingers of the other hand. Close your eyes. Have your partner apply torques at two different locations. Do the reactions (forces on your two hands) change with the position where torque is applied? Change roles and repeat this step.

AA) If so instructed, remove the batteries from the working compartment of the scales and place them in the storage compartments.

BB) Return all components to the storage container the way you found them, and return the kit to the storage trolley.

1.1.7 Summative Comments

List the three most important things that you learned by doing this activity:

1)

2)

3)