Chapter 8

Extended Bodies at Rest

8.1 Extended and rigid bodies

8.1.1 Observe and find a pattern

***PIVOTAL* Lab or class:** *Equipment per group:* irregularly-shaped piece of plywood or thick cardboard, smooth surface.

Use a pencil eraser to push at several points on the edge of a thin, flat, irregularly-shaped piece of plywood or cardboard that you put on the smooth surface. Work with your group members to identify a pattern in the direction of the forces that do not cause the object to rotate. *Hint:* Draw lines on the object in the direction of the forces. Compare your findings to the findings of other groups.

8.1.2 Observe and find a pattern

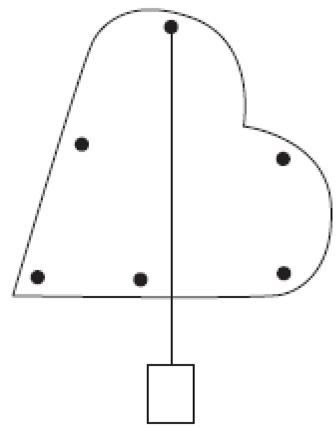
***PIVOTAL* Lab or class:** *Equipment per group:* whiteboard and markers, irregularly-shaped piece of plywood or thick cardboard (from the previous activity), and a heavy object (500-g block), smooth surface.

Repeat Activity 8.1.1, only this time place a 500-g block on top and near one side of the plywood or cardboard. Does the pattern change in the direction of the forces that do not cause the object to rotate?

8.1.3 Test your idea

***PIVOTAL* Lab or class:** *Equipment per group:* irregularly-shaped piece of plywood or cardboard with holes drilled at the edges (same as in the previous activities), nails, string, objects to hang.

Work with your group members and use your knowledge of the gravitational force exerted by Earth and your knowledge of the center of mass to predict the outcome of the following experiment. Do not perform it yet. Imagine that you take the same irregularly-shaped board as in Activity 8.1.1 and hang it on a nail going through one of the holes drilled at its edges; the board should hang freely. You then attach the end of a string to the nail and hang a 100-g block at the string's other end so that the string hangs vertically (see the figure below). Next, suppose you hang the plywood and string on the nail through other holes. Predict where the lines (along which the string is oriented) intersect when you hang the board from different positions.



a. Write down your prediction.

b. Explain how you arrived at your prediction.

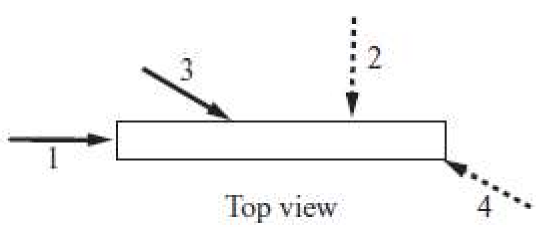
c. Perform the experiment; record the outcome.

d. Reconcile the results with your prediction.

8.1.4 Represent and reason

Class or lab

Imagine that you place a board on your desk and push it in different directions, as illustrated. Forces 1 and 3 cause the board to slide, and forces 2 and 4 cause it to slide and rotate. Collaborate with your group to find the center of mass of the board. What assumptions did you make? After you found the center of mass compare your finding with the result of other members of your group. Did you find the same location?



8.1.5 Reading exercise

Read Section 8.1 in the textbook and answer Review Question 8.1.

8.2 Torque: a new physical quantity

8.2.1 Observe and find a pattern

PIVOTAL ***Lab or class:*** *Equipment per group:* meter stick, play-dough, whiteboard marker, several identical-mass washers (or nuts).

Work with your group to conduct the following observational experiments: Place the whiteboard marker horizontally on the table and secure it in place with some play-dough so it cannot roll. Place the meter stick on top of the marker so that it balances at the 50 cm mark and doesn't touch the surface of the table. Note: If your meter stick doesn't balance at 50 cm exactly, add either a paper clip or some play-dough to a suitable place on it so that it does. Now place different numbers of washers on the left and on the right of the balance point. Figure out where you need to place the washers in order for the system to balance and complete the following table:

Number of washers on the left	Distance of left washer group from the middle	Number of washers on the right	Distance of right washer group from the middle
1	20 cm	1	
1	20 cm	2	
2	30 cm	3	
4	30 cm	3	

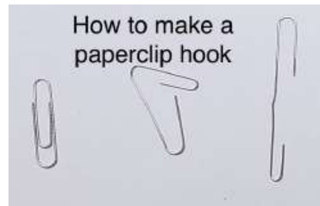
a. For each situation, draw a picture of the meter stick showing all of the forces exerted on it. In other words, sketch the apparatus and draw an extended-body force diagram for the meter stick, showing forces and points where those forces are exerted on the meter stick.

b. Find a pattern that relates the distances of the washers from the balance point and the magnitudes of the forces the washers exert on the meter stick. What is the relationship between the positions (as measured from the middle) of the left and right groups of washers, and the force that each group exerts on the ruler?

c. Put your ideas on a whiteboard and compare them with another group.

8.2.2 Observe and Explain

PIVOTAL Lab or class: *Equipment per group:* meter stick with center of mass at 50 cm, ring stand, paper clips, 10-N spring scale, 150-g object, whiteboard and markers.



Using the same meter stick as in Activity 8.2.1, suspend the meter stick 20 cm to the left of the center of the stick—at the 30 cm mark, using a paper clip (see photo at right). Suspend the meter stick from a spring scale and hang the spring scale on a ring stand. Using a paper clip to hang an object, find the point where you need to hang a 150-g object for the system to balance.

a. With the help of your group members, find a pattern between the distances from the suspension point and magnitudes of the forces exerted on the meter stick by the scale, by the hanging object, and by Earth. (You need to measure the mass of the meter stick.) To find the pattern, draw an extended-body force diagram showing all the forces exerted on the meter stick by other objects and the points at which those forces are exerted. Calculate and fill in the numerical values of the force magnitudes onto your force diagram.

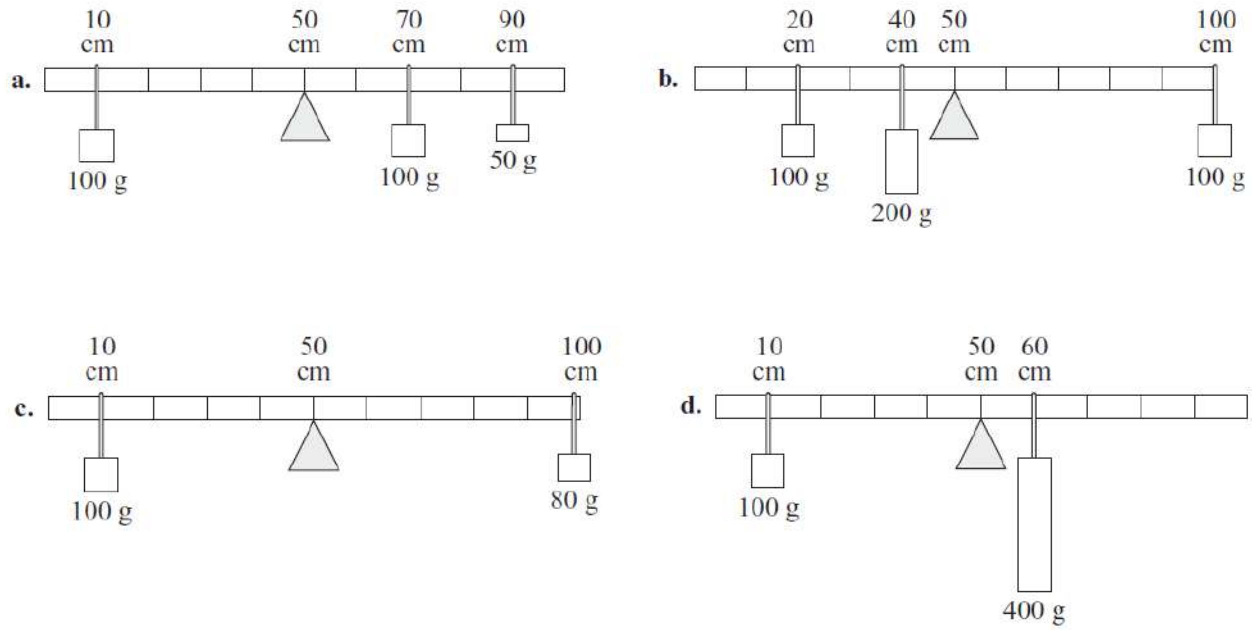
b. Describe the pattern you found, both in words and mathematically, and put it on a whiteboard.

c. Explain the scale reading (both in words and mathematically) using your knowledge of Newton's laws. Compare your ideas with those from another group.

8.2.3 Observe and find a pattern

PIVOTAL Class or lab: *Equipment per group:* whiteboard and markers.

A meter stick is balanced at its center. When you hang different mass blocks from different positions on the stick, as shown in the illustrations that follow, the stick remains balanced. Work on a whiteboard with your group: Draw *all* forces exerted on the stick by other objects. Remember the force exerted by Earth on the stick. Work together to devise a rule to explain this behavior (or extend the rules developed in the previous activities). Be sure that the rule is compatible with all of the experiments.



Describe the rule you devised, both in words and mathematically, and put it on your group's whiteboard. Compare your ideas with those from another group.

8.2.4 Test an idea

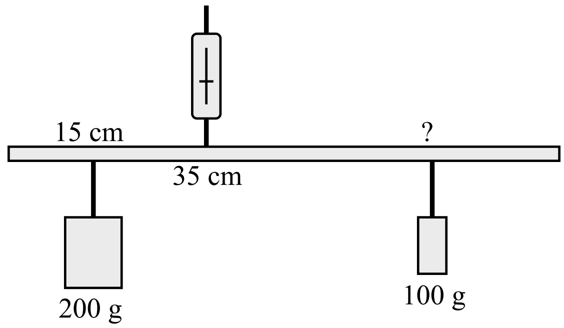
PIVOTAL Lab: *Equipment per group:* meter stick, an assortment of hanging objects, paper clips, spring scale, ring stand, whiteboard, markers.

Your task is to test whether the conditions of equilibrium are applicable to the behavior of this situation by predicting:

1. The scale reading of the spring scale the whole apparatus is suspended from.

2. The position of the 100-g block if the 200-g block and the spring scale are arranged as shown in the figure below. The indicated distances are relative to the left end of the meter stick.

Remember, since this is a testing experiment you need to make these predictions *before* you perform the experiment.



In your write-up, be sure to pay attention to the following points:

a. What is the hypothesis that you are going to test in this experiment?

b. Draw a labeled sketch of the experimental set-up.

c. Construct a force diagram using the meter stick as the system of interest.

d. Devise a mathematical procedure that you can use to make your prediction. State specifically how the prediction is based on the hypothesis being tested. What assumptions are you making in your mathematical procedure? Remember that an assumption is a simplification that you are making in the way you are thinking about the situation.

e. What if the assumption of the location of the center of mass of the stick is not valid? How might it affect your prediction?

f. Do you need to assume that the meter stick is horizontal in this experiment? How can you evaluate whether or not this assumption is reasonable?

g. Can you assume that the meter stick is massless? How would making this assumption affect the prediction?

h. Predict the reading of the scale and the position of the 100-g block using your mathematical procedure. First choose the origin of the coordinate system at the location where the spring scale is attached. Then repeat the analysis only this time place the origin of the coordinate system at the 15-cm position where the 200-g block hangs from the stick. Do you get the same prediction for the scale reading and the desired location of the 100-g block? If not, resolve the inconsistency.

In that last part you used an interesting and powerful property of Newton's second law for rotational motion. You applied the rotational equilibrium condition twice, with two different choices of origin, and the predictions in each case were identical. You are always able to choose the location of the origin wherever you wish. This can be very powerful in problem-solving because forces exerted at the origin do not exert torques and hence will not show up in the equation for rotational equilibrium. If you do not know the magnitude or direction of a particular force being exerted on the system of interest, it is therefore extremely useful to be able to choose the location of the origin to be where that force is exerted.

i. What are your sources of experimental uncertainty? What steps will you take to minimize them?

j. Build the apparatus and perform the experiment. Record the data in an appropriate format.

k. What is the outcome of the experiment? Is it consistent with the prediction within experimental uncertainty? If not, how might the assumptions contribute to the difference between the prediction and the outcome?

l. Improve how you model your system so that you are making as few assumptions as possible. Use this improved method to make new predictions. Repeat part k.

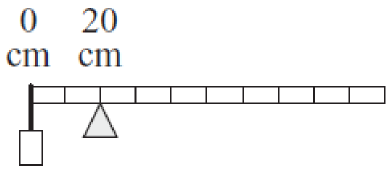
m. Given the consistency of the prediction and outcome, and the effects of the assumptions you made, make a judgment about the hypothesis you are testing.

8.2.5 Test your idea

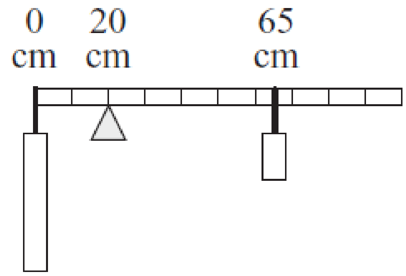
PIVOTAL ***Class:*** *Equipment per group:* whiteboard and markers.

Note: This as a "classroom alternate" version of Activity 8.2.4 above.

A fulcrum supports a uniform meter stick as shown. The center of mass of the meter stick is at its middle. Use the rule or rules you developed earlier to predict the mass of the meter stick in the following two experimental illustrations. In each picture, the available objects cause the meter stick to be balanced.



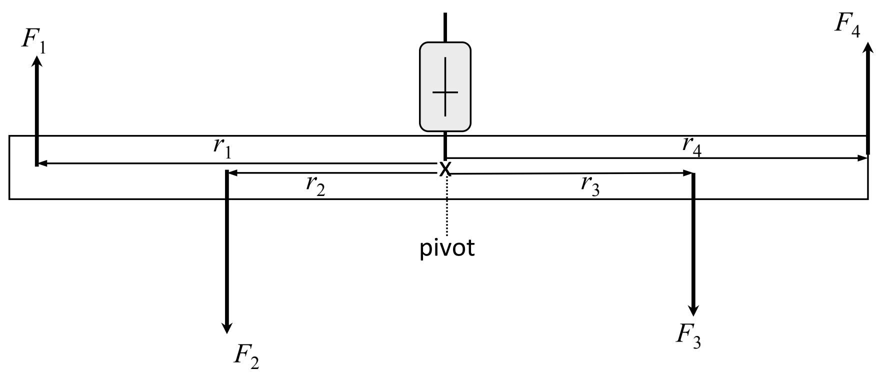
$m_{\text{object}} = 130$ g



$m_{\text{left object}} = 300$ g, $m_{\text{right object}} = 70$ g

8.2.6 Represent and reason

***PIVOTAL** Class or lab:* *Equipment per group:* whiteboard and markers.

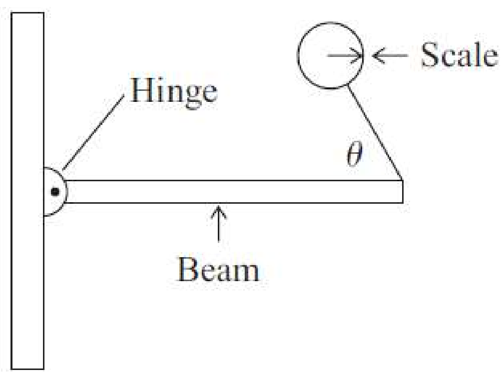


Four forces are exerted at different points on a meter stick (as shown in the diagram) that is held up at its center by a spring scale. The meter stick is in static equilibrium (not moving, not rotating). Work with your group to write a mathematical expression (in terms of F_1 to F_4 and r_1 to r_4) for the rotational condition for static equilibrium about the pivot point shown in the figure. Discuss with your group how you might develop a rule about the "direction" of torque and incorporate that into your equation for rotational equilibrium. Put your answer on a whiteboard and compare it with other groups.

8.2.7 Observe and find a pattern

PIVOTAL ***Class or lab:*** *Equipment per group:* A beam or meter stick hinged to a wall (or any fixed object) as shown in the figure, spring scale, platform scale, protractor, whiteboard, markers.

Working with your group members, measure and record the mass of the beam. Then, assemble the experiment as shown. Pull on the beam at the angles listed in the table and record the scale reading.



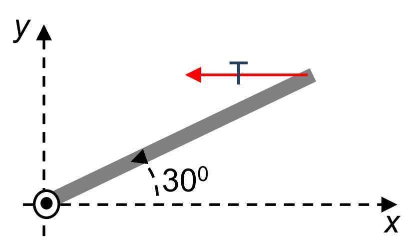
Angle (degrees)	90°	60°	45°	37°	30°
Force exerted by the string on the beam (N)					

Use the data that you collected to modify any rules you have made for the effect of a force on the rotation of a rigid body. In particular, discuss with your group members how the rotational effect of a force depends on its magnitude, direction, and the distance from the pivot point. Put your ideas on a whiteboard and compare them with another group.

8.2.8 Practice

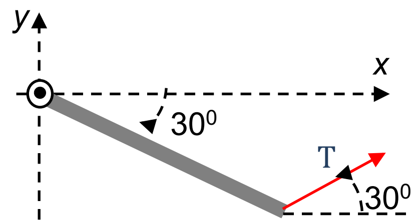
Class: *Equipment per group:* whiteboard and markers.

Three situations are shown on the right. Work with your group members to determine the torque caused by the force in each case:

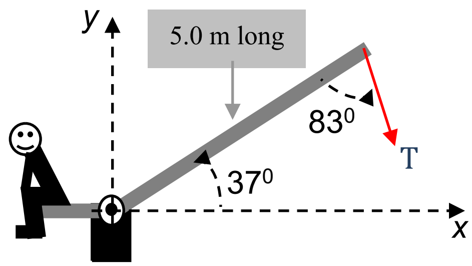


a. A rope exerts a 100-N tension force on the end of the 5.0-m long beam shown at the right. Determine the torque caused by this force.

b. A rope exerts a 100-N tension force on the 5.0-m long beam shown at the right. Determine the torque caused by this force.



c. A rope exerts a 100-N tension force on the end of the 5.0-m long beam shown at the right. Determine the torque caused by this force.



8.2.9 Reading exercise

Read Section 8.2 and answer Review Question 8.2.

8.3 Conditions of equilibrium

8.3.1 Explain

PIVOTAL Class: *Equipment per group:* whiteboard and markers.

a. Use the patterns and rules that you devised in the previous activities to summarize what you know about the sum of the forces exerted on an object that is in equilibrium and the sum of the torques caused by these forces. *Note:* Physicists give signs to torques. The torque caused by a force that tends to rotate an object counterclockwise about some pivot point is usually taken to be a positive torque, and the torque caused by a force that tends to rotate the object clockwise is taken to be negative.

b. Work with your group to summarize your ideas in the form of two equations (one for the sum of the forces and one for the sum of the torques) and put them on your whiteboard. Compare your ideas with those from another group.

c. Watch this video https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-8-3-1 and describe your observations.

d. Use the ideas you discussed in part **b** to explain why the placement of the bob did not matter for the balancing of the board.

8.3.2 Design an experiment

Lab: *Equipment:* To be determined.

Work with the members of your group to design an experiment to test the second condition of equilibrium (the rotational (torque) condition of equilibrium).

a. List the necessary equipment.

b. Sketch the apparatus.

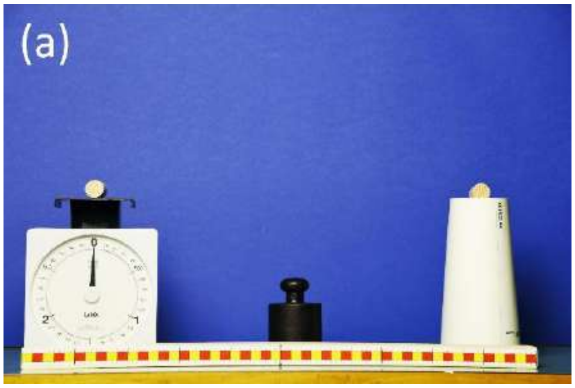
c. Write down the quantities that you will measure.

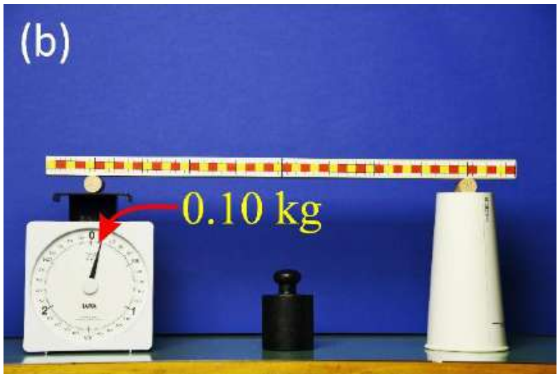
d. Use the conditions of equilibrium to make your prediction. Carefully list additional assumptions.

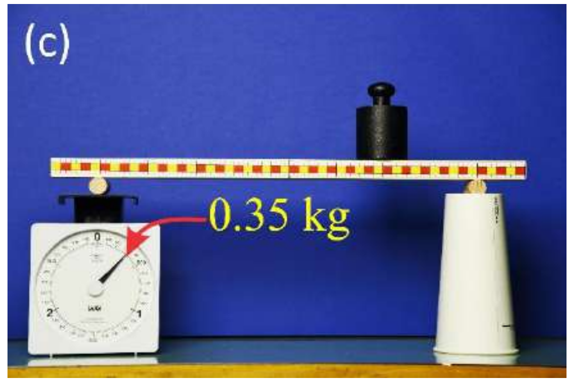
e. Conduct the experiment and record the outcome. Do you need to revise the assumptions?

8.3.3 Apply

We have a scale, a ruler with an unmarked scale, a paper cup and an object of unknown mass (figure (a)). If we place the ruler with one end on the scale and the other end on the paper cup (figure (b)), the scale reads 0.10 kg. If we then place the object on the ruler, the scale shows 0.35 kg (figure (c)).







a. Draw a force diagram for the ruler for the case shown in figure b and for the case shown in figure (c). Indicate any assumptions that you made.

b. Using the force diagrams and the information above, calculate the mass of the object and the mass of the ruler.

8.3.4 Reading exercise

Review Section 8.3 and answer Review Question 8.3.

8.4 Center of mass

8.4.1 Design an application experiment

***PIVOTAL* Lab:** *Equipment per group:* whiteboard and markers, meter stick, 100-g object.

You have a meter stick of unknown mass and a small 100-g object. Design an experiment to determine the mass of the meter stick using your knowledge of static equilibrium.

a. Draw a picture of the experimental set-up.

b. Describe the procedure in words.

c. Apply the concepts of equilibrium to develop equations that can be used to predict the mass of the meter stick. Then predict the mass.

d. Use a scale to measure the mass and compare the result to the predicted value.

e. How can you explain the difference between the predicted and the measured value?

8.4.2 Test an idea

Lab: *Equipment per group:* whiteboard, markers, meter stick, variety of objects of different mass, masking tape, platform scale.

Your friend says that the mass of any object is distributed evenly around its center of mass. Design an experiment to test your friend's idea. You have a meter stick, a set of small objects of different masses, masking tape, and a mass measuring scale. Describe your experiment and predict the outcome based on your friend's idea. Then conduct the experiment, collect and analyze data. What can you say about your friend's idea?

8.4.3 Represent and reason

You balance a bread knife by laying the flat side across one finger. Where is the center of mass of the knife? How does the mass of the knife on the left side of the balance point compare to the mass of the knife on the right side of the balance point?

8.4.4 Reading exercise

Review Section 8.4 in the textbook and answer Review Question 8.4.

8.5 Skills for analyzing situations using equilibrium conditions

8.5.1 Practice problem solving strategy

PIVOTAL ***Class:*** *Equipment per group:* whiteboard and markers.

Use the problem-solving strategy to solve the following problem, then compare your solution to the one in Example 8.5. After you have corrected your solution if needed, work on the *Try it yourself* exercise.

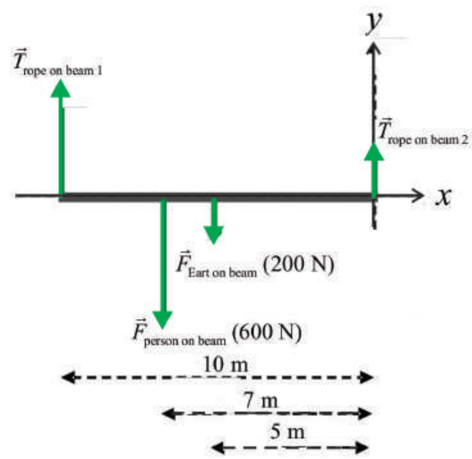
Imagine that you hold a 6.0-kg lead ball in your hand with your arm bent. The ball is 0.35 m from the elbow joint. The biceps muscle attaches to the forearm 0.050 m from the elbow joint and exerts a force on the forearm that allows it to support the ball. The center of mass of the 12-N forearm is 0.16 m from the elbow joint. Work with your group on a whiteboard to estimate the magnitude of (a) the force that the biceps muscle exerts on the forearm and (b) the force that the upper arm exerts on the forearm at the elbow.

Sketch and translate • Construct a labeled sketch of the situation; mark knowns and unknowns. Choose an axis of rotation. • Choose a system for analysis.	
Simplify and diagram • Decide whether you will model the system as a rigid body or as a pointlike object. • Construct a force diagram for the system. Include the chosen coordinate system and the axis of rotation (the origin of the coordinate system).	
Represent mathematically • Use the force diagram to apply the conditions of equilibrium.	
Solve and evaluate • Solve the equations for the quantities of interest. • Evaluate the results. Check to see if their magnitudes are reasonable and if they have the correct signs and units. Also see if they have the expected values in limiting cases.	

8.5.2 Represent and reason

***PIVOTAL* Class:** *Equipment per group:* whiteboard and markers.

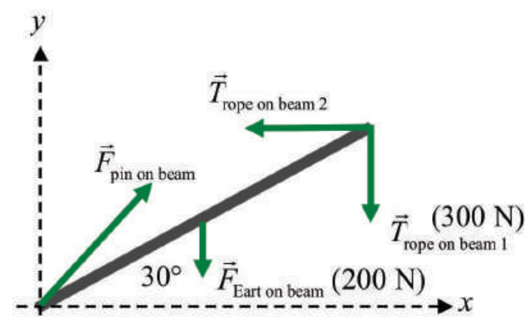
A force diagram for a beam is shown at the right. Help your group members to apply the first and second conditions of equilibrium for this situation and solve for the unknown forces. Draw a picture of a situation that the diagram might describe. Put your work on a whiteboard.



8.5.3 Represent and reason

Class: *Equipment per group:* whiteboard and markers.

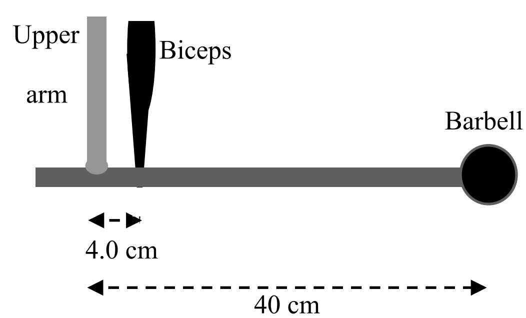
A force diagram for a 2.0-m long uniform beam is shown at the right. Apply the first and second conditions of equilibrium for this situation and solve for the unknown forces. Draw a picture of a situation that the diagram might describe. What assumptions did you make? Do it all on a whiteboard with your group.



8.5.4 Real-world application

Class: *Equipment per group:* whiteboard and markers.

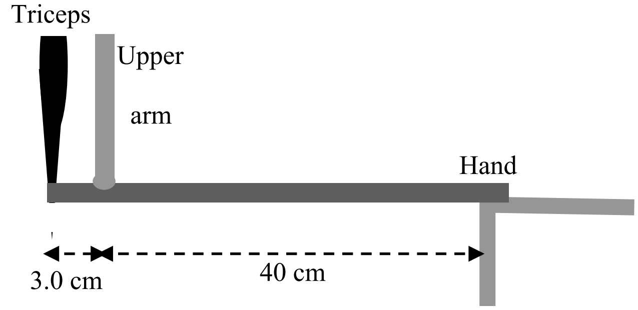
Your arm lifts an 8.0-kg barbell that is 40 cm from the elbow joint between the upper arm and the lower arm (forearm). Determine the force that the biceps muscle exerts on the forearm 4.0 cm from the joint. What assumptions did you make in working the problem? Work together with your group members on a whiteboard.



8.5.5 Real-world application

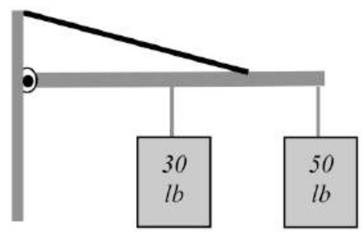
Class: *Equipment:* None.

Your hand exerts an 80-N force pressing down on a table 40 cm from the elbow joint between the upper arm and the lower arm (forearm). Determine the tension in the triceps muscle pulling 3.0 cm from the joint. What assumptions did you make in working the problem?



8.5.6 Real-world application

PIVOTAL ***Class:*** *Equipment per group:* whiteboard and markers.



The woman at the right is lifting a 30 lb barbell. A mechanical model of her upper body is shown below the photo. The beam is her backbone and the cable is her back muscles (a complex set of muscles in the real back). Earth's gravitational force on her upper body at its center of mass is 30 lb. Earth's gravitational force on her head, arms, and the barbell is 50 lb at the end of the beam. The back muscle (cable) connects 0.20 m from the right end of the 0.60 m long beam (the backbone) and makes a 15° angle with the beam. Apply the conditions of equilibrium to the beam and use them to estimate the force that one primary back muscle (it is a complex system) exerts on the backbone and the force that the hinge (joint) exerts on the backbone on the left side. (Each year more than half a million Americans get serious back problems by lifting this way.)

8.5.7 Equation Jeopardy

Class: *Equipment: Equipment per group:* whiteboard and markers.

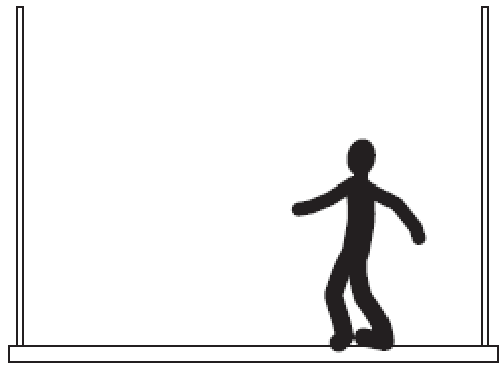
The conditions of equilibrium applied to two processes are shown below. Fill in the table that follows using the information in the equations. Remember that *N* stands for normal force and N for Newton, the unit of force.

a. Equations	$+(2.0\text{ N})(0.25\text{ m})+N(0)+(1.0\text{ N})(0)-T_2(0.40\text{ m})=0$ $-(2.0\text{ N})+N-(1.0\text{ N})-T_2=0$		
Determine the unknown quantities in the equations.		**Draw an extended-body force diagram consistent with the equations.**	
Describe a possible situation in words.		**Sketch the situation.**	
b. Equations	$+F_{\text{pin}}(0)-(2\text{ N})(0.5\text{ m})-(6\text{ N})(1.0\text{ m})+T_1(1.0\text{ m})\sin 37°=0$ x equation: $F_{\text{pin}}\cos\theta-T_1\cos 37°=0$ y equation: $F_{\text{pin}}\sin\theta-(2\text{ N})-(6\text{ N})+T_1\sin 37°=0$		
Determine the unknown quantities in the equations.		**Draw a force diagram consistent with the equations.**	
Describe a possible situation in words.		**Sketch the situation.**	

8.5.8 Evaluate the solution

PIVOTAL Class: *Equipment per group:* whiteboard and markers.

The problem: An 800-N painter stands 3.0 m from the right side of a 10.0-m-long beam of a scaffold, which is connected to cables at each end (see diagram below). The force exerted by Earth on the uniform beam is 200 N. Determine the forces that the cables exert on each end of the beam. Assume that $g=10\text{N/kg}$.



Proposed solution:

$$+T_{\text{left}}(10.0\text{ m})+(200\text{ N})(5.0\text{ m})+(800\text{ N})(3.0\text{ m})+T_{\text{right}}(0)=0$$

$$+T_{\text{left}}=-340\text{ N}$$

$$+T_{\text{left}}+(200\text{ N})+(800\text{ N})+T_{\text{right}}=0$$

$$T_{\text{right}}=-660\text{ N}$$

a. Work with your group to identify any missing elements or errors in the solution.

b. Provide a corrected solution or missing elements if there are errors.

8.5.9 Regular problem

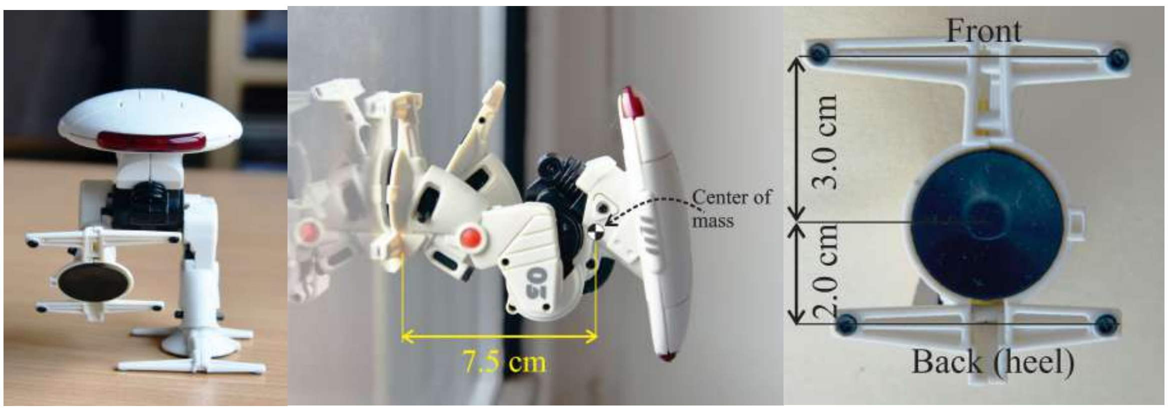
Class: *Equipment per group:* whiteboard and markers.

Any time you have to climb a ladder, you want the ladder to remain in static equilibrium. At what angle should a 60-kg painter place his ladder against the wall in order to climb two-thirds of the way up the ladder and have the ladder remain in static equilibrium? The ladder's mass is 10 kg and its length is 6.0 m. The exterior wall of the house is very smooth, meaning that it exerts a negligible friction force on the ladder. The coefficient of static friction between the floor and the ladder is 0.50.

8.5.9 Real-world application

Class or lab *Equipment per group:* whiteboard and markers.

Widow climbing robot A 0.150-kg toy robot can climb up the window (see the figures below) using suction cups on its feet. The center of the mass of the robot is shown on the photo in the middle, and the details of its foot on the photo on the right.



a. Propose a simplified model of the robot that will allow you to determine the forces that other objects exert on the robot when it is in the position shown on the photo in the middle (the robot is at rest). Draw a sketch of the model. (*Hint*: Note that the robot's right foot is not touching the window; also note that the front part of the left foot is not touching the window; replace the forces exerted on the suction cup with a single force in the center of the cup).

b. Determine the forces that other objects exert on the robot when it is in the position shown on the photo in the middle. Indicate any assumptions that you made.

c. The robot on the middle photo is facing up. Discuss how the forces exerted on the robot will change if the robot is facing down and then determine the forces.

d. In which case it is more likely that the suction cups will detach from the window: when the robot is facing up or when it is facing down? Explain.

8.5.10 Reading exercise

Read Section 8.5 in the textbook and answer Review Question 8.5.

8.6 Stability of equilibrium

8.6.1 Observe and explain

PIVOTAL ***Class:*** *Equipment per group:* whiteboard and markers.

You have probably observed that it is easier to balance and avoid falling while standing in a moving bus or subway train if you spread your feet apart in the direction of motion. By doing this you are increasing the area of support, the area of contact between an object and the surface it is supported by.

a. Working with your group on a whiteboard, draw force diagrams and consider the torques exerted on two people by the gravitational force and normal forces at their feet when they are on a slowing-down train. Person A is standing with their feet close together and person B is standing with their feet wide apart.

b. Discuss with your group members: who is more likely to fall? Explain.

c. Devise a rule for the stability of equilibrium. Put it on a whiteboard and share your ideas with another group.

8.6.2 Test your idea

PIVOTAL ***Class or lab:*** *Equipment:* whiteboard and markers, box full of crackers.

a. Place a full box of crackers on a flat but rough surface, such as a wooden desk. Its center of mass is at its geometric center. Place the box so that the tall side is upward. Tilt the box a little and release it. Tilt the box at larger and larger angles. Use the rule you developed in Activity 8.6.1 to predict the angle at which the box will tip over.

b. Conduct the experiment and record the outcome. Did it match the prediction?

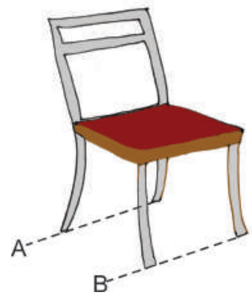
c. Then remove some crackers from the box and make a new prediction. Conduct the experiment and record the outcome. Did it match the prediction?

d. What is your conclusion about the conditions for the stability of equilibrium?

8.6.3 Apply your knowledge I

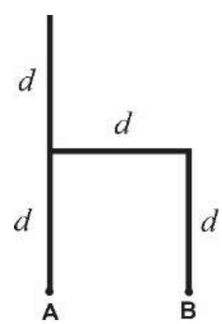
***PIVOTAL* Class or lab:** *Equipment per group:* whiteboard and markers, chair.

a. Obtain a simple chair (see the figure below) and try to tip it over by slowly tilting it either around the axis A or around the axis B. In which case do you need to tilt the chair at a larger angle to tip it over? Estimate both angles.



b. Work with your group members to explain the outcome of your experiment qualitatively using physics arguments. Put your explanation on a whiteboard.

c. Assume the following simplified model of a chair (the figure below shows a side view). All parts of the chair are made of the same board. Work with your group to determine the tipping angle for tilting the chair around A and the tipping angle for tilting the chair around B. Put all your diagrams and calculations on a whiteboard.

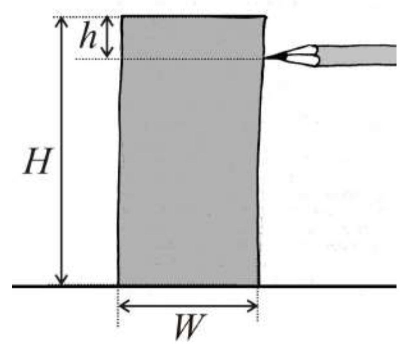


d. Compare the result that you got in **b.** with the outcome of your experiments with the real chair and discuss and explain any discrepancies between the two.

8.6.4 Apply your knowledge II

Class or lab: *Equipment:* A solid block (such as wooden block), a pencil, whiteboard, markers.

While searching in the literature for simple experiments that will allow you to determine the coefficient of static friction, you came across the following method:



Using a pencil, exert a force in a horizontal direction on a wooden block (height H, width W) and try to tip the block over. Start at the top of the block and move down in small steps (see the figure on the right and the video [https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-8-6-4]). At some point you will reach a distance h where the block will not tip but rather slide forward. Repeat the procedure several times to determine the distance h where this transition happens, as precisely as possible. The coefficient of static friction between the block and the supporting surface is determined by the following expression:

$$\mu_s = \frac{W}{2(H - h)}$$

a. Obtain a block and try the experiment described above.

b. Evaluate the equation given above. Then derive the equation.

c. Why does the result not depend on the mass of the block? Explain.

8.6.5 Reading exercise

Read Section 8.6 in the textbook and answer Review Question 8.6.

