Lecture 17: Rotational Statics

Physics 2210
Fall Semester 2014

Local example of the utility of rotational statics…

Today's Concepts:

a) Torque due to gravity

b) Static Equilibrium

Prelecture Feedback

- It would be good to get a refresher going back a few chapters...
- I would like to review torque and center-of-mass displacement again... also statics problems
- Homework-like problems

New Topic, Old Physics:

"statics" = the study of systems that don't move

The key equations are familiar: $\Sigma\vec{F} = m\vec{a}$ $\Sigma\vec{\tau} = I\vec{\alpha}$

If an object doesn't move:

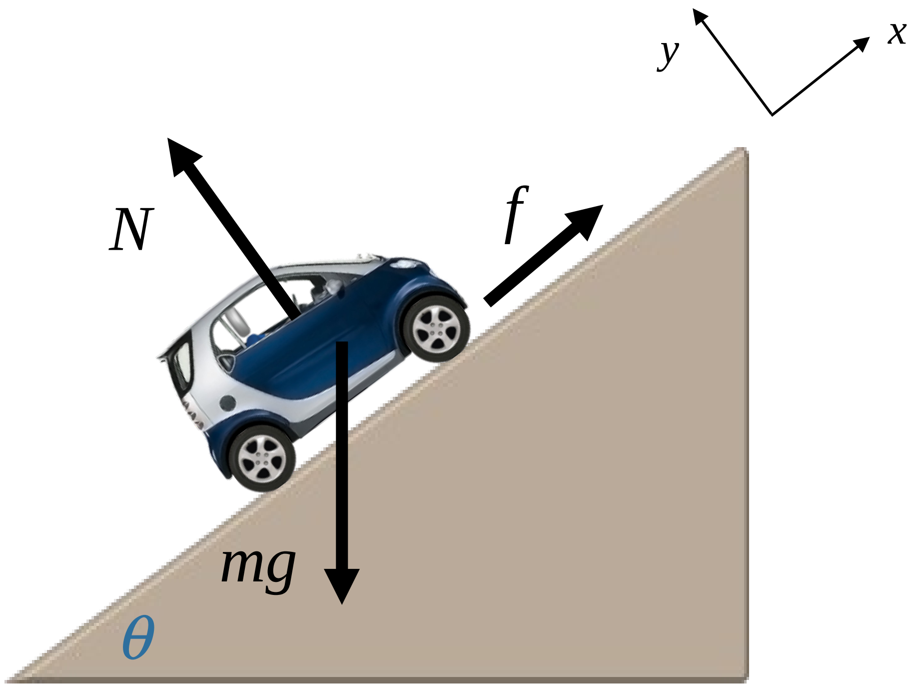
$\Sigma\vec{F} = 0$ $\Sigma\vec{\tau} = 0$

The net force on the object is zero

The net torque on the object is zero (for *any* axis)

Statics:

Example: What are all of the forces acting on a car parked on a hill?



Car on Hill:

Use Newton's 2nd Law: $F_{NET} = MA_{CM} = 0$

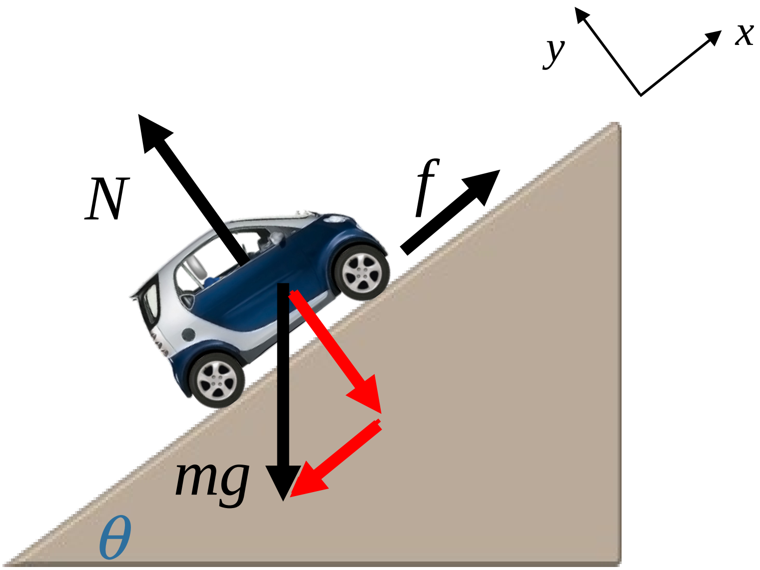
Resolve this into x and y components:

x: $f - mg\sin\theta = 0$

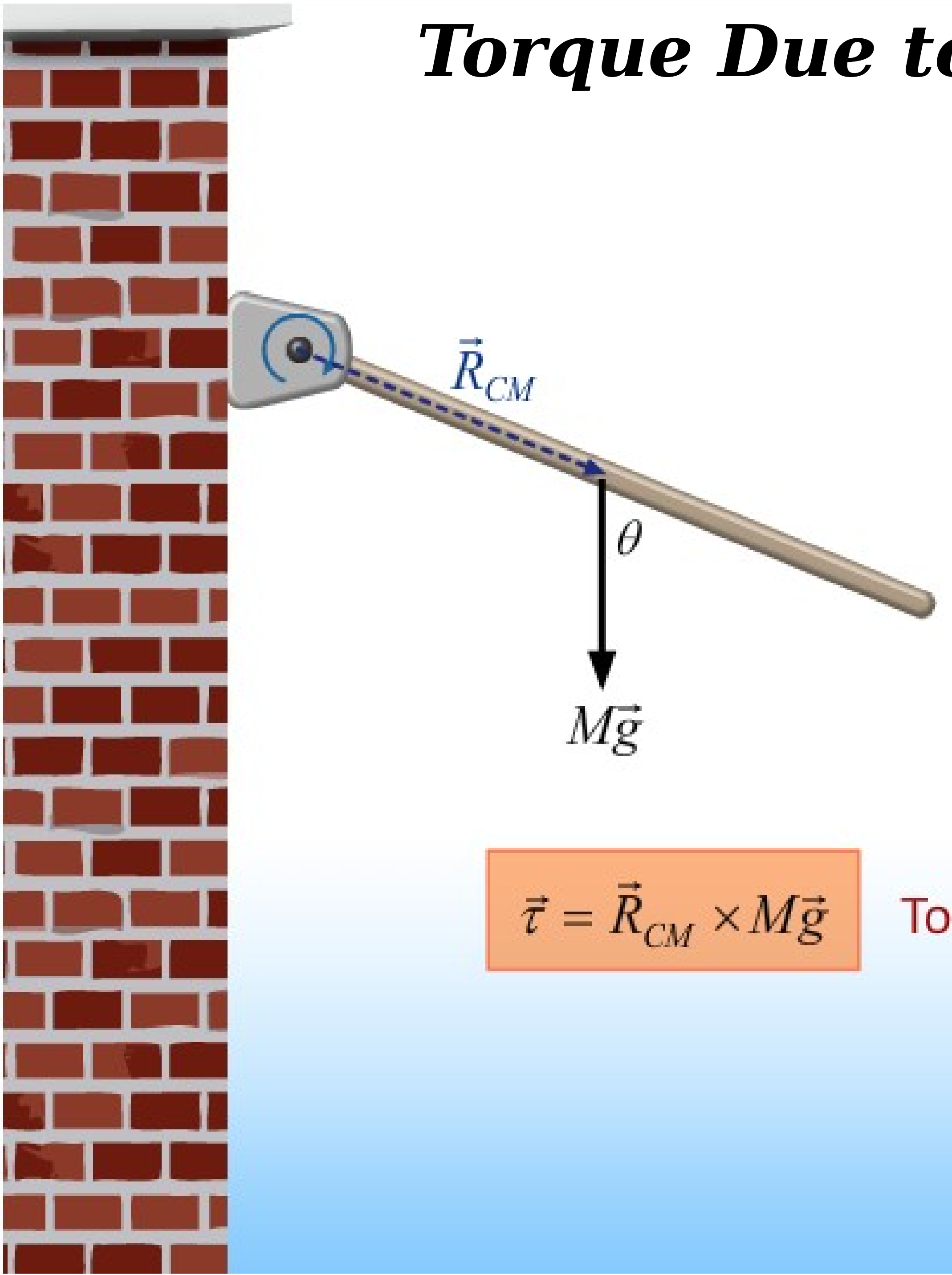
$$f = mg\sin\theta$$

y: $N - mg\cos\theta = 0$

$$N = mg\cos\theta$$



Torque Due to Gravity

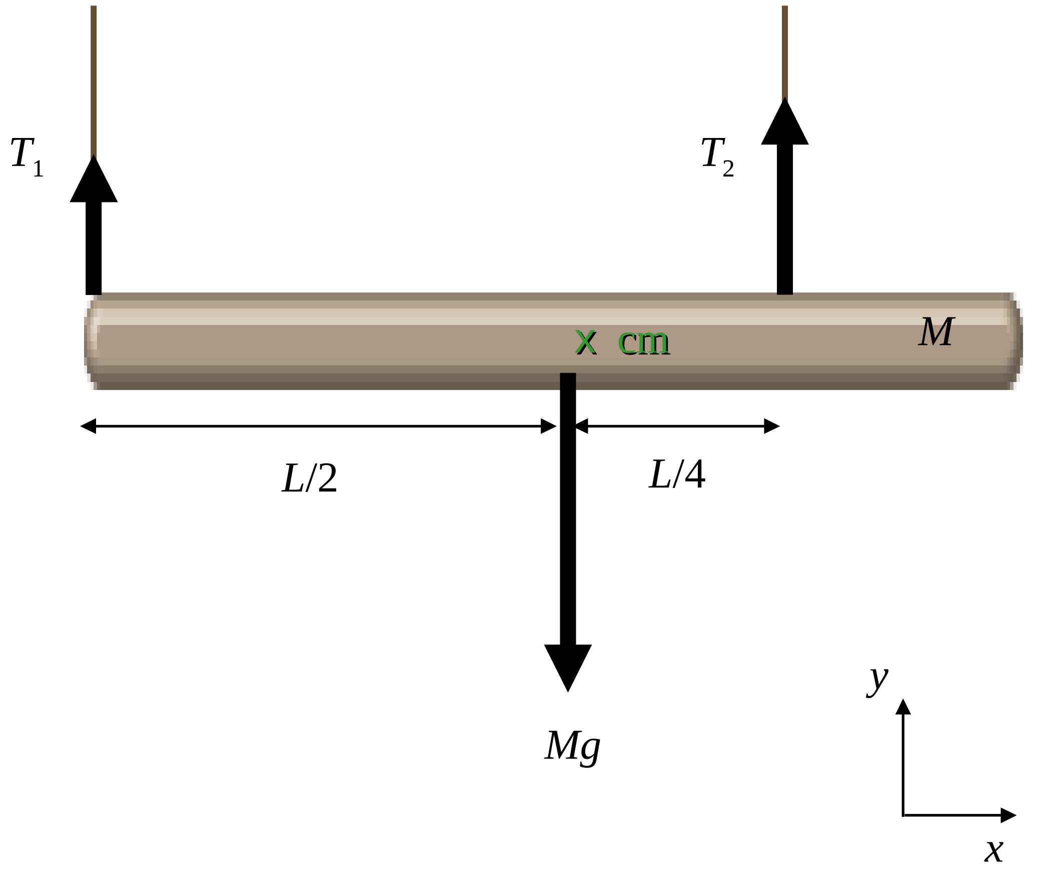


$$\vec{\tau} = \vec{R}_{CM} \times M\vec{g}$$

Torque by the Gravitational Force

Example:

Consider a plank of mass M suspended by two strings as shown. What is the tension in each string?



Approach to Statics: Summary

In general, we can use the two equations

$$\Sigma\vec{F} = 0 \qquad \Sigma\vec{\tau} = 0$$

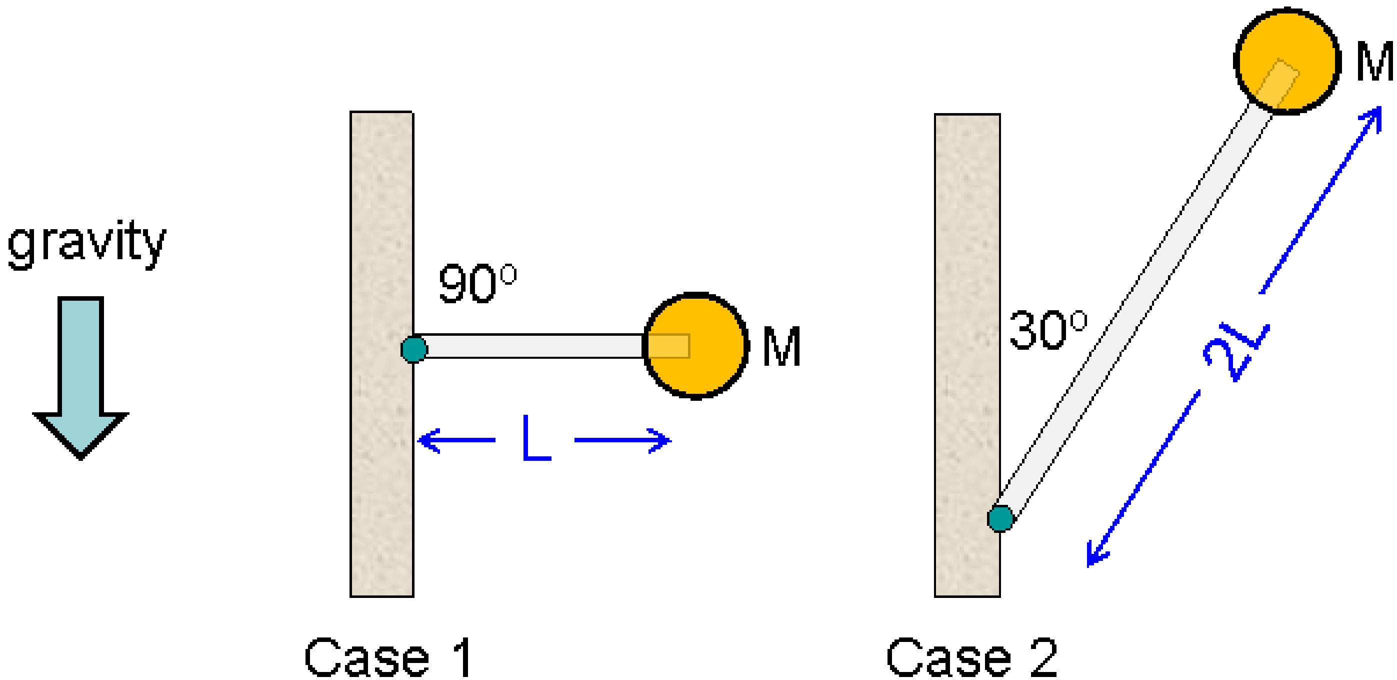
to solve any statics problem.

When choosing axes about which to calculate torque, we can sometimes be clever and make the problem easier....

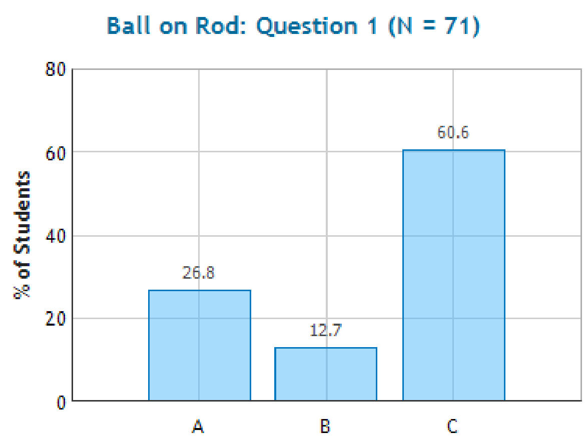
Checkpoint

Ball on Rod

? ?



In case 1, one end of a horizontal massless rod of length L is attached to a vertical wall by a hinge, and the other end holds a ball of mass M. In case 2 the massless rod is twice as long and makes an angle of 30o with the wall as shown.



1) In which case is the total torque about an axis through the hinge biggest?

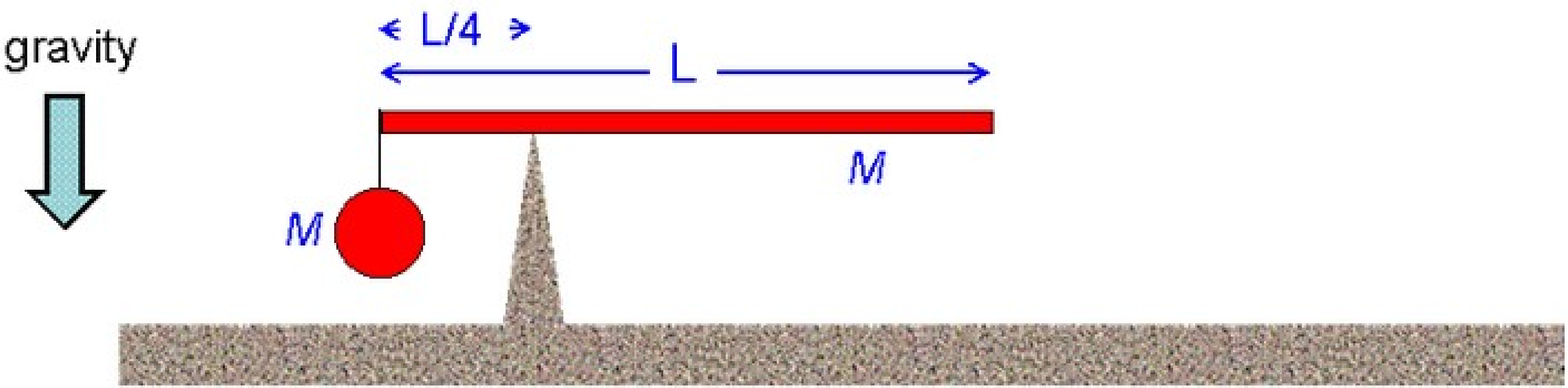
- Case 1
- Case 2
- Same

Submit

Checkpoint

Ball and Beam

? ?



An object is made by hanging a ball of mass M from one end of a plank having the same mass and length L. The object is then pivoted at a point a distance L/4 from the end of the plank supporting the ball, as shown below.

1) Is the object balanced?

- Yes
- No, it will fall to the left.
- No, it will fall to the right.

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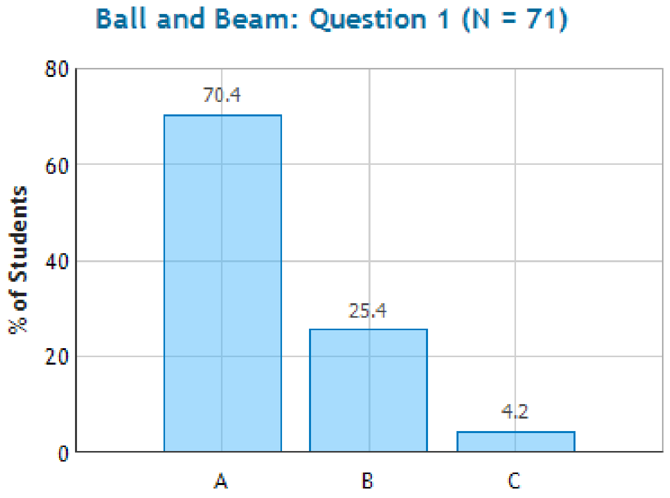
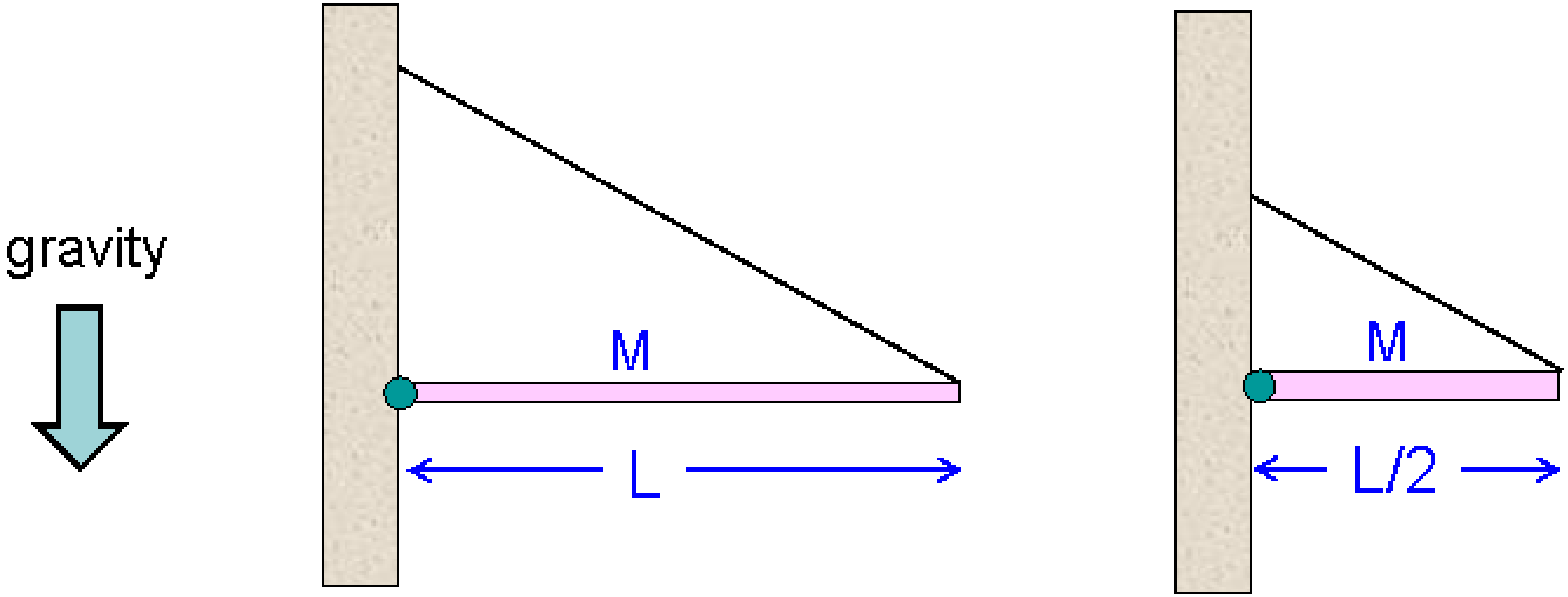


Checkpoint

Sign

? ?



In case 1, one end of a horizontal plank of mass M and length L is attached to a wall by a hinge and the other end is held up by a wire attached to the wall. In case 2 the plank is half the length but has the same mass as in case 1, and the wire makes the same angle with the plank.

1) In which case is the tension in the wire biggest?

- Case 1
- Case 2
- Same

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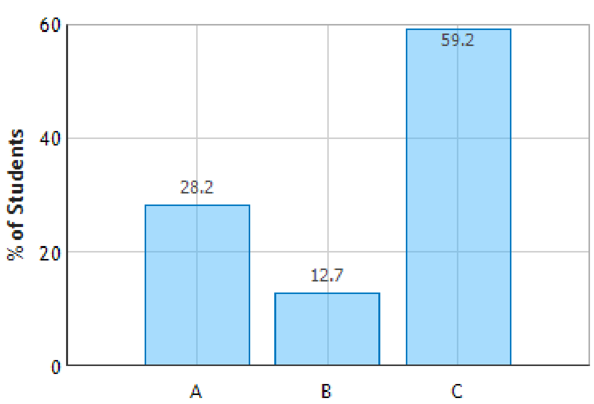
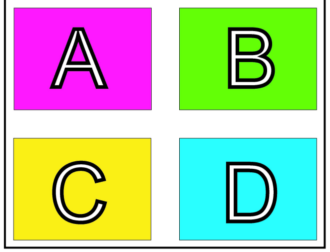




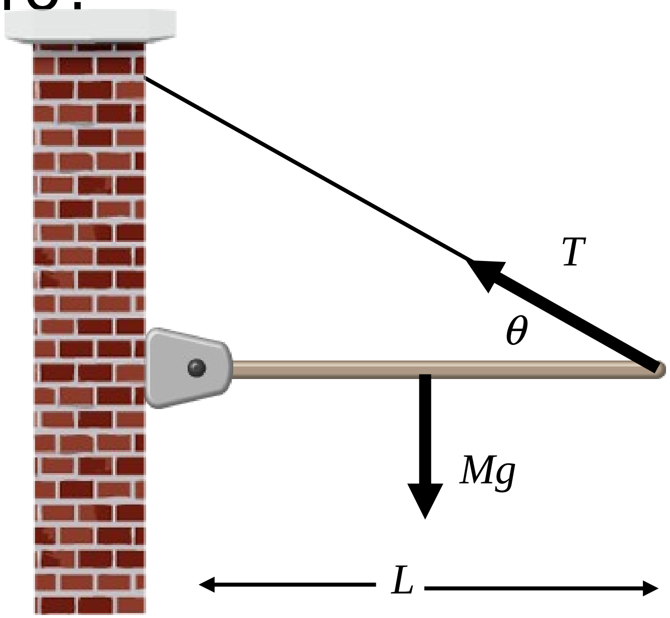
Flashcard Question

Which equation correctly expresses the fact that the total torque about the hinge is zero?

A) $TL\sin\theta - Mg\frac{L}{2} = 0$

B) $TL - Mg\frac{L}{2} = 0$

C) $TL - MgL\sin\theta = 0$



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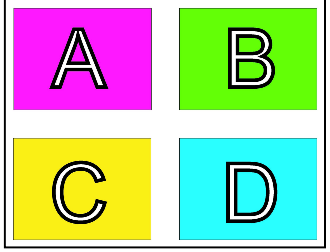

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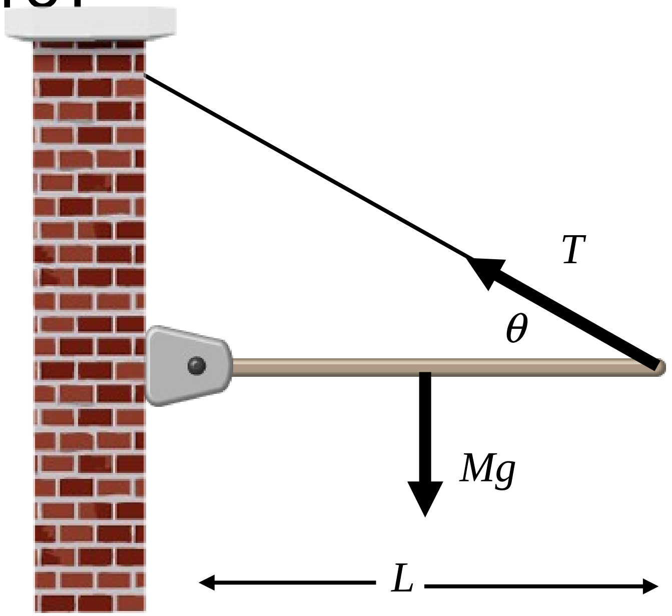
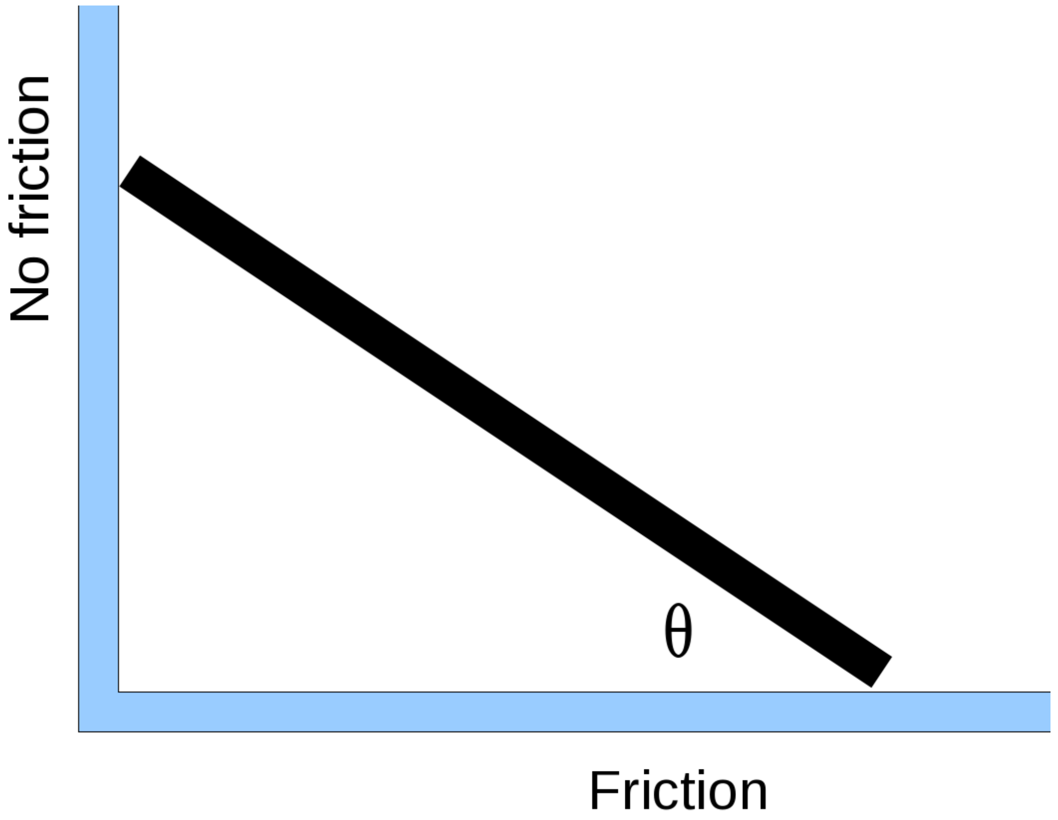


Example

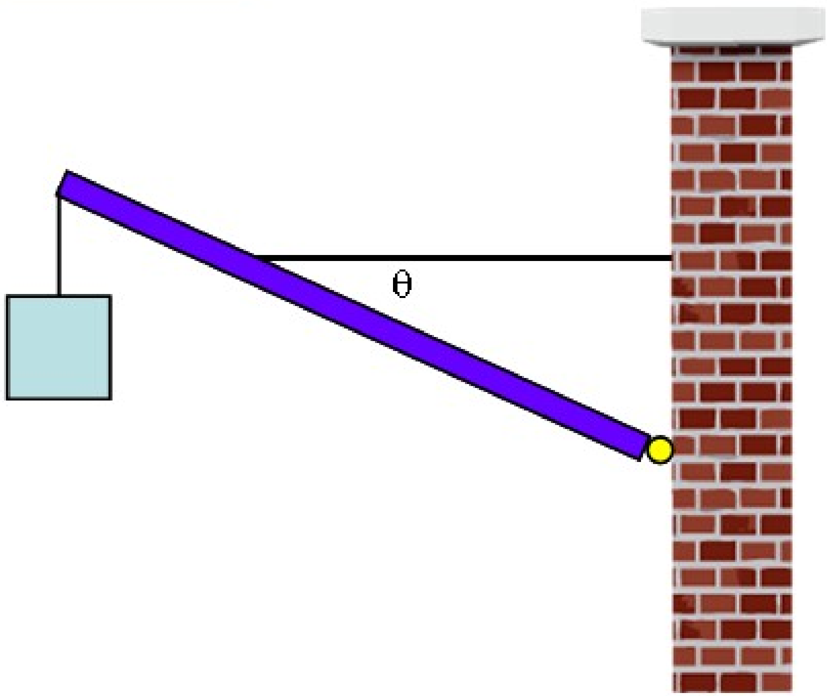
A rod of length 1.5 meters, mass 5 kg, rests against a wall making an angle of θ = 34°. Assume the wall is frictionless. What is the minimum value that the coefficient of static friction μ_s (between the rod and the floor) can have, given that the rod doesn't slip?



Homework

Hanging Beam

1 2 3 4 5



A purple beam is hinged to a wall to hold up a blue sign. The beam has a mass of m_b = 6.7 kg and the sign has a mass of m_s = 17.1 kg. The length of the beam is L = 2.76 m. The sign is attached at the very end of the beam, but the horizontal wire holding up the beam is attached 2/3 of the way to the end of the beam. The angle the wire makes with the beam is θ = 33.6°.

- What is the tension in the wire?
- What is net force exerted by the hinge on the beam?
- Given a T_{max}, what is the heaviest sign that can be hung?