PHY131H1F - Class 23

This is a torque wrench.

Today:

8.1 Extended and Rigid Bodies

8.2 Torque (rhymes with “fork”)

1

Mastering Physics

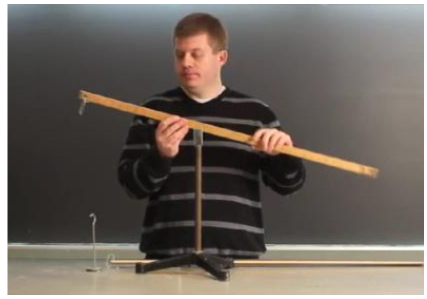
What’s up on the MyLab and Mastering?

- Notice that Homework 8 has been posted on MyLab and Mastering. It is due Monday Nov.16, which is after Reading Week.
- Also, I have posted a not-for-homework-credits item called “Videos and Practice for Chapter 8” which I recommend you check out.

2

Mastering Physics

Videos and Practice for Chapter 8 (Optional)



- Return of “Buzzcut Guy”! Woot!

- Including, Buzzcut Guy walks the plank!
- And two Khan-Academy-style videos about solving Ch.8 problems.

3

What’s the Big Idea of Chapters 8 and 9?

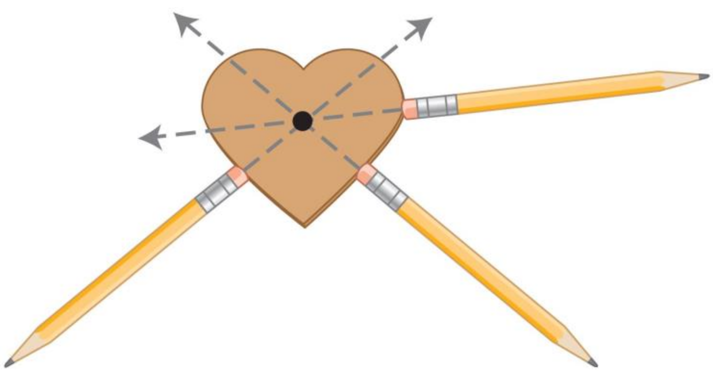
- So far we’ve kind of been neglecting the fact that objects have size and shape.
- This has been the “point particle” approximation.
- For chapters 8 and 9 we will start thinking about “extended bodies”, which just means objects that are not points, but have some shape and size.
- Force, momentum and energy are still important, but there are some new things, like:
  - **Torque:** kind of like force (with different units), but it’s what get’s objects turning.
  - **Rotation:** things can spin or roll!

4

- A **rigid body** is a model for an extended object.
- We assume that the object has a nonzero size but the distances between all parts of the object remain the same (the size and shape of the object do not change).

5

Center of mass

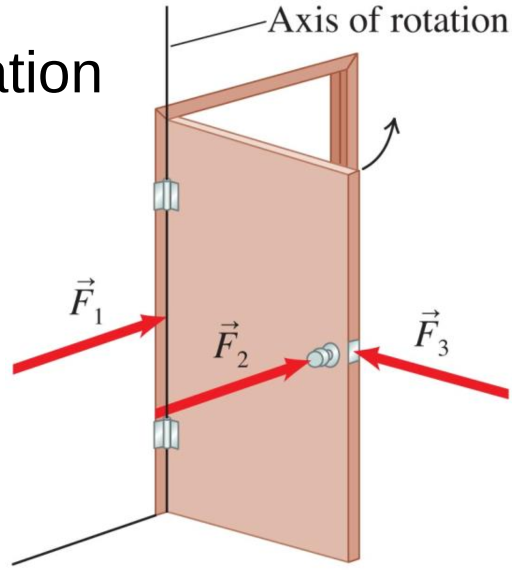


- A rigid body possesses a special point such that if a force is exerted on that point, the object will not turn.
- We call this point the object's center of mass.

6

Axis of rotation

- When objects turn around an axis, physicists say that they undergo **rotational** motion.
- We call the imaginary line passing through the hinges the **axis of rotation.**

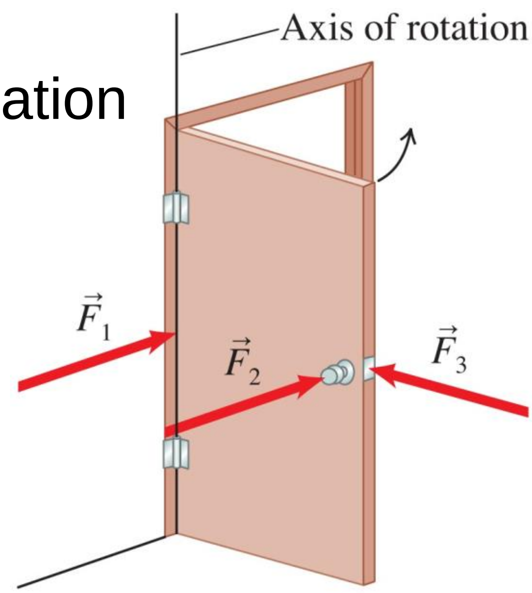


$\vec{F}_1$ and $\vec{F}_3$ do not rotate the door, whereas $\vec{F}_2$ moves it easily.

7

Causing rotation

- Three factors affect the turning ability of a force:
  1. The **place** where the force is exerted
  2. The **magnitude** of the force
  3. The **direction** in which the force is exerted

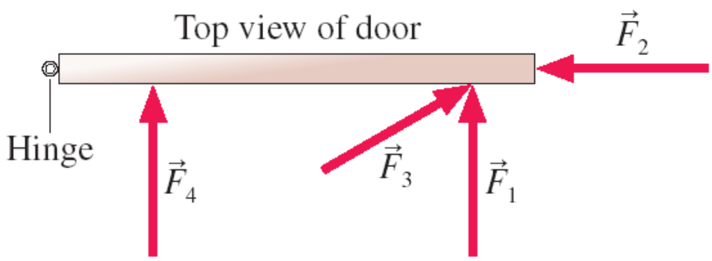


$\vec{F}_1$ and $\vec{F}_3$ do not rotate the door, whereas $\vec{F}_2$ moves it easily.

8

Poll Question

Consider the common experience of pushing open a door. Shown is a top view of a door hinged on the left. Four pushing forces are shown, all of equal strength. Which of these will be most effective at opening the door?



A. F_1

B. F_2

C. F_3

D. F_4

Torque τ produced by a force

Torque τ produced by a force The torque produced by a force exerted on a rigid body about a chosen axis of rotation is

$$\tau = \pm F l \sin\theta$$

where F is the magnitude of the force, l is the magnitude of the distance between the point where the force is exerted on the object and the axis of rotation, and θ is the angle that the force makes relative to a line connecting the axis of rotation to the point where the force is exerted

- The SI unit of force is the Newton-meter (N-m).

Ch.8 Example. Luis uses a 20 cm long wrench to turn a nut. The wrench handle is tilted 30° above the horizontal, and Luis pulls straight down on the end with a force of 100 N. Calculate the torque exerted by Luis.

SKETCH & TRANSLATE.

SIMPLIFY & DIAGRAM

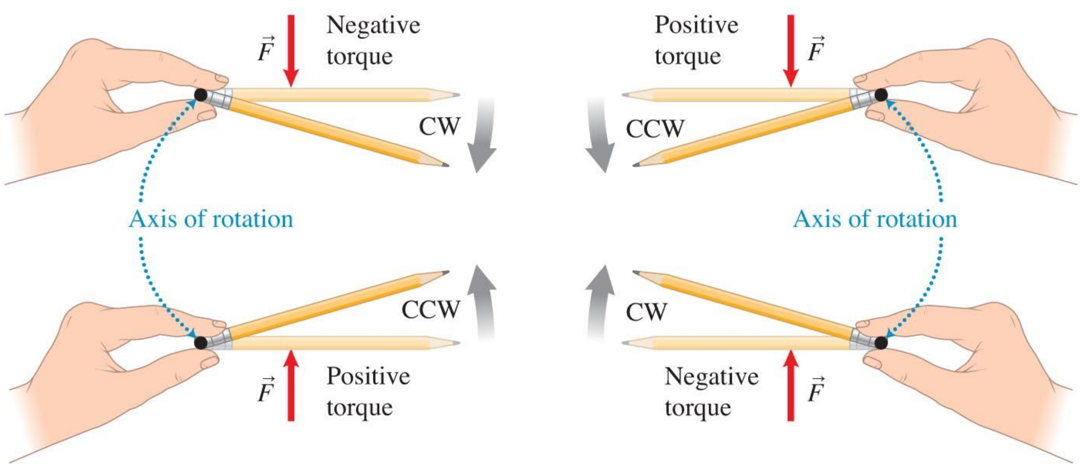
REPRESENT MATHEMATICALLY

SOLVE & EVALUATE

11

Sign Convention for Torque (historical)

- If the torque tends to produce a **counterclockwise** rotation, this is **positive** torque.
- If the torque tends to produce **clockwise** rotation, this is **negative** torque.



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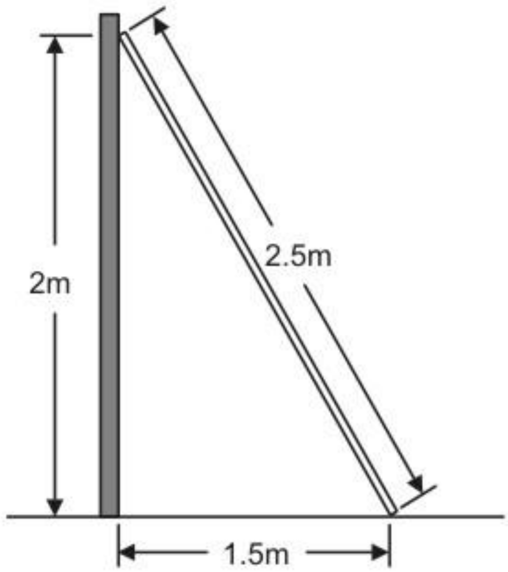
Poll Question



- A ladder leans against a wall.
- What is the **sign** of the torque of the normal force of the wall on the ladder, $N_{\mathrm{W\ on\ L}}$?

A. Positive

B. Negative

C. The torque is zero

D. It depends on where we choose the rotation axis to be

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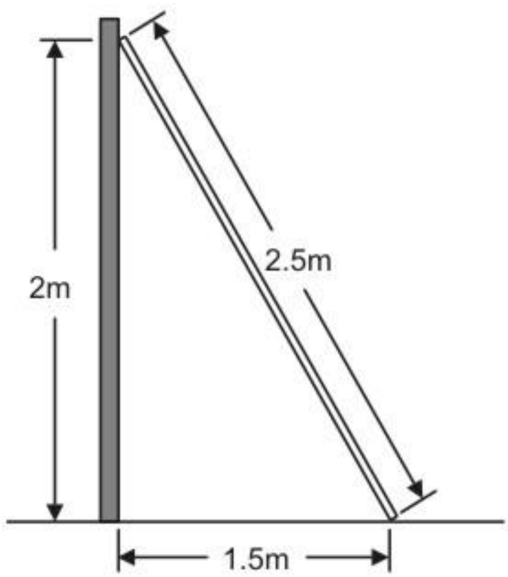
Poll Question



- A ladder leans against a wall.
- Let's choose the rotation axis to be at the bottom of the ladder.
- What is the **sign** of the torque of the normal force of the wall on the ladder, $N_{\mathrm{W\ on\ L}}$?

A. Positive

B. Negative

C. The torque is zero

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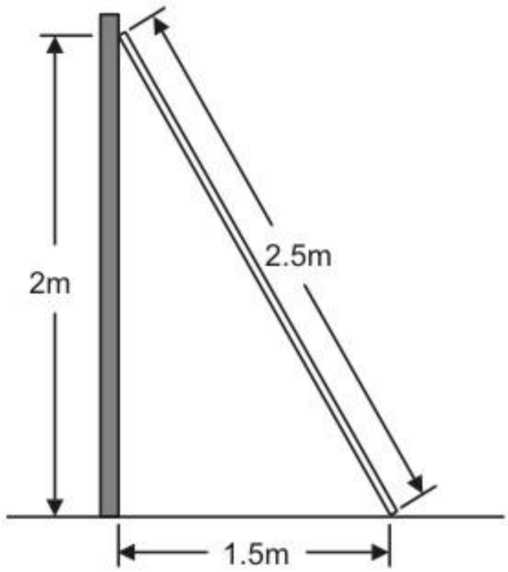
Poll Question



- A ladder leans against a wall.
- Let's choose the rotation axis to be at the bottom of the ladder.
- What is the **sign** of the torque of the static friction force of the floor on the ladder, $f_{s\ F\ on\ L}$?

A. Positive

B. Negative

C. The torque is zero

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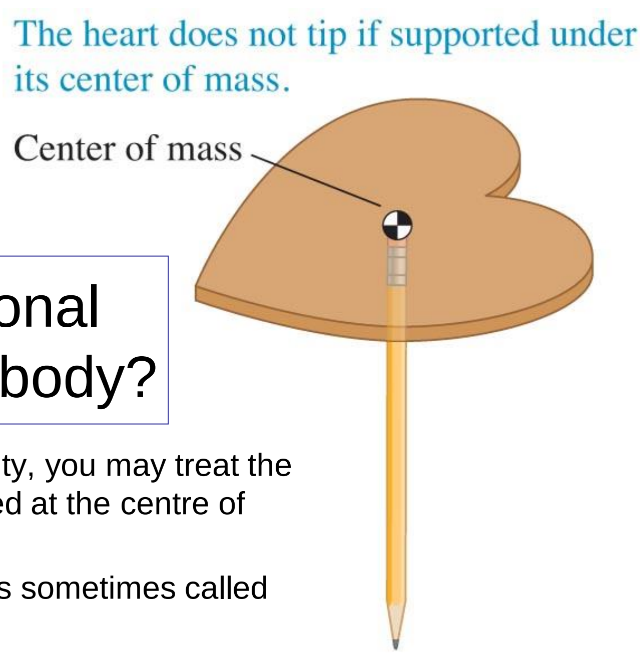
Where is the gravitational force exerted on a rigid body?



- When calculating the torque due to gravity, you may treat the object as if all its mass were concentrated at the centre of mass.
- That is why the object's center of mass is sometimes called the object's **centre of gravity.**

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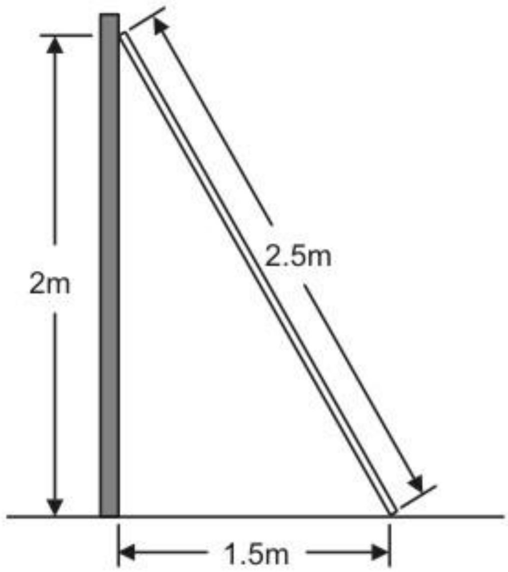
Poll Question



- A uniform ladder leans against a wall.
- Let's choose the rotation axis to be at the bottom of the ladder.
- What is the **sign** of the torque of the force of gravity of the Earth on the ladder, $F_{\text{g E on L}}$?

A. Positive

B. Negative

C. The torque is zero

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Trick: "Lever Arm"

$$\tau = \pm Fl \sin\theta$$

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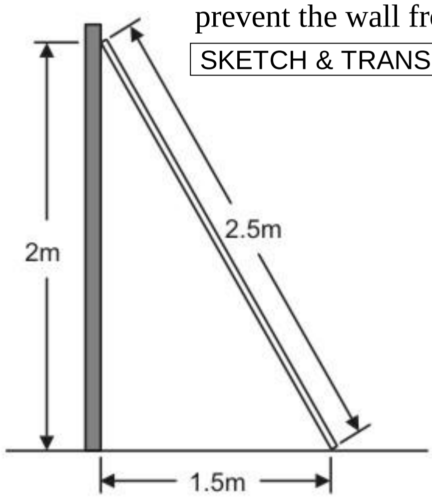
Example

A uniform ladder leans against a wall, as shown. The wall is frictionless. What is the minimum coefficient of static friction between the ladder and floor needed to prevent the wall from slipping?

SKETCH & TRANSLATE.



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SIMPLIFY & DIAGRAM

REPRESENT MATHEMATICALLY

SIMPLIFY & DIAGRAM

REPRESENT MATHEMATICALLY

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SOLVE & EVALUATE

Before Class 24 on Friday

- Please continue reading Chapter 8:
- 8.3 Static Equilibrium
- 8.4 Centre of Mass

- Plan to meet up with your Practical Pod during Friday's class – you should be able to turn on your microphone in order to participate in the TeamUp Quiz Module 4 Ch.8.
- If you cannot do the TeamUp quiz during class, it can be done either with your pod or on your own at any time over the weekend.