# Torque and rotational dynamics

Physics 211
Syracuse University, Physics 211 Spring 2022
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# Announcements

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- Homework 8 is due tomorrow in recitation (both the new problems and the exam re-do)
- Remember:
  - All of our homework is designed as an opportunity for you to *learn things*
  - If you're not able to finish understanding everything by the due date, should you:
    - **A:** Contact Walter and ask for an extension
    - **B:** Contact your TA and ask for an extension
    - **C:** Half-ass something and turn it in anyway; it's due when it's due
    - **D:** Copy someone else's solutions
  - **We want you to understand this material** – please ask questions here/on Discord/to your classmates/in the Clinic!

# Announcements

We will have one more homework assignment after this one.

It will be due on the last day of the semester, May 3. It will be somewhat long.

This Friday I will send out a poll about *missed exams* and other "behind on work" issues. Please make sure you answer it.

# Final exam conflicts

If your final exam for another class is scheduled at the same time as this one (economics, human sexuality):

- Take your final exam for your other class
- Take an hour for dinner
- Come to the Physics Clinic at 6pm for your physics exam

# Today's agenda

- Finish our discussion from before, talking about static equilibrium
- Talk about what is required for an object to balance on a surface
- Have the professor walk the plank, like the scurvy dog that he is (arr)

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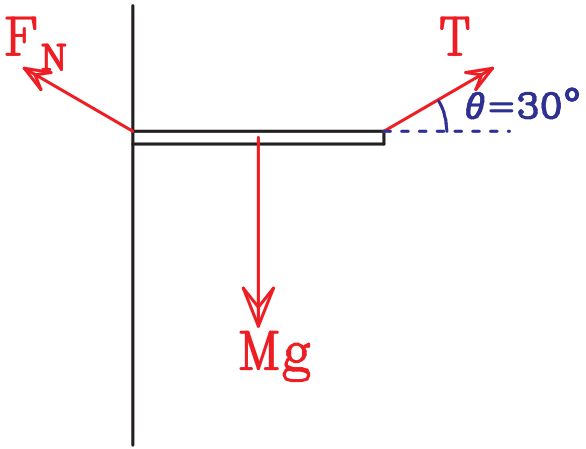
- Talk about rotational dynamics:
  - One problem where one object translates and another object rotates
  - One problem where one object both translates and rotates




How does the tension $T$ compare to the weight of the beam?

A: $T \leq Mg/2$

B: $Mg/2 < T < Mg$

C: $T = Mg$

D: $Mg < T < 2Mg$

E: $T >= 2Mg$

How will the required tension to support the beam change if I walk to the side? (See demo.)

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What force must the hinge apply to the beam?

Which will make the hanging object fall faster?

A: Increasing the diameter of the spool the string is wound around
B: Decreasing the diameter of the spool the string is wound around
C: Moving the spinning masses inward
D: Moving the spinning masses outward
E: None of the above; it falls at $g$ no matter what

# Solving problems with both translation and rotation

Recall how you solved problems back in Unit 2:

- Write down force diagrams for everything
- Construct $\sum \vec{F} = m\vec{a}$ for everything
- This will generate a system of equations
- Determine constraints (often the accelerations are related: $a_{1,y} = -a_{2,y}$, etc.
- Solve the system of equations

How does this change now?

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How does this change now?

- You also need $\sum \tau = I\alpha$ for objects that rotate
- This means you need extended force diagrams for them to determine $\sum \tau$
- Often now you will have different kinds of constraints: $a = \pm\alpha r$...
- If one object both translates and rotates (for instance, if it rolls), you need both $\sum \vec{F} = m\vec{a}$ and $\sum \tau = I\alpha$ for it

That's it!

# How fast will the hanging mass fall?

A string is wound around a light pulley at radius $r$. Two brass weights of mass $M$ are at either end of a bar attached to the pulley.

A mass $m$ hangs from the string. How fast does it fall?

# The Ping-Pong ball on a table

A Ping-Pong ball of mass $m$ rests on a table. The coefficient of static friction between the ball and the table is $\mu_s$.

(Since the ball is a hollow shell, its moment of inertia is $I = \frac{2}{3}mr^2$.)

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The wind starts to blow, exerting a force $F_w$ on the ball from one side, directed uniformly across the ball.

If the wind blows gently, the ball will roll without slipping. If the wind blows more strongly, the ball will begin to skid along the table.

What is the maximum value of $F_w$ so that the ball rolls without slipping?