Torque and rotational dynamics

Physics 211
Syracuse University, Physics 211 Spring 2019
Walter Freeman

April 17, 2019

Announcements

We are still grading Exam 3; we will get those back to you Friday.

Homework 8 is posted.

There will be a Homework 9, due to your TA's mailbox on the last day of class.

Office hours this week:

- Thursday, 1:45-3:45
- Friday, 9:30-11:30

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Going to miss recitation Friday for a religious holiday? Talk to your TA.

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 yesterday, 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

Undergraduate Colloquium

Breaking the Myth of the "Non-Traditional" Physicist:

The Real Story About Employment for Physics Graduates

Crystal Bailey

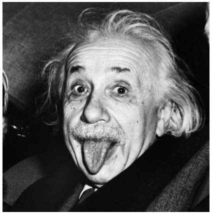
American Physical Society

Thurs, Apr. 18, 3:45 PM-4:45 PM

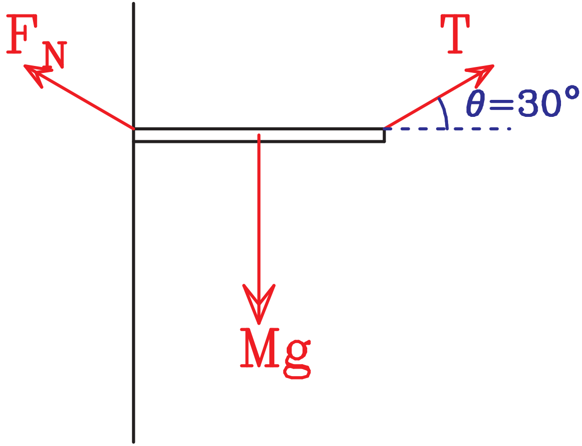
Refreshments at 3:30 PM

Room: 202/204 Physics Bldg.

All are welcome!



Crystal is a great speaker and will also be talking about how to get jobs as a technical person, whatever your degree is in!



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?

Balancing objects: will it topple?

If an object extends out past the end of a support like the table, how do you know if it will fall?

Suppose an object extends off the right side of the table.

- Choose the pivot point to be the right edge of the table
- Recall that normal forces can only push, never pull
- The torque from the table must be clockwise

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This suggests the following strategy to see if something will fall or not:

- Choose the pivot point at the right edge of the table
- Write down $\sum \tau = 0$, with τ_{table} as an unknown
- Solve for the necessary value of τ_{table} to keep the object in equilibrium ($\sigma\tau = 0$)
- If τ_{table} is clockwise, it can stay balanced; if τ_{table} is counterclockwise it must fall

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Another way to say this: *the object begins to fall when the sum of the torques around the edge, from everything other than the table, is zero.*

Walking the plank

How far out can I stand before I fall?

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

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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 μ_s.

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

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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?