Torque and rotational dynamics

Physics 211
Syracuse University, Physics 211 Spring 2022
Walter Freeman

April 17, 2023

Announcements

Homework 9 (last one of the class, other than the second-chance ones) will be posted this afternoon. It is due next Wednesday.

Announcements

Homework 9 (last one of the class, other than the second-chance ones) will be posted this afternoon. It is due next Wednesday.

Lots of tutorial opportunities this week to prepare for the final...

Email announcements today

I will send some important announcements today about end of term accommodations for people who need them.

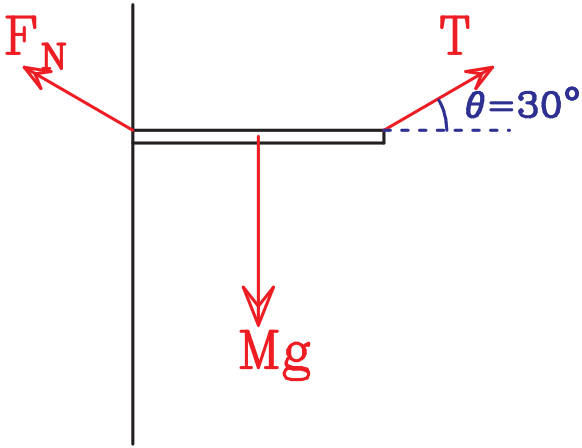
Today's agenda

- 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)

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)

- Talk about rotational dynamics:
  - One problem where one object both translates and rotates
  - One problem where two objects translate and another object 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.)

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

How will the required tension to support the beam change if I lift my hand? (See demo.)

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

How will the required tension to support the beam change if I lift my hand? (See demo.)

What force must the hinge apply to the beam?

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?

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?

- 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!

An example: a cat and some string

A cat knocks a cylindrical spool of thread off of a table while standing on the thread.

How fast does it accelerate downward?

The big example: the Atwood machine

This looks intimidating but it's not:

- Draw force diagrams for everything
- Choose coordinate systems
- $\vec{F} = m\vec{a}$ for everything that translates; $\tau = I\alpha$ for everything that rotates
- Use $a = \pm\alpha r$ constraint where appropriate, think about signs
- Solve the system of equations