# Rotational motion

Physics 211
Syracuse University, Physics 211 Spring 2015
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April 18, 2016

# Announcements

- Homework deadline extended until Friday
- I should be able to answer all your emails this afternoon
- After the retake, the average on Exam 2 was 70%

# Rotational motion, summarized

- Force diagrams: draw the entire object, and label at what point the forces act on them
- Choose a pivot (for rotating things, choose the rotation axis
- Newton's law for rotation: $\tau = I\alpha$
  - Applies separately for each rotating object
- Sometimes you will also need $\vec{F} = m\vec{a}$
- For static equilibrium problems: $\alpha = 0$

# Statics problems

- Often we know $\alpha = \vec{a} = 0$
- This tells us that the net torque (about *any* pivot) and the net force are both zero
- Usually this is because an object isn't moving, but sometimes it's moving at a constant rate (tomorrow's recitation problem)
- Plan of attack:
  - Compute the torque about any point and set it to zero
  - Choose a pivot conveniently at the location of a force we don't care about
  - If needed, also write $\sum \vec{F} = 0$

## When do objects balance?

- Remember normal forces can only push, never pull
- Think about what happens as something begins to tip
- As an object topples over, its entire weight rests on the corner of the surface...

# Statics problems: a sample

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- What if I hang weights from it?

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Which of these can drive up a snowy hill more easily?

Consider two gears: one with a radius r, one with a radius R, touching each other.

If they turn at constant angular velocity, and a torque $\tau_1$ is applied to gear 1, what torque can gear 2 apply to something else?

- How are their tangential velocities related?

# Rotational dynamics: gears

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- How does the power applied to each relate?

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- How are their tangential velocities related?
- How are their angular velocities related?
- How does the power applied to each relate?
- This problem is very similar to problem 6 on your homework!

# Rotational dynamics: how do gears work?

- Two touching gears or wheels apply the same force of static friction to each other
- Their tangential velocities are also the same
- If their radii are different, this allows you to trade angular velocity for torque

$$F_1 = F_2 \rightarrow \frac{\tau_1}{\tau_2} = \frac{r_1}{r_2}$$

$$v_{T,1} = v_{T,2} \rightarrow \omega_1 r_1 = \omega_2 r_2 \rightarrow \frac{\omega_1}{\omega_2} = \frac{r_2}{r_1}$$