Today's Topics: Rotational Motion & Energy

http://video.mit.edu/watch/mit-physics-demo-bicycle-wheel-gyroscope-3039/

Where are we?

Energy:
- Work
- Kinetic energy
- Gravitational potential energy
- Spring potential energy
- Rotational energy (today)

Descriptive Motion:
- Kinematics
- Centripetal
- Rotational Kinematics

We can describe:
- Static conditions (no motion)
- Linear Constant Motion
- Linear Changing Motion
- 2D motion (projectiles)
- 2D motion (rotation)

Still to come:

Multi-particle Systems: Collisions

Harmonic motion (oscillations)

Atomic level motion & changes

Fluids

Forces:
- Different types (gravity, tension, normal, spring, resistive)
- Free Body Diagrams
- Newton’s Laws
- Momentum Principle
- Stress/Strain

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~~Fluids~~

Result – Schedule will Change

- http://www.pa.msu.edu/people/vashtis/Teaching/fl2014/LB%20273%20Calendar,%20Fall%202014.html#october
- Chapter 12 reading questions due next THURSDAY 11/6
- Homework on rotational motion due on MONDAY 11/3 (sections 8.3/9.5)
- Homework on Collisions (Ch11) spread out over Friday 11/7 & Friday 11/14
- Exam 3 will be over Ch 10 - 14

How do you feel about this proposal?

A. Thank goodness! I was feeling overwhelmed!!
B. It’s OK – I see the reasoning
C. Blah – whatever
D. No!!!!
E. Wait, I still don’t understand

We’re doing it.

What we have so far

Linear Motion

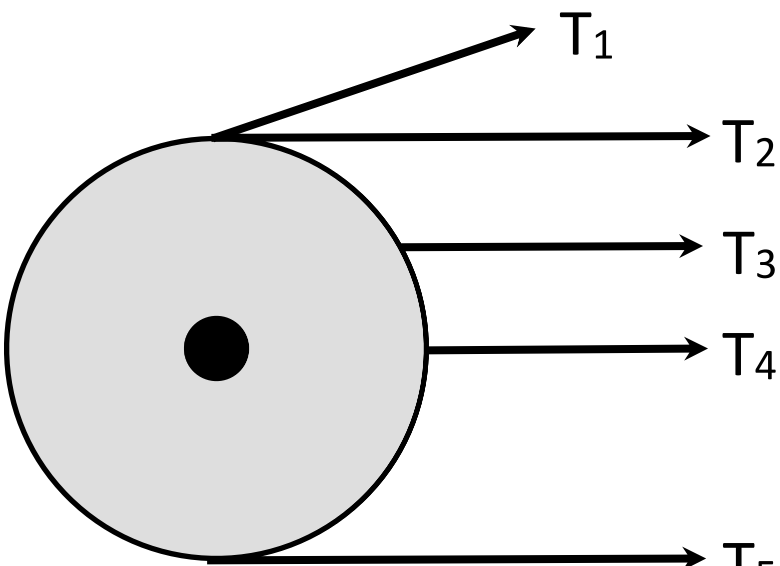
- $v_f = v_0 + at$
- $\Delta x = v_0 t + ½ at^2$
- $v_f^2 = v_0^2 + 2a \Delta x$

- $\vec{F}_{net} = m\vec{a}$
- $\vec{p} = m\vec{v}$
- $KE_{linear} = ½ mv^2$

Angular Motion

- $\omega_f = \omega_0 + \alpha t$
- $\Delta\theta = \omega_0 t + ½\alpha t^2$
- $\omega_f^2 = \omega_0^2 + 2\alpha\Delta\theta$

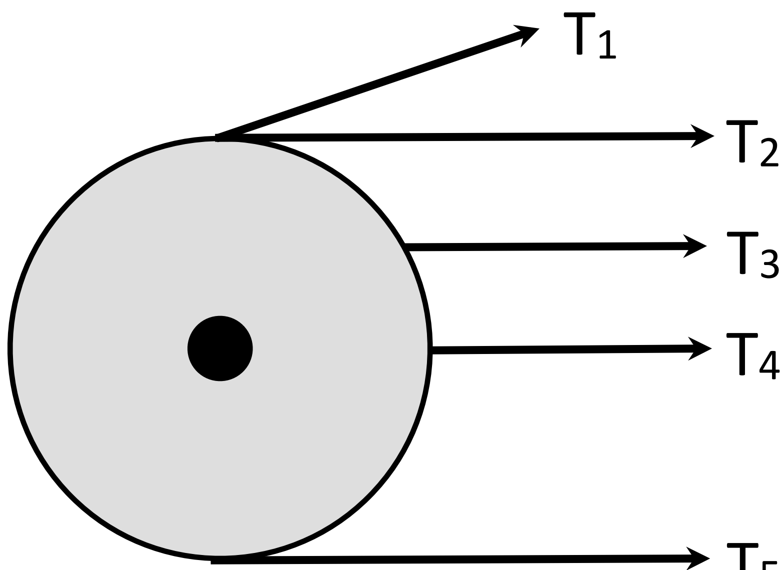
- $\tau_{net} = I\alpha$
- $L = I\omega$
- $KE_{rot} = ½ I\omega^2$



A solid disk is mounted on an axis, as shown, and is initially at rest. The same force is applied along five different pieces of rope, as shown.

Which rope exerts the **smallest** torque on the disk?

A. T_1
B. T_2
C. T_3
D. T_4
E. T_5



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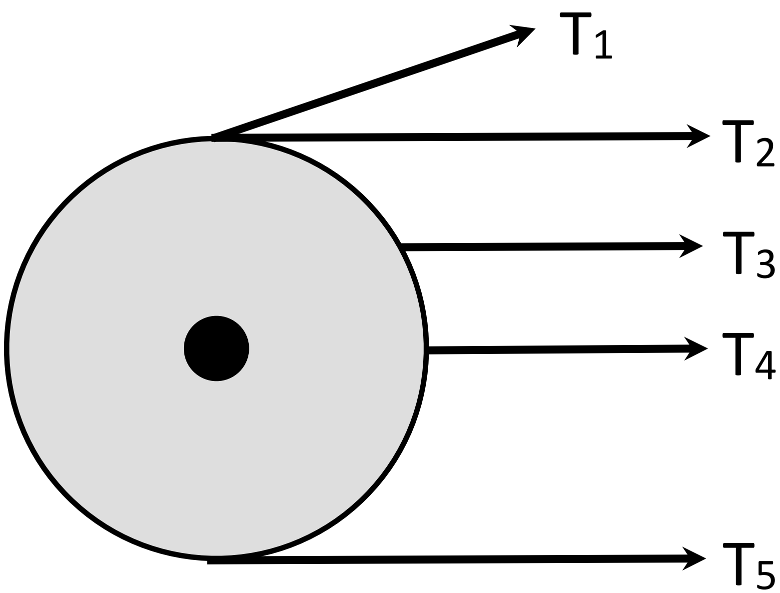
D. T_4
E. T_5

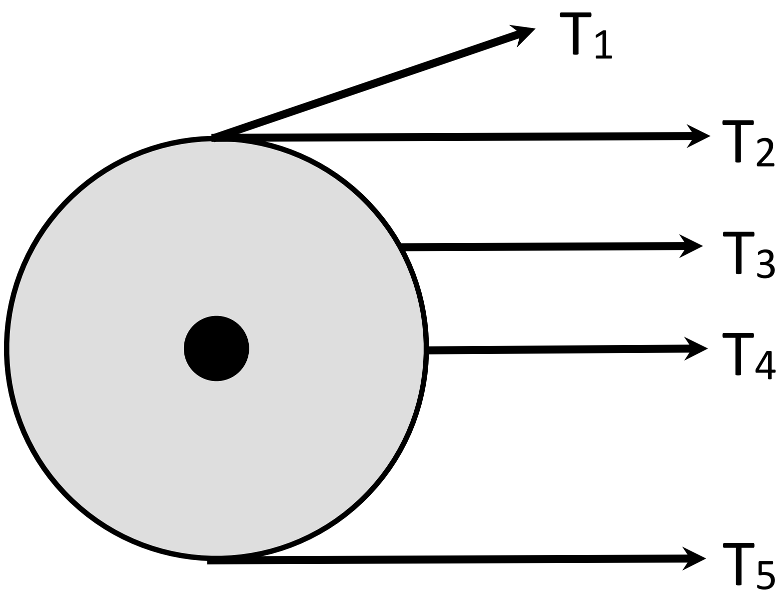
This torque is not perpendicular to the moment-arm, so the torque will be 0.



A solid disk is mounted on an axis, as shown, and is initially at rest. The <u>same force</u> is applied along five different pieces of rope, as shown.

Compare the magnitudes of T_1 and T_2.

A. $|T_1| > |T_2|$
B. $|T_1| < |T_2|$
C. $|T_1| = |T_2|$
D. None of the above



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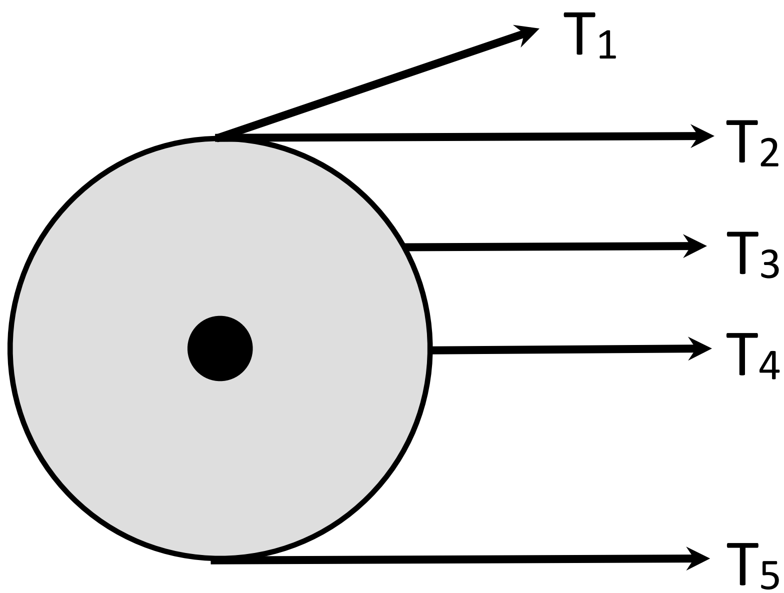
C. $|T_1| = |T_2|$
D. None of the above

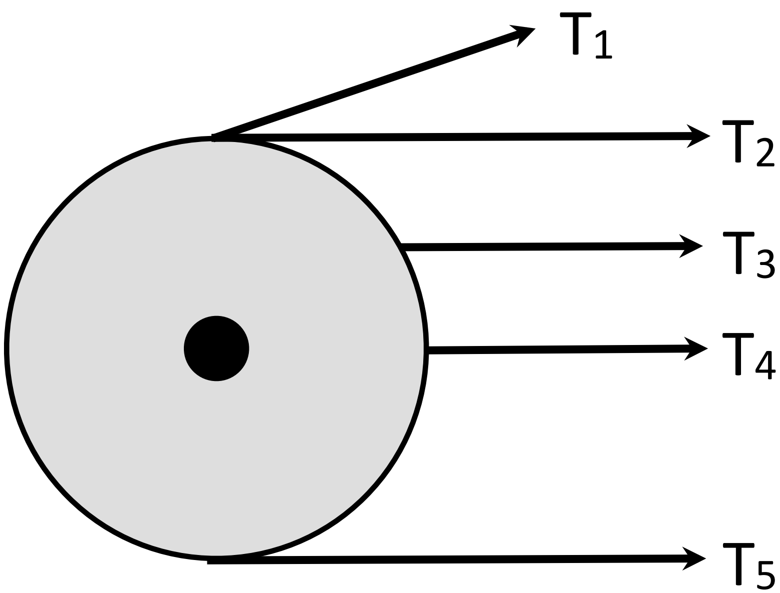
Only a piece of T_1 contributes to the torque whereas all of T_2 contributes. So $T_1 < T_2$



A solid disk is mounted on an axis, as shown, and is initially at rest. The same force is applied along five different pieces of rope, as shown.

Compare the magnitudes of T_2 and T_5.

A. $|T_2| > |T_5|$
B. $|T_2| < |T_5|$
C. $|T_2| = |T_5|$
D. None of the above



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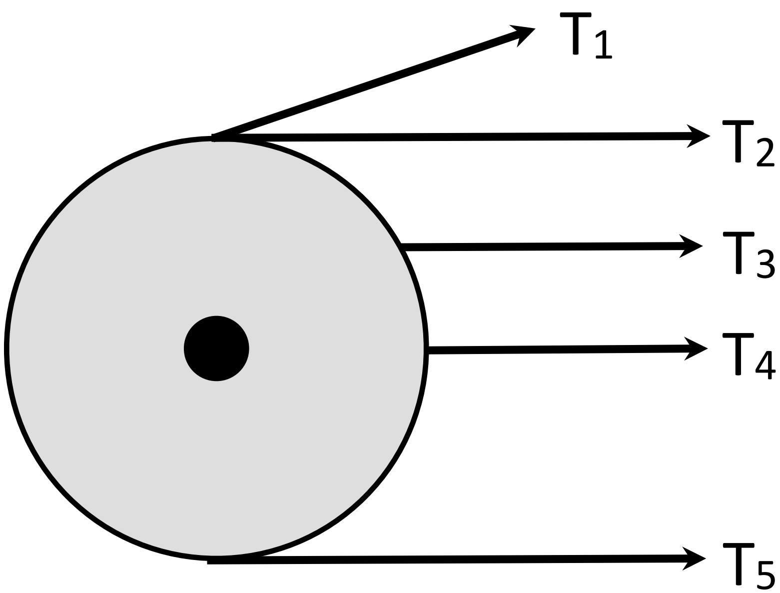
D. None of the ab

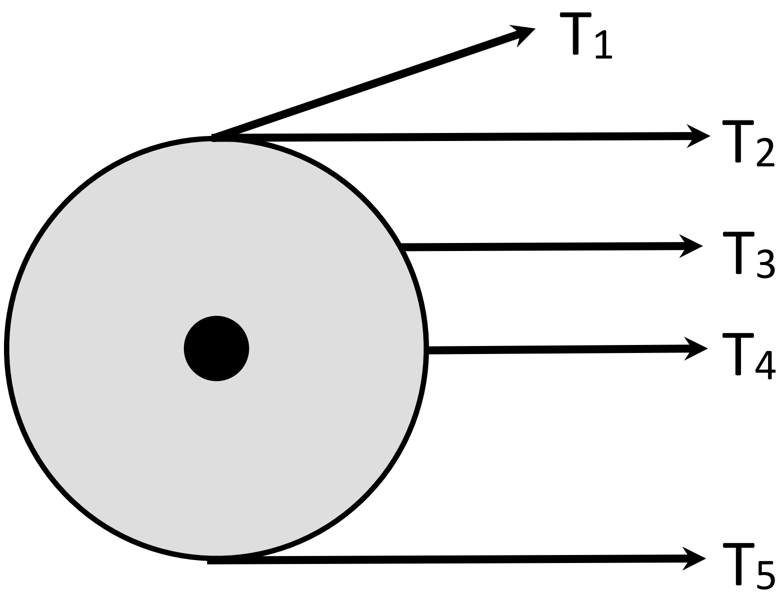
Both are equal in how much of the force is perpendicular to the momentum arm, so while the directions are different, the magnitudes are the same.



A solid disk is mounted on an axis, as shown, and is initially at rest. The same force is applied along five different pieces of rope, as shown.

If T_5 is the one that is actually used, what direction does the torque point?

A. Into the screen
B. Out of the screen
C. Neither



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B. Out of the screen
C. Neither

Point your figures in the direction of the torque, and curl them in the direction of the rotation -> your thumb will point in the direction of the torque.

Angular Momentum

- Angular momentum (L) is really telling us about how something will rotate when the momentum is not AT the center of mass
  - (Demo with ball catching)

$$\vec{\mathbf{L}} = \vec{\mathbf{r}} \times \vec{\mathbf{p}}$$

- However, a convenient way of expressing this is in parallel to linear momentum

$$L = I\omega$$

Think of a person holding a dumbbell in each hand, with their hands in front of their chest, rotating around on a stool. When they move their arms outward horizontally from their chest, what happens to their moment of inertia?

A. Gets larger
B. Gets smaller
C. Stays the same

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The mass stays the same, but the radius gets bigger so the moment of inertia gets bigger.

Think of a person holding a dumbbell in each hand, with their hands in front of their chest, rotating around on a stool. When they move their arms outward horizontally from their chest (with no **external** forces acting on them) what happens to their **total angular momentum**?

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B. Gets smaller
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There are no external forces acting on the system, therefore the momentum CANNOT change.

Think of a person holding a dumbbell in each hand, with their hands in front of their chest, rotating around on a stool. When they move their arms outward horizontally from their chest (with no **external** forces acting on them) what happens to their **rate of rotation**?

A. Gets larger
B. Gets smaller
C. Stays same

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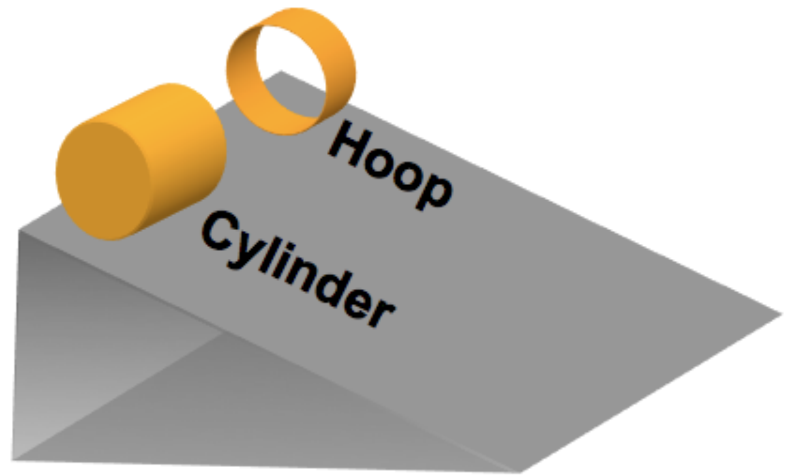
If the momentum (L) stays the same, but the moment of inertia (I) gets bigger, then the angular velocity (ω) must get smaller.

Angular Energy

- Kinetic energy is energy stored in motion; things that rotate have two kinds of motion
  - Linear $KE_{Linear} = \frac{1}{2} mv^2$
  - Rotation $KE_{rot} = \frac{1}{2} I\omega^2$

$$KE_{tot} = \frac{1}{2} I\omega^2 + \frac{1}{2} mv^2$$

Two objects, a cylinder and a hoop, roll down without slipping from the top of a frictional ramp at the same time. They are made of different materials, but have the same mass and radius. Which has the largest change in gravitational potential energy?



A. Cylinder
B. Hoop
C. Both have the same change in gravitational potential energy
D. Not enough information to determine

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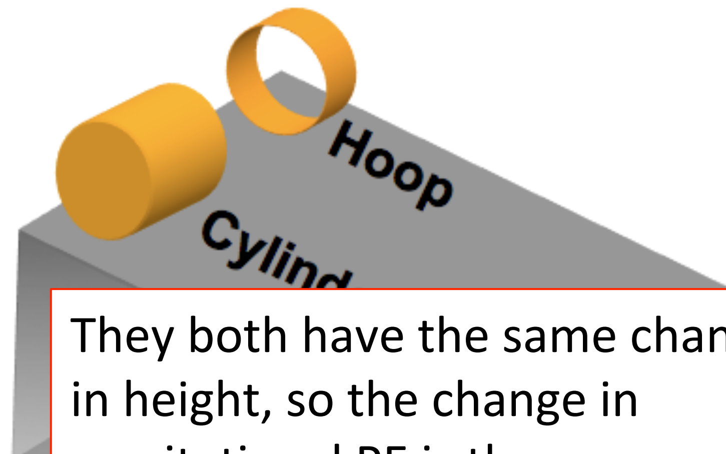

They both have the same change in height, so the change in gravitational PE is the same.

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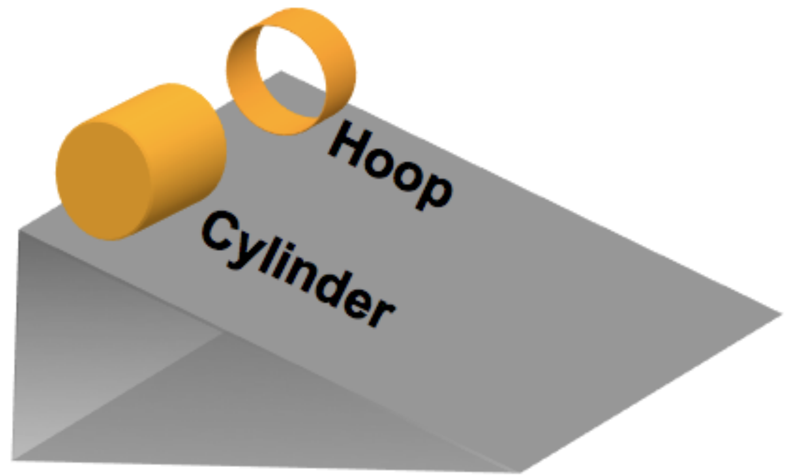

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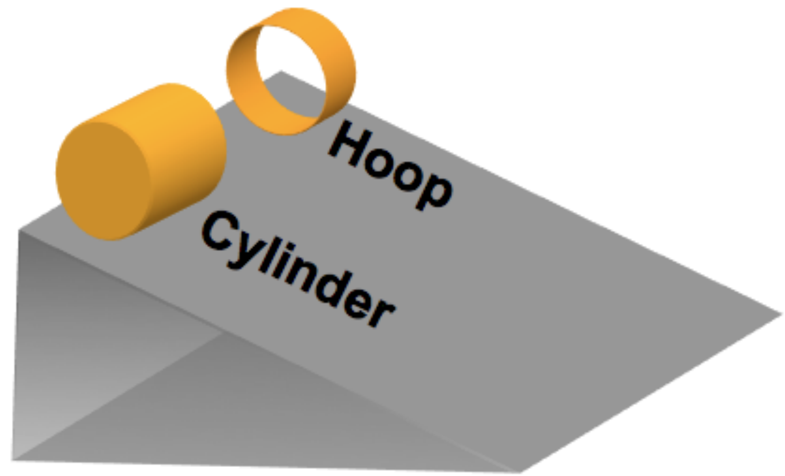
All of the gravitational energy must go to kinetic energy (as long as the friction is low enough to keep them rolling without slipping) so the change in kinetic energy is the same. (NOTE: the change in ROTATIONAL kinetic energy is not the same.)



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