UEQ #1: How can the rotational motion be described in a measurable and quantitative way?

Unit 8
Rotational Motion

UEQ: How can rotational motion be described, measured, and quantified?

VOCABULARY

- Radians
- Angular Displacement
- Angular Velocity
- Angular Acceleration
- Frequency
- Period
- Axis of Rotation
- Moment Arm
- Torque
- Right-Hand Rule
- Static Equilibrium
- Cantilever
- Stable Equilibrium
- Unstable Equilibrium
- Neutral Equilibrium
- Moment of Inertia
- Rotational Inertia
- Rotational Kinetic Energy
- Angular Momentum

UEQ(s): †How can rotational motion be described in a measurable and quantitative way?; †What factors affect changes in an object's rotational motion?; †How does an object's mass distribution, interaction with other objects, and force at a distance influence the object's motion?

LESSON 7

Conservation of Angular Momentum

Rotational Motion: Conservation of Angular Momentum

EQ(s): How can rotational inertia and angular velocity of an object be represented in terms of it angular momentum and kinetic energy?

Start: What happens if you sit on rotating seat and turn a spinning bicycle tire?

How can rotational inertia and angular velocity of an object be represented in terms of it angular momentum and kinetic energy?

8-8 Angular Momentum and Its Conservation

In analogy with linear momentum, we can define angular momentum L:

$$L = I\omega \qquad (8\text{-}18)$$

We can then write the total torque as being the rate of change of angular momentum.

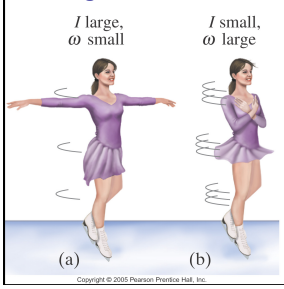
If the net torque on an object is zero, the total angular momentum is constant.

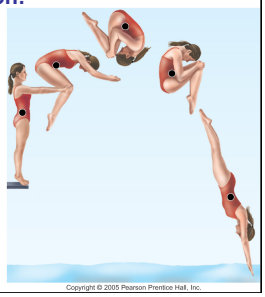
$$I\omega = I_0\omega_0 = \text{constant}$$

How can rotational inertia and angular velocity of an object be represented in terms of it angular momentum and kinetic energy?

8-8 Angular Momentum and Its Conservation

Therefore, systems that can change their rotational inertia through internal forces will also change their rate of rotation:

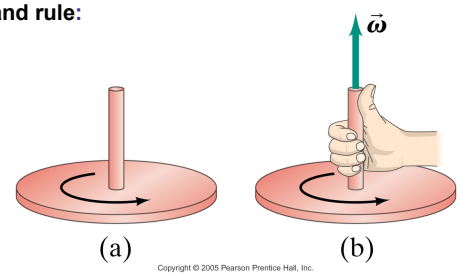




How can rotational inertia and angular velocity of an object be represented in terms of it angular momentum and kinetic energy?

8-9 Vector Nature of Angular Quantities

The angular velocity vector points along the axis of rotation; its direction is found using a right hand rule:



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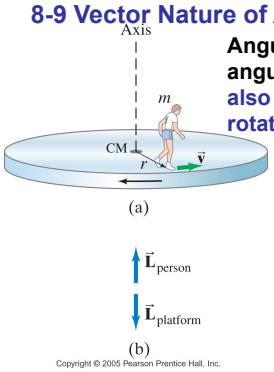
8-9 Vector Nature of Angular Quantities

Angular acceleration and angular momentum vectors also point along the axis of rotation.



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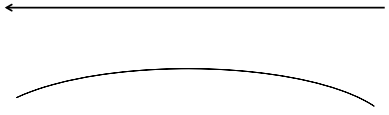
THOUGHT QUESTION

Can an object that is traveling in a straight line have an angular momentum?



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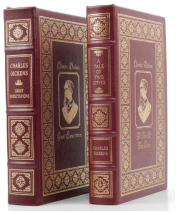
Reading Enrichment



- The Physics of Ice Skating
  - https://www.real-world-physics-problems.com/physics-of-ice-skating.html
- Olympic Physics: The Discus
  - https://news.ncsu.edu/2012/07/olympic-physics-the-discus/
- Trebuchet Physics
  - https://www.real-world-physics-problems.com/trebuchet-physics.html
- Arms and Men: The Trebuchet
  - http://www.historynet.com/weaponry-the-trebuchet.htm

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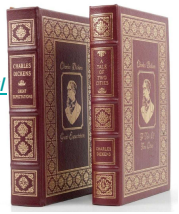

- The Rise and Fall of Artificial Gravity
  - http://www.bbc.com/future/story/20130121-worth-the-weight
- Artificial Gravity Future Plans for ISS
  - https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20150009516.pdf
- International Space Station: Facts, History, & Tracking
  - https://www.space.com/16748-international-space-station.html

How can rotational inertia and angular velocity of an object be represented in terms of its angular momentum and kinetic energy?

2x4 Derby Competition

- Important Criteria:
  - Bearings are NOT Allowed
  - Maximum Mass: 1050 g
  - Maximum L x W x H Dimensions: 12″ x 8″ x 8″ (20.35 cm x 15.25 cm x 7.65 cm)
  - The Wheels must be altered from their original design to increase the angular acceleration (and to beat Mr. Roe's modified car).
- You are allowed to modify the wheels, axles, and body. In fact, it is expected!
- SAFETY: Goggles must be worn!

How can rotational inertia and angular velocity of an object be represented in terms of its angular momentum and kinetic energy?

2x4 DERBY REPORT

- *One Report for each group of no more than 4 people.
- Refer to the Laboratory Report Expectations Handout.

UEQ(s): †How can rotational motion be described in a measurable and quantitative way?; †What factors affect changes in an object's rotational motion?; †How does an object's mass distribution, interaction with other objects, and force at a distance influence the object's motion?

2x4 Derby RACE DAY

- Competition Grading Criteria:
  - Passing Score (70%): Your car must beat Mr. Roe's unmodified car's time
  - A (93% – 100%): Your Wheels must be altered from their original design to increase the angular acceleration (and it must beat Mr. Roe's modified car's time).
- Report Grading Criteria:
  - Refer to the Handout for the Facets of Understanding Criteria
- SAFETY: Goggles must be worn!

How can rotational inertia and angular velocity of an object be represented in terms of its angular momentum and kinetic energy?

WebAssign/Lab Time

- Work on WebAssign PIM Ch.08G – Angular Momentum Problems or the 2x4 Derby Lab Report
- Final Copy Criteria
  - State the problem (Ex. Find displacement)
  - Draw a picture/diagram
  - Provide a list or table of all given data (Ex. $\Delta t = 2$ s)
  - Solve the problem symbolically (Ex. $v=\Delta x/\Delta t \rightarrow \Delta x = v\Delta t$)
  - Plug in numbers and units to obtain answer. (Ex. $\Delta x = (5 \text{ m/s})(2 \text{ s}) = 10 \text{ m}$)
- Notes about WebAssign:
  - Positive vs. negative answers (Try a negative sign)
  - Look at the final unit (hours or minutes or seconds)

How can rotational inertia and angular velocity of an object be represented in terms of its angular momentum and kinetic energy?

Summary

- Answer the Essential Questions.
- Ticket out the Door:
  - What happens to a skater's angular velocity if she pulls her arms in?
  - What happens to a skater's angular velocity if she extends her arms?
  - Draw a picture of a skater pulling her arms in and then extending them so they follow a straight line.

INSERT PICTURE OF SKATER PULLING HER ARMS IN

- HW:
  - WebAssign PIM Ch.08G – Angular Momentum Problems
  - 2x4 Derby Lab Report (Questions and Conclusions)

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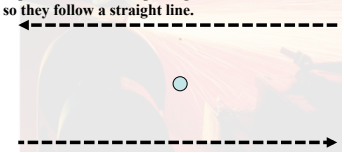

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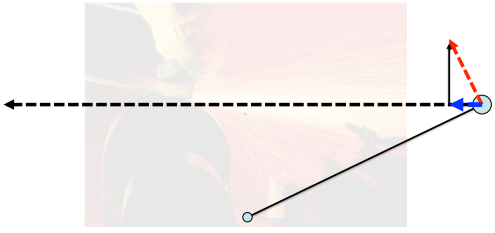

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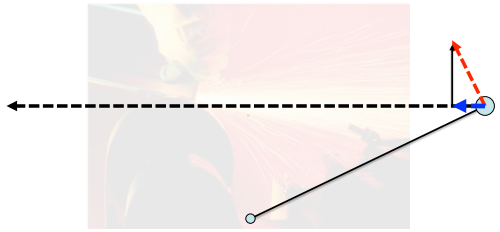

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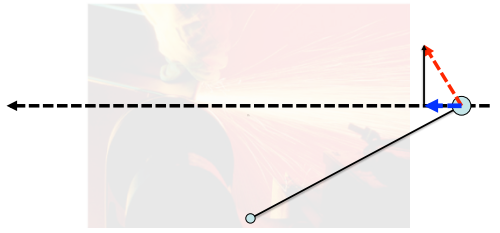

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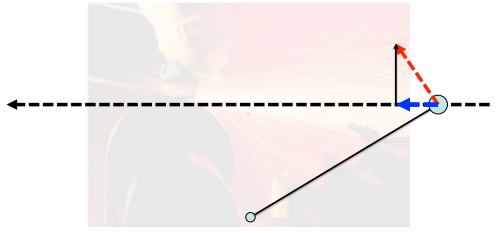

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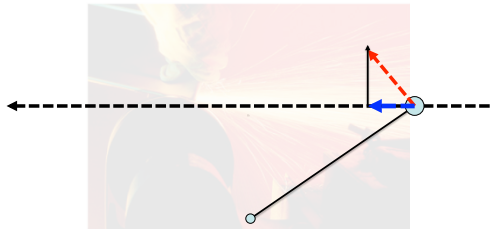

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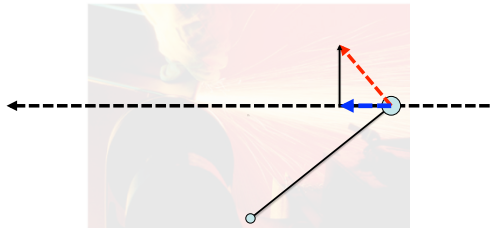

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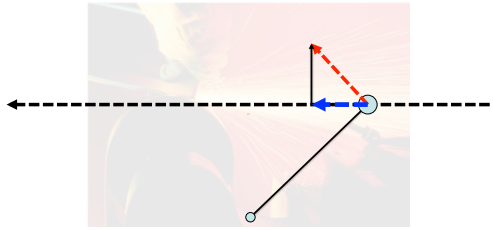

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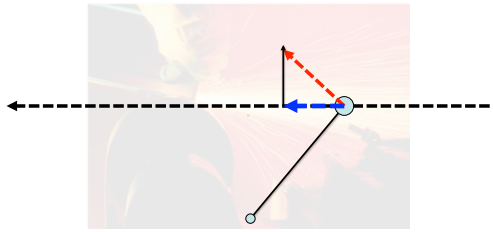

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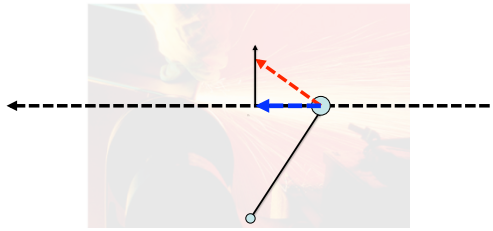

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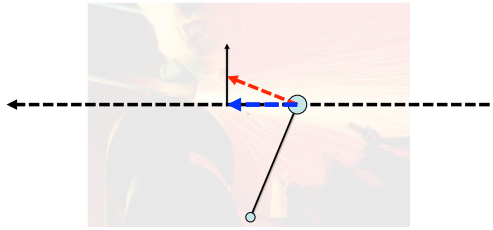

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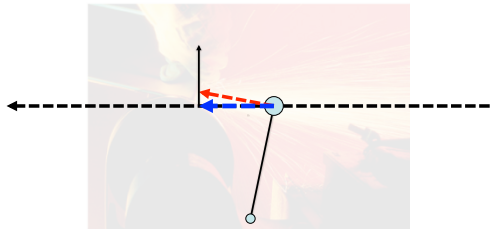

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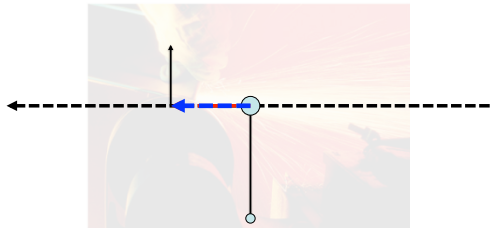

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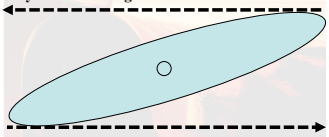
- **Draw a picture of a skater pulling her arms in and then extending them so they follow a straight line.**

Next Slide: Animation



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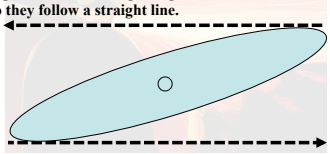

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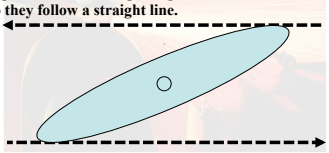

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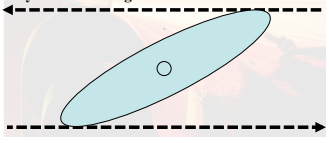

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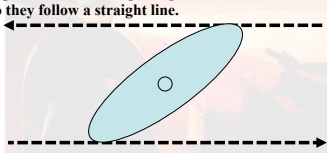

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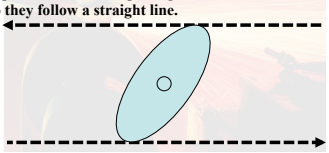

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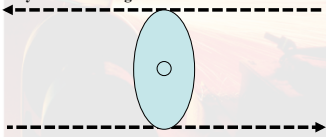

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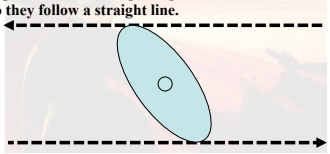

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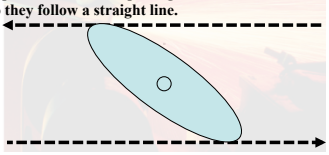

UEQ(s): †How can rotational motion be described in a measurable and quantitative way?; †What factors affect changes in an object's rotational motion?; †How does an object's mass distribution, interaction with other objects, and force at a distance influence the object's motion?

REVIEW OF THOUGHT QUESTION

Yesterday's TOTD:

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- What happens to a skater's angular velocity if she extends her arms?
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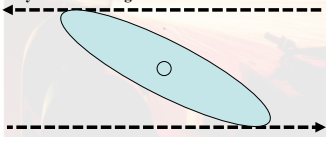

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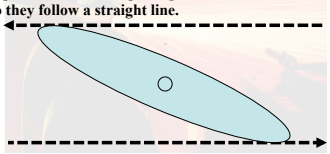

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