Bumper Cars

Introductory Question

- You are riding on the edge of a spinning playground merry-go-round. If you pull yourself to the center of the merry-go-round, what will happen to its rotation?

A. It will spin faster.
B. It will spin slower.
C. It will spin at the same rate.

Observations about Bumper Cars

- Moving cars tend to stay moving
- Changing a car's motion takes time
- Impacts alter velocities and angular velocities
- Cars often appear to exchange their motions
- The fullest cars are the hardest to redirect
- The least-full cars get slammed during collisions

3 Questions about Bumper Cars

- Does a moving bumper car carry a "force"?
- Does a spinning bumper car carry a "torque"?
- On an uneven floor, which way does a bumper car accelerate?

Question 1

- Does a moving bumper car carry a "force"?
- Starting and stopping a bumper car seems to require the "investment" and "withdrawal" of some directed quantity of motion. What is it?

Momentum

- A translating bumper car carries momentum
- Momentum
  - is a conserved quantity (can't create or destroy)
  - is a directed (vector) quantity
  - measures the translational investment the object needed to reach its present velocity

$$\text{momentum} = \text{mass} \cdot \text{velocity}$$

Exchanging Momentum

- Bumper cars exchange momentum via impulses
- An impulse is
  - the only way to transfer momentum
  - a directed (vector) quantity

impulse = force · time

- When car_1 gives an impulse to car_2, car_2 gives an equal but oppositely directed impulse to car_1.

Head-On Collisions

- Bumper cars exchange momentum via impulses
- The total momentum never changes
- Car with the least mass changes velocity most
- The littlest riders get creamed

Clicker Question

- You pound on a nail with two different mallets, one softer than the other. Their masses are equal and you swing them equally fast. Compared to the harder mallet, the momentum transferred by the softer mallet to the nail is

A. the same and it exerts the same force.
B. the same, but it exerts a smaller force.
C. less, but it exerts the same force.
D. less and it exerts a smaller force.

Question 2

- Does a spinning bumper car carry a “torque”?
- Spinning and un-spinning a bumper car seems to require the “investment” and “withdrawal” of some directed quantity of rotational motion. What is it?

Angular Momentum

- A spinning car carries angular momentum
- Angular momentum
  - is a conserved quantity (can’t create or destroy)
  - is a directed (vector) quantity
  - measures the rotational investment the object needed to reach its present angular velocity

angular momentum = rotational mass· angular velocity

Newton’s Third Law of Rotational Motion

- For every torque that one object exerts on a second object, there is an equal but oppositely directed torque that the second object exerts on the first object.

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Exchanging Angular Momentum

- Bumper cars exchange angular momentum via angular impulses
- An angular impulse is
  - the only way to transfer angular momentum
  - a directed (vector) quantity

    angular impulse = torque· time
- When car_1 gives an angular impulse to car_2, car_2 gives an equal but oppositely directed angular impulse to car_1.

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Glancing Collisions

- Bumper cars exchange angular momentum via angular impulses
- Total angular momentum about a specific inertial point in space remains unchanged
- Bumper car with the smallest rotational mass about that point changes angular velocity most
- The littlest riders tend to get spun wildly

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Rotational Mass can Change

- Mass can't change, so the only way an object's velocity can change is if its momentum changes
- Rotational mass can change, so an object that changes shape can change its angular velocity without changing its angular momentum

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Introductory Question (revisited)

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A. It will spin faster.
B. It will spin slower.
C. It will spin at the same rate.

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Question 3

- On an uneven floor, which way does a bumper car accelerate?

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Potential Energy, Acceleration, and Force

- An object accelerates in the direction that reduces its total potential energy as rapidly as possible
- Forces and potential energies are related!
- A car on an uneven floor accelerates in whatever direction reduces its total potential energy as rapidly as possible

Summary about Bumper Cars

- During collisions, bumper cars exchange
  - momentum via impulses
  - angular momentum via angular impulses
- Collisions have less effect on
  - cars with large masses
  - cars with large rotational masses