Bumper Cars

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?

1. It will spin faster.
2. It will spin slower.
3. It will spin at the same rate.

Observations About Bumper Cars

- Moving or spinning cars tend to keep doing so
- It takes time to change a car's motion
- Impacts change velocities & ang. velocities
- Cars often seem to exchange their motions
- Heavily loaded cars are hardest to redirect
- Heavily loaded cars pack the most wallop

Momentum

- A translating bumper car carries momentum
- Momentum
  - A conserved quantity (can't create or destroy)
  - A directed (vector) quantity
  - Measures difficulty reaching velocity

Momentum = Mass · Velocity

Exchanging Momentum

- Impulse
  - The only way to transfer momentum
  - Impulse = Force · Time
  - Impulse is a directed (vector) quantity
- Because of Newton's third law:
  An impulse of one object on a second is accompanied by an equal but oppositely directed impulse of the second on the first.

Head-On Collisions

- Cars exchange momentum via impulse
- Total momentum remains unchanged
- The least-massive car experiences largest change in velocity

Angular Momentum

- A spinning car carries angular momentum
- Angular momentum
  - A conserved quantity (can't create or destroy)
  - A directed (vector) quantity
  - Measures difficulty reaching angular velocity

Angular momentum = Moment of inertia · 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.

Exchanging Angular Momentum

- Angular Impulse
  - The only way to transfer angular momentum
  - Angular impulse = Torque · Time
  - Angular impulse is a directed (vector) quantity
- Because of Newton's third law of rotation: An angular impulse of one object on a second is accompanied by an equal but oppositely directed angular impulse of the second on the first.

Glancing Collisions

- Cars exchange angular momentum via angular impulse
- Total angular momentum about a chosen point in space remains unchanged
- The car with smallest moment of inertia about that chosen point experiences largest change in angular velocity

Changing Moment of Inertia

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

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Kinetic Energy

- A moving bumper car has kinetic energy:
  Kinetic energy = ½ · Mass · $Speed^2$
- A spinning bumper car has kinetic energy:
  Kinetic energy = ½ · Moment of inertia · Angular $speed^2$
- Overall, a bumper can can have both
- Colliding at high speeds releases lots of energy!

Physics Concept

- Acceleration always occurs toward the direction that reduces an object’s potential energy as rapidly as possible.