Bumper Cars

Turn off all electronic devices

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

5 Questions about Bumper Cars

1. Does a moving bumper car carry a force?
2. How is momentum transferred from one bumper car to another?
3. Does a spinning bumper car carry a torque?
4. How is angular momentum transferred from one bumper car to another?
5. How does a bumper car move on an uneven floor?

Question 1

Q: Does a moving bumper car carry a force?

A: No, the bumper car carries momentum.

Momentum is a conserved vector quantity

- cannot be created or destroyed, but it can be transferred
- has a direction (unlike energy)
- has no potential form and cannot be hidden (unlike energy)
- combines bumper car's inertia and velocity

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

Question 2

Q: How is momentum transferred from one bumper car to another?

A: The bumper cars push on one another for a period of time.

Bumper cars exchange momentum via impulses

$$\text{impulse} = \text{force} \cdot \text{time}$$

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

- Individual momenta change as the result of an impulse
- The total momentum doesn't change
- Car with least mass changes velocity most, so the littlest riders get pounded

Question 3

Q: Does a spinning bumper car carry a torque?

A: No, the bumper car carries angular momentum

Angular momentum is a conserved vector quantity

- cannot be created or destroyed, but it can be transferred
- has a direction (unlike energy)
- has no potential form and cannot be hidden (unlike energy)
- combines bumper car's rotational inertia and velocity

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

Question 4

Q: How is angular momentum transferred from one bumper car to another?

A: The bumper cars twist one another for a period of time.

Bumper cars exchange angular momentum via angular impulses

$$\text{angular impulse} = \text{torque} \cdot \text{time}$$

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

- Individual angular momenta change as the result of an angular impulse
- The total angular momentum doesn't change
- Car with least rotational mass changes angular velocity most.

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

Question 5

Q: How does a bumper car move on an uneven floor?

A: It accelerates in the direction that reduces its potential energy as quickly as possible

- Forces and potential energies are related!
  - A bumper car accelerates in the direction that reduces its total potential energy as quickly as possible
  - The bumper car accelerates opposite to the potential energy gradient
  - On an uneven floor, that is down the steepest slope

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