Bumper Cars

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

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

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

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

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.

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.

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

Bumper Cars 13

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

Bumper Cars 14

Question 3

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

Bumper Cars 15

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

Bumper Cars 16

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