Ball Sports: Bouncing

Turn off all electronic devices

Observations about Bouncing Balls

- Some balls bounce better than others
- Dropped balls don't rebound to their full height
- Balls bounce differently from different surfaces
- Balls bounce differently from moving objects

4 Questions about Bouncing Balls

1. Why doesn't a ball rebound to its original height?
2. Why does the floor's surface affect the bounce?
3. How does a moving bat drive a ball forward?
4. What happens to the bat when a ball hits it?

Question 1

Q: Why doesn't a ball rebound to its original height?

A: It wastes some of its energy during the bounce

- While slowing as it hits a rigid floor, a ball's
  - kinetic energy decreases by the collision energy
  - elastic potential energy increases as it dents
- While rebounding from the floor, the ball's
  - elastic potential energy decreases as it undents
  - kinetic energy increases by the rebound energy
- Not all collision energy becomes rebound energy

Measuring a Ball's Liveliness

- Two common measures of a ball's liveliness:

$$\text{coefficient of restitution} = \frac{\text{rebound speed}}{\text{collision speed}}$$

$$\text{energy ratio} = \frac{\text{rebound energy}}{\text{collision energy}}$$

- Since kinetic energy is proportional to speed^2,

$$\text{energy ratio} = \text{coefficient of restitution}^2$$

Question 2

Q: Why does the floor's surface affect the bounce?

A: If the floor dents, it also receives collision energy

- The denting floor stores and returns energy
  - Floor also has an energy ratio that affects the bounce
- Impact forces on ball & floor: equal but opposite,
  - so work done on each is proportional to its dent
  - fraction of collision energy is proportional to its dent
- A soft, lively floor can help the ball bounce!

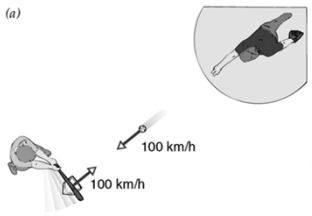
Question 3

Q: How does a moving bat drive a ball forward?
A: Ball bounces off bat, in bat's frame of reference

- When bat and ball are moving toward one another
  - Collision speed is their speed of approach
  - Rebound speed is their speed of separation
- In the bat's inertial frame of reference,
  - perspective in which bat's center of mass is motionless,
  - the ball simply bounces off the bat

Ball and Bat (Part 1)

- Ball heads toward home plate at 100 km/h
- Bat heads toward pitcher at 100 km/h
- Collision speed is 200 km/h

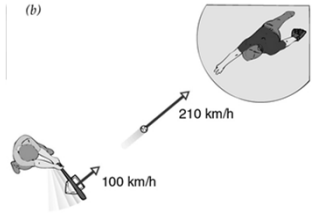


Ball and Bat (Part 2)

- Collision speed is 200 km/h
- Baseball's coefficient of restitution: 0.55
- Rebound speed is 110 km/h

Ball and Bat (Part 3)

- Rebound speed is 110 km/h
- Bat heads toward pitcher at 100 km/h
- Ball heads toward pitcher at 210 km/h



Question 4

Q: What happens to the bat when a ball hits it?
A: It accelerates, angular accelerates, and vibrates

- The ball's impact force on the bat
  - transfers momentum and angular mom to the bat
  - can deform the bat, causing it to vibrate
  - increases with the stiffnesses of the bat and ball
  - lasts longer when the bat and ball are livelier

Summary about Bouncing Balls

- Each ball has a coefficient of restitution
- Energy lost in a bounce becomes thermal
- The bouncing surface can affect a ball's bounce
- Surfaces bounce, too