Bouncing Balls

Question:

- If you place a tennis ball on a basketball and drop this stack on the ground, how high will the tennis ball bounce?

- To approximately its original height.
- Much higher than its original height.
- Much less than its original height.

Observations About Bouncing Balls

- Some balls bounce better than others
- Underinflated balls bounce poorly
- Balls don't bounce higher than they started
- Ball can bounce from moving objects

Bouncing from Rigid, Motionless Surfaces

- Approaching ball has "collision" KE.
- During impact, ball has elastic PE.
- Rebounding ball has "rebound" KE.
- Some collision energy becomes thermal.
  - "Lively" balls lose little energy.
  - "Dead" balls lose much energy.
- In general: rebound KE < collision KE

Coefficient of Restitution

- Measure of a ball's liveliness.
- Ratio of outgoing to incoming speeds.

Coefficient of restitution =
Outgoing speed / Incoming speed

Bouncing from Elastic, Motionless Surfaces

- Both ball and surface dent during bounce.
- Work is proportional to dent distance.
- Denting surface stores & returns energy.
  - "Lively" surface loses little energy.
  - "Dead" surface loses much energy.
- Surface has a coefficient of restitution, too.

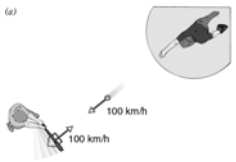
Bouncing from Moving Surfaces

- Incoming speed → Approaching speed.
- Outgoing speed → Separating speed.
- Coefficient of Restitution becomes:

Coefficient of restitution =
Separating speed / Approaching speed

Ball and Bat Part 1

- Ball approaches home plate at 100 km/h.
- Bat approaches pitcher at 100 km/h.
- Approaching speed is 200 km/h.

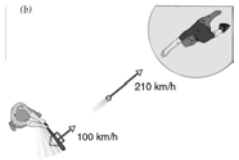


Ball and Bat Part 2

- Approaching speed is 200 km/h.
- Baseball's Coefficient of Restitution: 0.55.
- Separating speed is 110 km/h.

Ball and Bat Part 3

- Separating speed is 110 km/h.
- Bat approaches pitcher at 100 km/h.
- Ball approaches pitcher at 210 km/h.



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Bouncing's Effects on Objects

- Bouncing involves momentum transfer
  - Momentum transferred while stopping
  - Momentum transferred while rebounding
  - A better bounce transfers more momentum
- Bouncing can involve energy transfer
- Together, these transfers govern bouncing
  - Identical elastic balls transfer motion perfectly

Impact Forces

- Harder surfaces bounce faster
  - Momentum is transferred faster
  - Time is shorter, so force is larger
- No one likes bouncing off hard surfaces

Ball's Effects on a Bat

- Ball pushes bat back and twists it, too
- When ball hits bat's center of percussion,
  - backward and rotational motions balance.
  - handle doesn't jerk.
- When ball hits vibrational node
  - bat doesn't vibrate.
  - more energy goes into ball.

Summary About Bouncing Balls

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