

Bouncing Balls

Question:

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

1. To approximately its original height.
2. Much higher than its original height.
3. Much less than its original height.

Bouncing from Stationary, Rigid Surfaces

- Approaching ball has kinetic energy.
- Bouncing ball has elastic potential energy.
- Rebounding ball has kinetic energy.
- Approaching energy \equiv “collision” energy.
- Rebounding energy \equiv “rebound” energy.
- Some energy is lost to thermal energy.
- Lively balls lose little, dead balls lose much.

Coefficient of Restitution

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

$$\text{Coefficient of Restitution} = \frac{\text{Outgoing Speed}}{\text{Incoming Speed}}$$

Bouncing from Stationary, Elastic Surfaces

- Both ball and surface dent during bounce.
- Work is proportional to dent distance.
- Surface stores part of collision energy.
- Surface returns part of rebound energy.
- Surface liveliness or deadness is important.

Bouncing from Moving Surfaces

- Incoming speed becomes approaching speed.
- Outgoing speed becomes separating speed.
- Coefficient of Restitution becomes:

$$\text{Coefficient of Restitution} = \frac{\text{Separating Speed}}{\text{Approaching Speed}}$$

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 is 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

- 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 wants to bounce off a hard surface

Ball's Effects on a Bat

- Ball pushes bat back and twists it, too
- At center of percussion,
 - motion backward and rotation cancel at handle
 - Handle doesn't jerk when the ball hits it
- Ball makes bat vibrate in fundamental mode
- At vibrational node,
 - bat doesn't vibrate when the ball hits it