A 15kg Boulder Is Going 55 M/s West When It Collides With An 8kg Bolder Going 3 M/s East. They Smash

A 15kg Boulder Is Going 55 M/s West When It Collides With An 8kg Boulder Going 3 M/s East. They Smash

Understanding the dynamics of collision between two objects is fundamental in physics, particularly within the realms of momentum and energy conservation. In this scenario, a massive 15kg boulder traveling at 55 m/s west collides with a smaller 8kg boulder moving at 3 m/s east. Such an event raises questions about the resulting velocities, energy transfer, and the principles governing elastic and inelastic collisions. This comprehensive guide aims to analyze the collision, explore the physics involved, and provide insights into the outcome of these two colliding boulders.

Overview of the Collision Scenario

Initial Conditions

- Mass of Boulder 1 (m_1): 15 kg
- Velocity of Boulder 1 (v_1): 55 m/s west
- Mass of Boulder 2 (m_2): 8 kg
- Velocity of Boulder 2 (v_2): 3 m/s east

Direction Convention

- For clarity, define west as the negative direction and east as the positive direction.
- Therefore:
- $v_1 = -55$ m/s
- $v_2 = +3$ m/s

Fundamental Physics Principles Involved

Conservation of Momentum

- Momentum (p) is conserved in isolated collisions.
- The total momentum before the collision equals the total momentum after:

$$
m_1 v_1 + m_2 v_2 = m_1 v_1' + m_2 v_2'
$$

Where v_1' and v_2' are the velocities after collision.

Conservation of Kinetic Energy

- Applies in elastic collisions.
- For inelastic collisions, some energy is transformed into other forms like heat or deformation.
- The total kinetic energy before:

$$
KE_{initial} = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2
$$

- The total kinetic energy after:

$$
KE_{final} = \frac{1}{2} m_1 v_1'^2 + \frac{1}{2} m_2 v_2'^2
$$

Type of Collision

- Elastic collision: Both momentum and kinetic energy are conserved.
- Inelastic collision: Momentum conserved, kinetic energy is not; some energy is lost as heat, sound, or deformation.
- Perfectly inelastic collision: The objects stick together after collision.

Given the scenario, we will analyze both elastic and inelastic cases to understand possible outcomes.

Calculating the Final Velocities

Assuming an Elastic Collision

- In elastic collisions, the relative speed of approach equals the relative speed of separation:

$$
v_1 - v_2 = -(v_1' - v_2')
$$

- Using conservation of momentum:

$$
m_1 v_1 + m_2 v_2 = m_1 v_1' + m_2 v_2'
$$

- Solving these equations yields the final velocities:

$$
v_1' = \frac{(m_1 - m_2) v_1 + 2 m_2 v_2}{m_1 + m_2}
$$

$$
v_2' = \frac{(m_2 - m_1) v_2 + 2 m_1 v_1}{m_1 + m_2}
$$

Plugging in the numbers:

- $v_1 = -55\, \text{m/s}$
- $v_2 = +3\, \text{m/s}$
- $m_1 = 15\, \text{kg}$
- $m_2 = 8\, \text{kg}$

Calculations:

$$
v_1' = \frac{(15 - 8)(-55) + 2 \times 8 \times 3}{15 + 8} = \frac{7 \times (-55) + 48}{23} = \frac{-385 + 48}{23} = \frac{-337}{23} \approx -14.65\, \text{m/s}
$$

$$
v_2' = \frac{(8 - 15) \times 3 + 2 \times 15 \times (-55)}{23} = \frac{-7 \times 3 + 30 \times (-55)}{23} = \frac{-21 - 1650}{23} = \frac{-1671}{23} \approx -72.65\, \text{m/s}
$$

Interpretation:
- Post-collision, the 15kg boulder moves west at approximately 14.65 m/s.
- The 8kg boulder moves west at approximately 72.65 m/s.
- Both objects end up moving west, indicating a significant transfer of momentum and energy.

Assuming a Perfectly Inelastic Collision

- When objects stick together after collision, they share a common velocity v_f:

$$
v_f = \frac{m_1 v_1 + m_2 v_2}{m_1 + m_2}
$$

Calculating:

$$
v_f = \frac{15 \times (-55) + 8 \times 3}{15 + 8} = \frac{-825 + 24}{23} = \frac{-801}{23} \approx -34.83\, \text{m/s}
$$

Interpretation:
- The combined boulder moves west at approximately 34.83 m/s after collision.
- In this case, some kinetic energy is lost, likely converted into heat, sound, or deformation.

Energy Analysis

Initial Kinetic Energy

Calculations:

$$
KE_{initial} = \frac{1}{2} \times 15 \times 55^2 + \frac{1}{2} \times 8 \times 3^2
$$

$$
= 7.5 \times 3025 + 4 \times 9 = 22,687.5 + 36 = 22,723.5\, \text{J}
$$

Final Kinetic Energy (Elastic Case)

Using the final velocities:

$$
KE_{final} = \frac{1}{2} \times 15 \times (-14.65)^2 + \frac{1}{2} \times 8 \times (-72.65)^2
$$

$$
= 7.5 \times 214.87 + 4 \times 5277.22 \approx 1611.5 + 21,108.9 = 22,720.4\, \text{J}
$$

- Slight decrease due to rounding, but essentially energy is conserved.

Final Kinetic Energy (Perfectly Inelastic Case)

\[

KE_{final} = \frac{1}{2} \times (15 + 8) \times 34.83^2 = 11.5 \times 1214.4 \approx 13,956\, \text{J}
\]

- Notice the significant loss of kinetic energy compared to initial energy, typical of inelastic collisions.

Real-World Implications and Applications

Understanding Impact Forces

- The collision's force depends on the impact duration and deformation.
- Larger masses and higher velocities generate greater forces, potentially causing fractures or deformation.

Applications in Engineering and Safety

- Designing protective gear, vehicle crumple zones, and safety barriers relies on understanding such collision dynamics.
- Analyzing rockfalls and landslides involves similar physics principles to predict impact outcomes.

Relevance in Space and Planetary Science

- Collisions between celestial objects, such as asteroids, follow similar physics.
- Understanding momentum transfer helps in planetary defense strategies.

Conclusion

The collision between a 15kg boulder moving at 55 m/s west and an 8kg boulder traveling at 3 m/s east exemplifies fundamental physics principles. Depending on whether the collision is elastic or inelastic, the objects will exhibit different post-collision velocities and energy distributions. The calculations reveal that in an elastic collision, the objects rebound with velocities indicating a significant transfer of momentum and energy, while in a perfectly inelastic collision, they stick together and move as a single mass at a reduced speed, losing a substantial portion of their initial kinetic energy.

Understanding these principles not only provides insights into natural phenomena like rockfalls and planetary impacts but also informs engineering practices that ensure safety and durability in various fields. Recognizing how mass, velocity, and collision type influence outcomes is essential for scientists, engineers, and safety professionals alike.

Keywords: collision physics, momentum conservation,

Frequently Asked Questions

What is the total momentum of the system before the collision?

The total momentum is the sum of the individual momenta: (15 kg)(55 m/s west) + (8 kg)(3 m/s east). Assuming west is negative and east is positive, total momentum = (15)(-55) + (8)(3) = -825 + 24 = -801 kg·m/s.

What law applies to the collision between the two boulders?

The law of conservation of momentum applies, stating that the total momentum of an isolated system remains constant during the collision.

If the collision is elastic, how would the velocities of the boulders change after impact?

In an elastic collision, both momentum and kinetic energy are conserved. The boulders would exchange velocities based on their masses, potentially reversing their directions depending on their initial velocities.

How can we determine the velocity of each boulder after the collision?

Using conservation of momentum and kinetic energy (if elastic), we can set up equations to solve for the final velocities. For inelastic collisions, only momentum conservation applies, simplifying the calculations.

What factors influence whether the collision is elastic or inelastic?

Factors include the material properties of the boulders and whether energy is conserved during the impact. Most real-world collisions are inelastic, with some energy converted to heat, sound, or deformation.

What practical applications relate to understanding collisions like this?

Understanding collisions helps in fields such as crash safety design, planetary science (asteroid impacts), and engineering applications involving impact forces and energy transfer.

How does the initial direction of each boulder affect the final outcome after collision?

The initial directions determine the momentum vectors. The resulting velocities after collision depend on these directions, influencing whether the boulders bounce apart, stick together, or change path significantly.

Additional Resources

A 15kg Boulder Is Going 55 M/s West When It Collides With An 8kg Boulder Going 3 M/s East. They Smash

The collision between two boulders—one significantly larger and faster than the other—serves as a compelling case study in classical mechanics, specifically in the realm of momentum and energy conservation. This scenario not only illustrates fundamental physics principles but also provides insights into real-world applications such as collision analysis in engineering, geological processes, and even safety assessments. Analyzing such a collision involves understanding the variables at play, calculating the resulting velocities, and exploring the implications of the impact.

Understanding the Scenario

Before delving into detailed calculations and physics principles, it's essential to grasp the basic setup. We have two boulders:

- Boulder A: Mass = 15 kg, Velocity = 55 m/s West
- Boulder B: Mass = 8 kg, Velocity = 3 m/s East

They are moving toward each other and collide. The key aspects to consider include their initial velocities, directions, and the nature of the collision—whether elastic or inelastic.

Coordinate System and Direction Convention

To analyze the collision accurately, establishing a coordinate system is crucial. Typically, one direction is chosen as positive; here, we can define:

- East as positive (+)
- West as negative (−)

Thus:

- Boulder A: velocity = -55 m/s (West)
- Boulder B: velocity = +3 m/s (East)

This sign convention simplifies calculations and clarifies the directionality of velocities before and after impact.

Pre-Collision Analysis

Understanding the initial conditions:

Velocity and Momentum

- Boulder A:
- Momentum = mass × velocity = 15 kg × (−55 m/s) = −825 kg·m/s
- Boulder B:
- Momentum = 8 kg × 3 m/s = 24 kg·m/s

Total momentum before collision:

$P_{total\_initial} = (-825) + 24 = -801$ kg·m/s

The negative value indicates that the system's overall momentum points toward the West.

Kinetic Energy

- Boulder A:
- KE = (1/2) × 15 kg × (55 m/s)^2 = 7.5 × 3025 = 22,687.5 Joules
- Boulder B:
- KE = 0.5 × 8 kg × (3 m/s)^2 = 4 × 9 = 36 Joules

Total kinetic energy:

22,687.5 + 36 ≈ 22,723.5 Joules

This high energy reflects the substantial speed of the larger boulder.

Type of Collision: Elastic or Inelastic?

In real-world scenarios, collisions are often inelastic, meaning some kinetic energy is converted into deformation, heat, or sound. For simplicity, initial calculations often assume elastic collisions, where kinetic energy is conserved, but this scenario likely involves some energy loss due to deformation, especially given the size and speed of the boulders.

Features:

- Elastic collision:
- Kinetic energy conserved
- Momentum conserved
- Boulders bounce off with predictable velocities
- Inelastic collision:
- Kinetic energy not conserved
- Boulders may stick together or deform
- Momentum still conserved

Given the size and nature of the objects, an inelastic collision is more realistic, but for illustrative purposes, both cases can be analyzed.

Calculating Post-Collision Velocities

Assuming a perfectly elastic collision to illustrate the principles, we use conservation laws.

Conservation of Momentum

$$
m_A v_{A_i} + m_B v_{B_i} = m_A v_{A_f} + m_B v_{B_f}
$$

Where:

- m_A, m_B are masses
- v_{A_i}, v_{B_i}: initial velocities
- v_{A_f}, v_{B_f}: final velocities

Conservation of Kinetic Energy (Elastic case)

$$
\frac{1}{2} m_A v_{A_i}^2 + \frac{1}{2} m_B v_{B_i}^2 = \frac{1}{2} m_A v_{A_f}^2 + \frac{1}{2} m_B v_{B_f}^2
$$

Using the initial velocities:

$$
15 \times (-55) + 8 \times 3 = 15 v_{A_f} + 8 v_{B_f}
$$
$$
-825 + 24 = 15 v_{A_f} + 8 v_{B_f}
$$
$$
-801 = 15 v_{A_f} + 8 v_{B_f}
$$

And energy:

$$
\frac{1}{2} \times 15 \times 3025 + \frac{1}{2} \times 8 \times 9 = \frac{1}{2} \times 15 v_{A_f}^2 + \frac{1}{2} \times 8 v_{B_f}^2
$$
$$
22,687.5 + 36 = 7.5 v_{A_f}^2 + 4 v_{B_f}^2
$$
$$
22,723.5 = 7.5 v_{A_f}^2 + 4 v_{B_f}^2
$$

Solving these equations yields the final velocities, but due to the complexity, it's often easier to use the relative velocity approach for elastic collisions:

$$
v_{A_f} - v_{B_f} = - (v_{A_i} - v_{B_i})
$$

Plugging in initial velocities:

$$
v_{A_f} - v_{B_f} = - (-55 - 3) = - (-58) = 58
$$

Now, from conservation of momentum:

$$
-801 = 15 v_{A_f} + 8 v_{B_f}
$$

Express v_{A_f} in terms of v_{B_f}:

$$
v_{A_f} = v_{B_f} + 58
$$

Substitute into momentum equation:

$$
-801 = 15 (v_{B_f} + 58) + 8 v_{B_f} = 15 v_{B_f} + 870 + 8 v_{B_f} = (15 + 8) v_{B_f} + 870 = 23 v_{B_f} + 870
$$

Solve for v_{B_f}:

$$
23 v_{B_f} = -801 - 870 = -1671
$$

$$
v_{B_f} = -1671 / 23 \approx -72.65\, \text{m/s}
$$

Calculate v_{A_f}:

$$
v_{A_f} = -72.65 + 58 = -14.65\, \text{m/s}
$$

Interpretation of Results

- Boulder A: final velocity ≈ −14.65 m/s (West), significantly slowed down.
- Boulder B: final velocity ≈ −72.65 m/s (West), now moving faster than initial.

This outcome indicates that after the collision, both boulders are moving westward, with the smaller boulder gaining speed at the expense of the larger one, consistent with momentum transfer principles.

Implications of the Collision

The physics of this collision reveal several key insights:

Energy Transfer

- The initial kinetic energy was dominated by the larger boulder, but post-collision, energy is redistributed.
- The calculated velocities suggest some energy could be lost if the collision is not perfectly elastic, which is realistic given the deformable nature of rocks.

Momentum Conservation

- Despite the energy loss, total momentum remains conserved, aligning with

Newton’s laws.
- The large mass difference causes a significant change in velocities, especially for the smaller boulder.

Practical Applications

- In engineering, such collision analyses help in designing impact-resistant structures.
- Geologists analyze similar impacts to understand rock formations and natural processes like landslides.
- Safety assessments for vehicles and machinery often incorporate similar physics principles to predict outcomes of collisions.

Limitations and Real-World Considerations

While the calculations provide a clear theoretical picture, real-world collisions are more complex:

- Deformation and Fracture: Rocks may crack or deform, absorbing energy.
- Friction and Surface Roughness: Contact surfaces affect energy dissipation.
- Three-Dimensional Effects: Real impacts are rarely perfectly head-on; angles matter.
- Material Properties: Rock hardness and elasticity influence the collision outcome.

Accounting for these factors often requires more advanced modeling, including finite element analysis and experimental validation.

Conclusion

The collision between a 15 kg boulder traveling 55 m/s west and an 8 kg boulder moving 3 m/s east exemplifies core physics concepts such as conservation of momentum and energy. Through detailed analysis, we observe how momentum transfer results in altered velocities, with the smaller boulder gaining significant speed post-collision. While idealized calculations assume

A 15kg Boulder Is Going 55 M S West When It Collides With An 8kg Bolder Going 3 M S East They Smash

A 15kg Boulder Is Going 55 M S West When It Collides With An 8kg Bolder Going 3 M S East They Smash

Related Articles

- 4. Given The Graph Below, Determine Whether Each Statement Is True Or False.Statement-3 Is A Zero Of
- 41) The Objective Of A(n) ________ System Is To Reduce Costs By Integrating All Of The Operations Of
- A Bag Contains 7 Red Cubes, 3 Yellow Cubes, 2 Green Cubes, And 4 Blue Cubes, One Cube Is Selectef At

Back to Home