



Drexel-SDP GK-12 ACTIVITY

Activity: Ramped Up

Subject Area(s) Data Analysis & Probability, Measurement, Number & Operations, Physical Science, Problem Solving, Science and Technology

Associated Unit Vital Mechanics

Associated Lesson Collisions

Activity Title Ramped Up



Rack 'em.

Grade Level 7 (6-12)

Activity Dependency

Time Required 45 minutes

Group Size 4 people

Expendable Cost per Group US \$5

Summary

Students are encouraged to investigate collisions of balls (spherical objects) that have similar, if not the same, sizes and different masses (golf balls, foam balls, and ping-pong balls). This will demonstrate the concept of momentum and how angles play into the role of *velocity*.

Engineering Connection

Elastic collisions are the cornerstone example of energy transfer, both on the molecular and macroscale levels. While chemistry and thermodynamics topics focus on the molecular level (gas laws, phase changes, etc.), collisions of solid objects are important considerations for those who work in fields involving ballistics, forensics, safety mechanisms, and athletics.

Theorems on Conservation of Energy and Conservation of Momentum provide a framework for analyzing and predicting the motion of particles or objects and forces associated with contact. If we assume that elastic contact occurs between two objects, we expect the energy transfer to result in purely physical motion of the two original objects, not heat or sound. Conversely, a plastic collision implies that the two objects changed somehow (think of clay or Play-Doh balling up). Use of both theorems allows us to equate the initial and final energy states of the system.

These concepts are used extensively in the design of sporting equipment (baseball bats, racket sports, golf balls, protective padding) and research and development for automotive safety products (seat belts, air bags) and military/aerospace applications.

Keywords

mass, velocity, momentum, kinetic energy, potential energy

Educational Standards

- PA Science:
 - 3.1.7 – Unifying themes
 - 3.2.7.B – Apply process knowledge to make and interpret observations
- PA Math:
 - 2.1.8.D – Apply ratio and proportion to mathematical problem situations involving distance, rate, time, and similar triangles
 - 2.4.5.B – Use models, number facts, properties, and relationships to check and verify predictions and explain reasoning
 - 2.5.8.B – Verify and interpret results using precise mathematical language, notation and representations, including numerical tables and equations, simple algebraic equations and formulas, charts, graphs, and diagrams
 - 2.7.8.D – Compare and contrast results from observations and mathematical models
 - 2.8.8.B – Discover, describe, and generalize patterns, including linear, exponential, and simple quadratic relationships

Pre-Requisite Knowledge

Students should know how to measure with a meter stick and a protractor.

Learning Objectives

After this activity, students should be able to:

- Relate velocity to ramp position and height (Conservation of Energy)
- Discuss the effect of mass and velocity on momentum
- Discuss the effect of angles on ramp height and 2-D particle velocity

- Predict the outcome of a collision with knowledge of particle momentum (1-D and 2-D Conservation of Linear Momentum)

Materials List

Each group needs:

- 2 ramps (meter sticks with taped-on dowel-rod tracks)
- 2 wood blocks (optional) to set angle of ramps
- 2 golf balls
- 2 foam balls
- 2 ping-pong balls

To share with the entire class:

- Graph paper
- Protractors
- Mass balance

Introduction / Motivation [with demonstration]

Today we are going to experiment with collisions and see what happens if we use different balls and make them collide at different speeds. There's a worksheet associated with this activity that your groups can follow. We are going to investigate collisions that occur head-on, at different angles, and purely side-to-side.

[call for 2 students to volunteer, set a piece of graph paper on a level table and have students position the ramps at similar angles so that the balls will make a head-on collision on the graph paper]

To do this, we're going to start with a head-on collision condition. You will want to set the ramps at similar angles and then start the balls at the same distance.

[position the balls at equal distances and release – done properly, the balls will make contact and stop on the graph paper]

You can control the speed of the balls off the ramp by setting the angle of the ramp and varying the position of the ball at that angle (see explanation in **Lesson Background** section of lesson writeup).

In groups of four (4), investigate what happens in head on collisions when balls of different mass are used, or when the speed of the two balls differs. Two of the group members are responsible for releasing the balls on the ramps. The remaining two group members should identify the point of contact for each ball and sketch the resulting angles on the graph paper.

Follow the worksheet and adjust the angles of the ramps, then note what happens when you vary the mass and speeds of the balls. Finally, look into oblique (sideswipe) collisions and note what happens.

Vocabulary / Definitions

| Word | Definition |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mass | A measure of matter packed into an object. Equal to weight divided by gravity. |
| Velocity | The speed and direction of a particle. In a 2-D representation of particle motion, each direction is defined by a magnitude which adds up to the overall speed. |

| | |
|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Momentum | The quantity defined as the product of mass and velocity of an object. |
| Collision | Impact of one object with another. |
| Oblique | Relating to the side of an object. An <i>oblique</i> collision is referred to as a “sideswipe.” |
| Potential Energy | Energy possessed by an object before it goes into motion. Springs and gravity are sources of potential energy. |
| Kinetic Energy | Energy possessed by an object in motion, calculated as $\frac{1}{2}mv^2$, which is half of the product of the mass and square of the velocity. |
| Mass | A measure of matter packed into an object. Equal to weight divided by gravity. |
| Velocity | The speed and direction of a particle. In a 2-D representation of particle motion, each direction is defined by a magnitude which adds up to the overall speed. |
| Momentum | The quantity defined as the product of mass and velocity of an object. |
| Conservation of Energy | Energy can neither be created nor destroyed, but transferred. |
| Conservation of Momentum | The total momentum of a system remains constant. |

Procedure

Background

Show demonstration in **Introduction/Motivation** and allow students to investigate things themselves.

Before the Activity

- Distribute worksheets and graph paper.
- Distribute activity materials (ramps, balls, wood blocks).

With the Students

1. To start, make sure groups are aligning ramps and graph paper properly.
2. Show proper positioning of wood blocks (at same point on ramp).
3. Hand out balls as groups progress.
4. Ask each group about their progress and what they are noticing.
5. Offer helpful suggestions to students having difficulty setting up the activity.

Attachments

vital_mechanics_rampedup_activity_worksheet.pdf

Safety Issues

- Warn students to be careful when carrying meter sticks
- Instruct students to only use balls for collisions and not as projectiles

Troubleshooting Tips

Use a wood block at the same position on meter sticks to attain the same angle for both ramps. Students wishing to try ramping momentum with lighter balls may stack some ramps in an open space – 2 groups may need to work together.

Investigating Questions

See activity worksheet.

Assessment

Check worksheet for completion, wrap-up with class discussion (see lesson).

Activity Scaling

- For lower grades, focus on linear collisions.
- For upper grades, extend into algebra theory to compare theoretical and experimental results with collision angles.

Owner

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