WAMC Lab Template

Math Concept(s): Newton's 3rd law of physics
Angle of attack (geometry)
Measurement
Displacement
Angle of travel
Source / Text:
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Attach the following documents:

- Lab Instructions
- Student Handout(s)
- Rubric and/or Assessment Tool

Short Description (Be sure to include where in your instruction this lab takes place):

Lab Plan

Lab Title: Water Bottle Rockets

Prerequisite skills: Basic knowledge of Newtons 3rd law of physics.

Standards: *(Note SPECIFIC relationship to Science, Technology, and/or Engineering)*

Mathematics K–12 Learning Standards:

- G-GMD Use volume formulas for cylinders to solve problems

Standards for Mathematical Practice:

- Makes sense of problems and persevere in solving them
- Use appropriate tools strategically
- Attend to precision

K-12 Learning Standards-ELA (Reading, Writing, Speaking & Listening):

- RST.9-10.3 Follow precisely a complex multistep procedure when carrying experiments, taking measurements, or performing technical tasks, attending to special cases or expectations defined in the text
- RST.9-10.4 Determine meaning of symbols, key terms, or other domain specific words and phrases as they are used in specific technical context.
- RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form and translate information expressed verbally or mathematically into words.

K-12 Science Standards

- PS2-A Forces and Motion
- PSI-3 Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles
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Technology

- 1.2.1 Communicate and Collaborate to learn with others
- 2.2.1 Develop skills to use technology effectively
- 2.4.1 Formulate and synthesize new knowledge

Engineering

- HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Leadership/21st Century Skills:

21st Century Interdisciplinary themes (Check those that apply to the above activity.)

☐ Global Awareness ☐ Financial/Economic/Business/Entrepreneurial Literacy ☐ Civic Literacy
☐ Health/Safety Literacy ☐ Environmental Literacy

21st Century Skills (Check those that students will demonstrate in the above activity.)

LEARNING AND INNOVATION
Creativity and Innovation
☐X Think Creatively
☐X Work Creatively with Others
☐X Implement Innovations
Critical Thinking and Problem Solving
☐X Reason Effectively
☐ Use Systems Thinking
☐X Make Judgments and Decisions
☐X Solve Problems
Communication and Collaboration
☐X Communicate Clearly
☐X Collaborate with Others

INFORMATION, MEDIA & TECHNOLOGY SKILLS
Information Literacy
☐X Access and Evaluate Information
☐ Use and manage Information
Media Literacy
☐ Analyze Media
☐ Create Media Products
Information, Communications and Technology (ICT Literacy)
☐ Apply Technology Effectively

LIFE & CAREER SKILLS
Flexibility and Adaptability
☐ Adapt to Change
☐X Be Flexible
Initiative and Self-Direction
☐ Manage Goals and Time
☐ Work Independently
☐ Be Self-Directed Learners
Social and Cross-Cultural
☐X Interact Effectively with Others
☐ Work Effectively in Diverse Teams

Productivity and Accountability
☐X Manage Projects
☐X Produce Results
Leadership and Responsibility
☐X Guide and Lead Others
☐X Be Responsible to Others

Teacher Preparation: (What materials and set-up are required for this lab?)

Materials

- 2 liter bottle
- Bottle rocket launcher (bike pump and cork work as well)
- Tag board or cardboard
- Tennis balls
- Duct tape or hot glue

Set-Up Required:

- Have materials available and launching method ready.

Lab Organization Strategies:

Leadership (Connect to 21st Century Skills selected):

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Cooperative Learning:

- Students will work in groups of 2 to 3

Expectations:

- Students work together to design a rocket able to travel 100 feet vertically with little displacement.

Timeline:

- Students should have one class period of lecture, one to build, and one to test.

Post Lab Follow-Up/Conclusions:

Discuss real world application of learning from lab

- How we see the 3rd law of physics in the everyday world such as riding in cars and day to day life.

Career Applications

- Aerospace Engineering

Optional or Extension Activities

- Chemical rockets
- Co2 cars
- Projectile labs

Newton's 3^{rd} Law

For every action.....

(The "Action Reaction Law")

Action and Reaction

- Newton's third law describes something else that happens when one object exerts a **force** on another object.

- According to **Newton's third law of motion**, forces always act in ***equal*** but opposite pairs.

Action and Reaction

- Another way of saying this ***is for every action, there is an equal but opposite reaction!****
- .

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Action and Reaction Forces Don't Cancel

- The forces exerted by two objects on each other are often called and **action-reaction** force pair.

- Action and reaction force pairs don't **cancel** because they act on different objects.

Action and Reaction Forces Don't Cancel

- You constantly use action-reaction force pairs as you move about.

- When you jump, you **push** down on the ground.
- The ground then pushes up on you. It is this **upward** force that pushes you into the air.

3

Action and Reaction Forces Don't Cancel

- When a bird flies, its wings push air in a **downward** and a backward direction.
- By Newton's third law, the air resistance pushes back on the bird in the opposite directions—**upward** and forward.
- This force keeps a bird in the air and propels it forward – an **OPPOSITE BUT *EQUAL* FORCE! Action Reaction!!!**

Large and Small Objects

- When you walk forward, you **push** backward on the ground.

- Your shoe pushes Earth backward, and Earth pushes your shoe **forward.**

3

Large and Small Objects…why don't I always feel this "push" back?!?

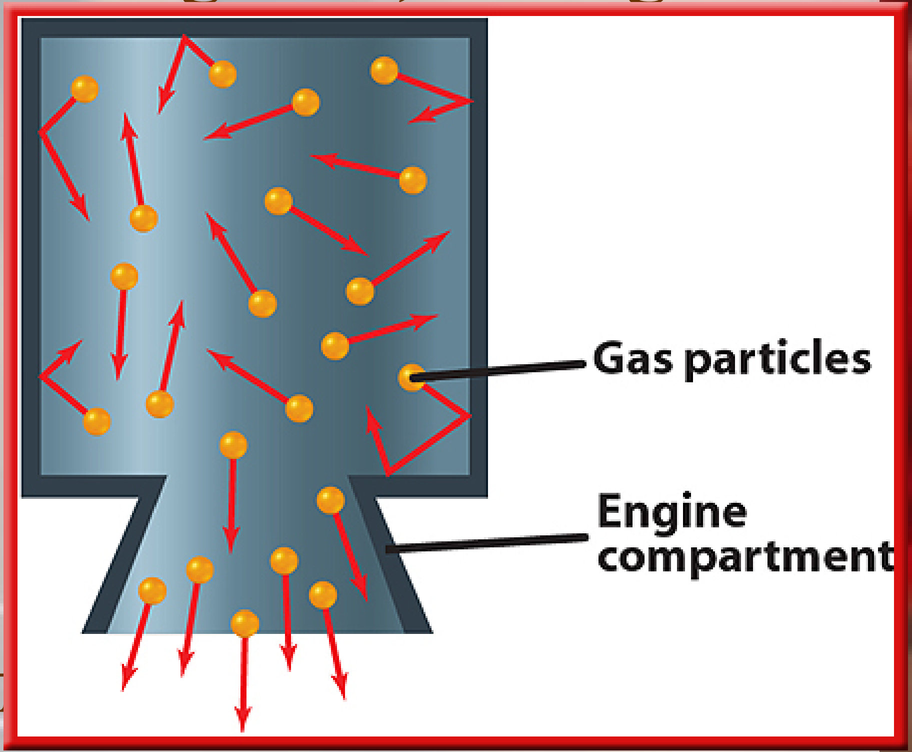
Earth has sooo much mass compared to you, that it does not move **noticeably** when you push it.

- If you step on something that has **less mass** than you do, like a skateboard, you can see it being pushed back.

3

A Rocket Launch

- (Don't write)
- When the rocket fuel is ignited, a hot gas is produced.
- As the gas molecules collide with the inside engine walls, the walls exert a force that pushes them out of the bottom of the engine.



A Rocket Launch

- (Don't write)
- This downward push is the action force.
- The reaction force is the upward push on the rocket engine by the gas molecules.
- This is the thrust that propels the rocket upward.

3

Weightlessness (Don't write)

- You might have seen pictures of astronauts floating inside a space shuttle as it orbits Earth.
- The astronauts are said to be weightless.
- Yet the force of gravity on the shuttle is almost 90 percent as large as at Earth's surface.
- Newton's laws of motion can explain why the astronauts float as if there were no forces acting on them.

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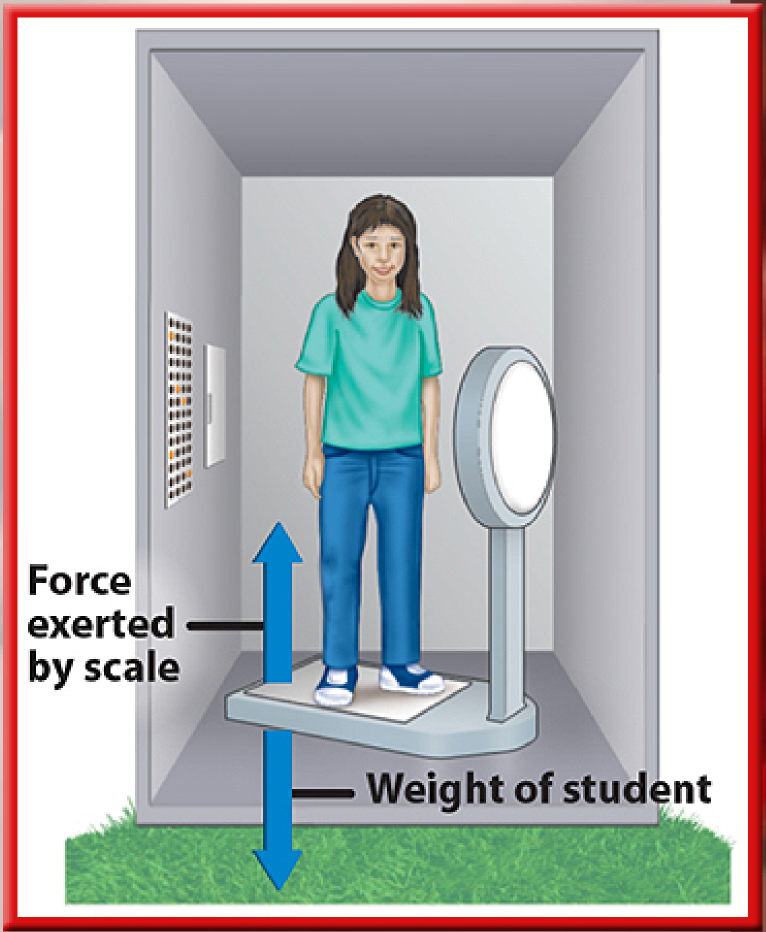
Measuring Weight (Don't write)

- When you stand on a scale, your weight pushes down on the scale.
- This causes the scale pointer to point to your weight.



Measuring Weight (Don't write)

- At the same time, by Newton's third law the scale pushes up on you with a force equal to your weight.
- This force balances the downward pull of gravity on you.

Free Fall and Weightlessness

- (Don't write)

Now suppose you were standing on a scale in an elevator that is falling.

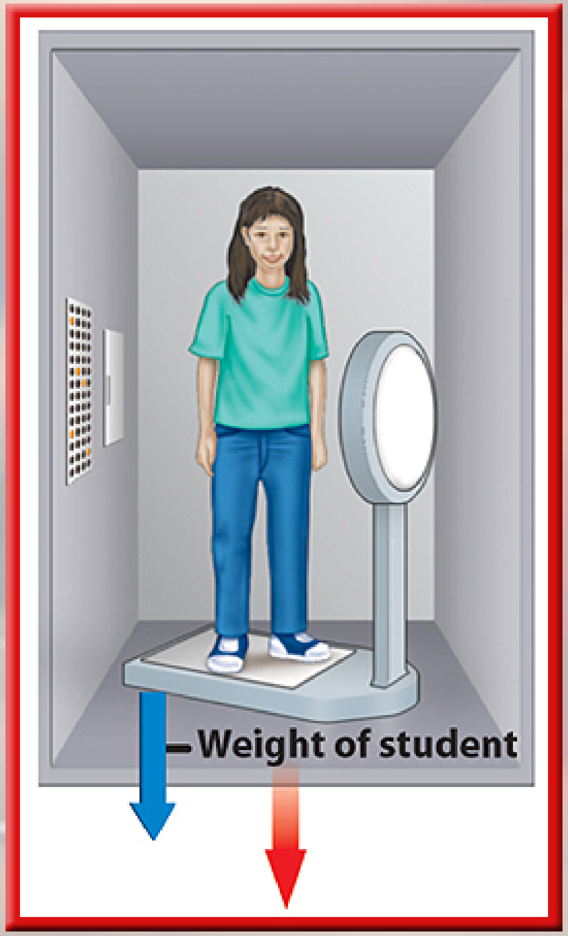
- A falling object is in free fall when the only force acting on the force is gravity.
- You and the scale are both in free fall.

Free Fall and Weightlessness

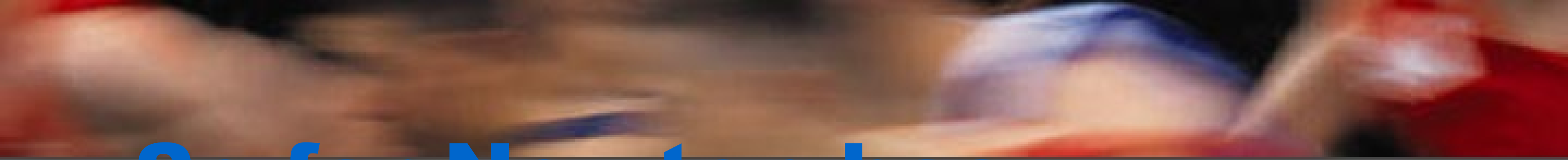
- (Don't write)
- Because the only force acting on you is gravity, the scale no longer is pushing up on you.
- According to Newton's third law, you no longer push down on the scale.

Free Fall and Weightlessness

- (Don't write)
- So the scale pointer stays at zero and you seem to be weightless.
- Weightlessness is the condition that occurs in free fall when the weight of an object seems to be zero.

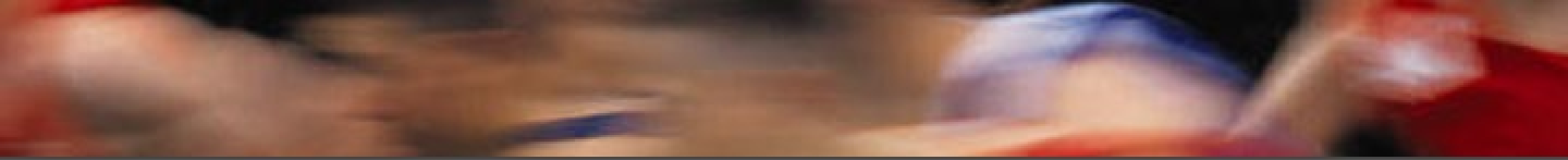


This is known as the “Action-Reaction” Law



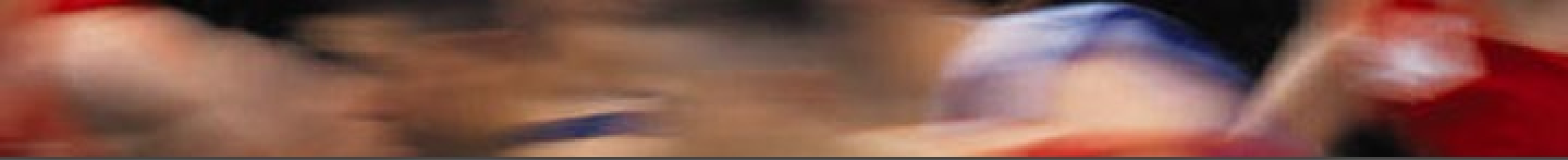
So far Newton has explained…

- Speed…
- Velocity…
- Acceleration…
- Force…
- Newton also went on to explain the ***"quantity of motion"*** called **<u>MOMENTUM!</u>**



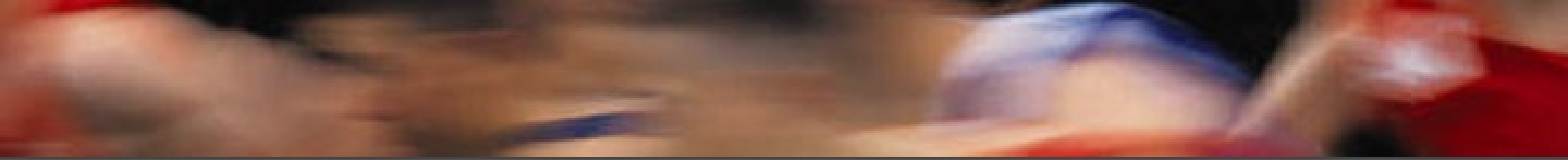
Momentum = Mass x Velocity

- Objects with a lot of **momentum,** have a lot of motion.
- They have a high amount of a *push* or *pull* **(force)** going on.
- An objects momentum is dependent upon its mass and its velocity (speed).
- **Momentum = mass x velocity**(units in kg x m/s)



- Objects with a ***greater mass*** have greater momentum. Objects with a **greater velocity** have greater momentum. And vise-versa for both concepts.
- If you know the mass and velocity of two different objects, you can determine their ***momentum*** by using:

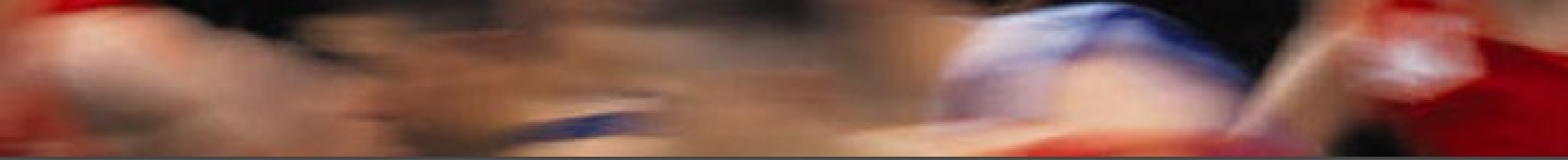
Momentum = mass x velocity



Conservation of Momentum:

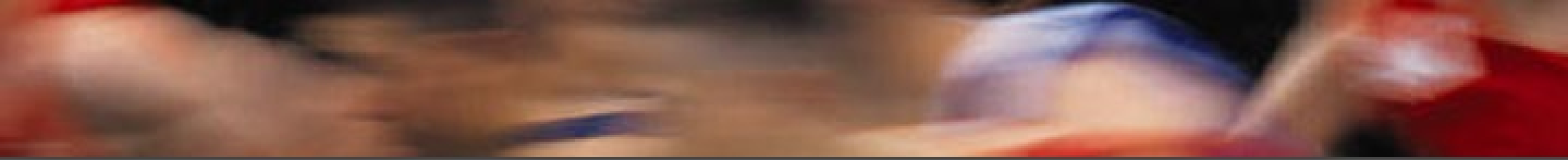
- If someone bumps in to you from behind, you gain momentum & move forward.
- When two objects collide, in the absence of friction, momentum is not lost.
- The **Law of Conservation of Momentum** says that momentum does not change when objects interact, it remains the same before and after the interaction.

- ***The Law of Conservation of Momentum*** states that the total momentum of any group of objects remains the same unless an outside force acts on the objects!



Guided PrAcTiCe!

- Which has more momentum, a 3 kg sledgehammer (a) swung at 1.5 m/s, or a 4 kg sledgehammer (b) swung at 0.9 m/s?
- (a) 3 kg x 1.5 m/s =   kg x m/s
- (b) 4kg x 0.9 m/s =   kg x m/s
- A has more momentum than the heavier one, because it is swung with a greater velocity – almost twice as fast!



Independent PrAcTiCe!

- 1. A golf ball travels at 16 m/s, while a baseball moves at 7 m/s. The mass of the golf ball is 0.045 kg and the mass of the baseball is 0.14 kg. Which had greater momentum?
- Golf ball =   = kg x m/s
- Baseball =   = kg x m/s
- 2. What is the momentum of a bird with a mass of 0.018 kg flying at 15 m/s?
- =

Bottle Rocket Lab Assessment

1. Distance traveled (1 point per foot) ______
2. Displacement (-1 point foot) ______
3. Total ______/100
4. What would you change in you design process?

   ______/5
5. What amount of water in your cylinder gave you the best results?

   ______/5
6. What angle of launch achieved the best results?

   ______/5
7. Why or why not was the flight of your rocket straight ______/5

Initial Design Worksheet

Rocket Fins

1. Rockets and arrows always have fins (or feathers) at the tail end.
   Why do you think this is so? What are the fins for?

2. How do you think the fins work?

Rocket Design: Weight and Propellant

3. In the "design matrix" below, circle the design you think will make the rocket fly STRAIGHT and FAR.

Propellant→	Air (A)	Water (W)
High Center of Mass (H)	AH	WH
Low Center of Mass (L)	AL	WL

Justification: Why did you choose this design?

4. The rocket should have a ____________________________________ center of mass because:

5. Using ________________________________ as propellant will make the rocket go further because: