Newton’s Second Law

Vanderbilt Student Volunteers for Science

VINSE/VSVS Rural

Training Presentation

Important!!!

- Please use this resource to reinforce your understanding of the lesson! Make sure you have read and understand the entire lesson prior to picking up the kit!
- We recommend that you work through the kit with your team prior to going into the classroom.
- This presentation does not contain the entire lesson—only selected experiments that may be difficult to visualize and/or understand.

I. Background Information

- **Newton's Laws** are laws which describe the motion of a body when a force acts on it. There are three laws:
  - **1st Law:** An object in motion stays in motion unless acted upon by a force and an object at rest stays at rest unless acted upon by a force
  - **2nd Law:** The force applied by an object is equal to the object's mass times its acceleration
  - **3rd Law:** For every action there is an equal and opposite reaction

III. Newton's 2^{nd} Law of Motion

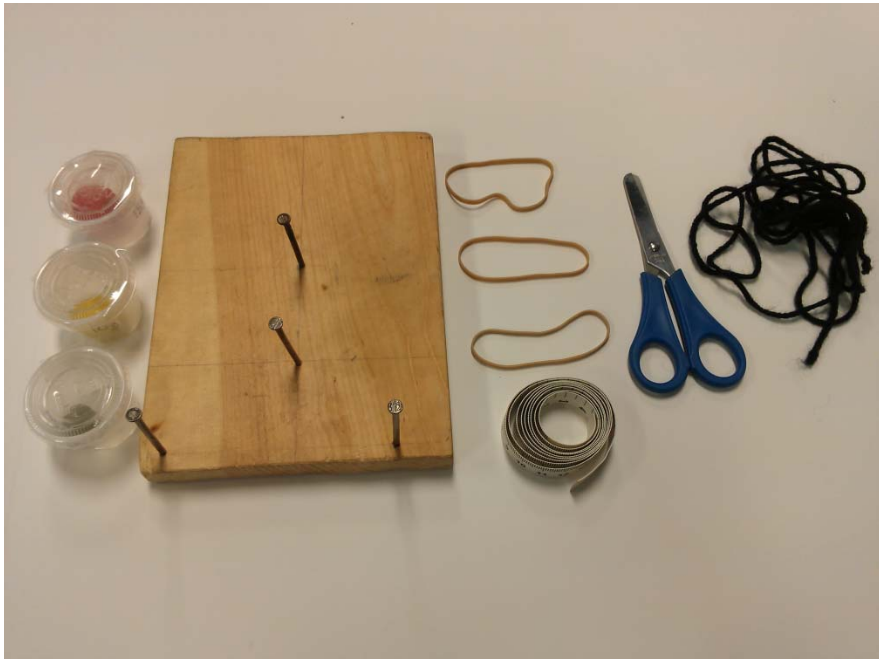
- Write the following equations on the board:
  - Force = mass * acceleration
  - Acceleration = Velocity/time
  - Velocity = distance/time
- Tell the students that these equations help relate acceleration with mass. They will examine how changing the mass of the cart, will affect it's acceleration and the time it takes to travel a certain distance.

Introduction (cont.)

- **Make a Prediction**
  - Have the students use the equation above to predict what they think will happen in the experiment in terms of the variables.
  - When the input force INCREASES and the mass is held CONSTANT, the distance the mass travels will _________________.
  - When the mass INCREASES and the input force is held CONSTANT, the distance each mass travels will ________________ from smallest mass to largest mass.
- **Visual Demonstration (Optional)**
  - If there is a chair with wheels in the class, bring it to the front of the room.
  - Ask a smaller student to sit in the chair and have another student push it with a somewhat constant force.
  - Now, have a larger/taller student or two students sit in the chair and have the same student as before push the chair again with the added mass.
  - Discuss the results with the class using terms from the prediction.

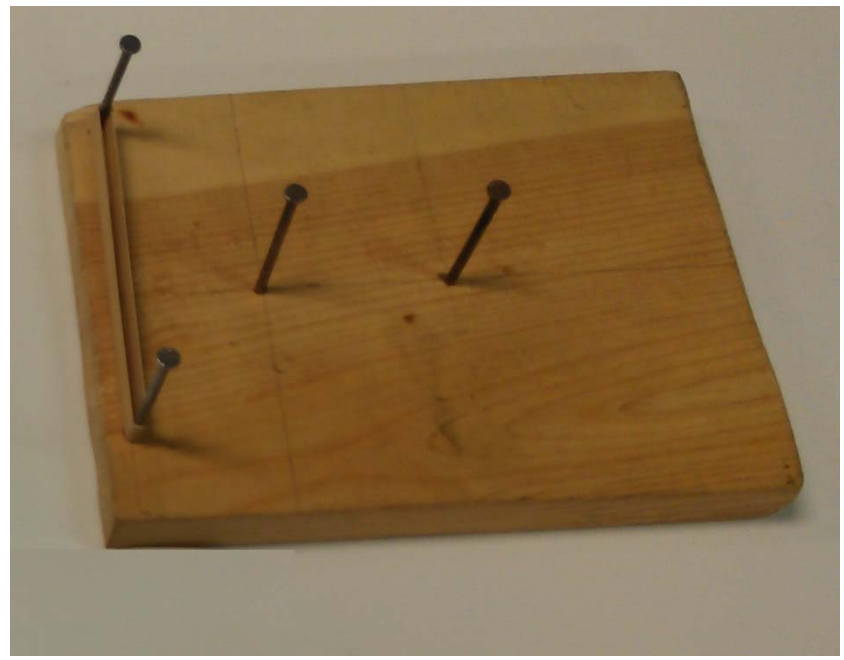
Materials for Each Group

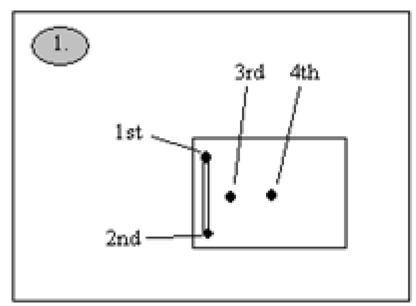
- Each group should receive the following materials:
- 1 plastic cup with clay, labeled 5g
- 1 plastic cup with clay, labeled 10 g
- 1 plastic cup with clay, labeled 20 g
- 1 wooden launcher
- 3 rubber bands of the same type (thickness, length, etc.)
- 1 tape measure
- 1 pair of safety scissors
- 1 ball of yarn



Setup

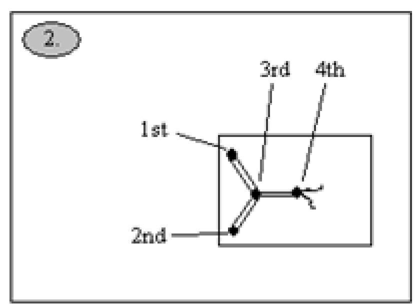
- Stretch the rubber band across the first and second nails

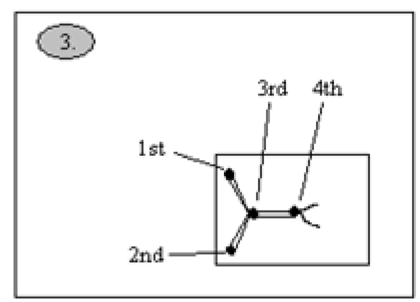




Setup (cont.)

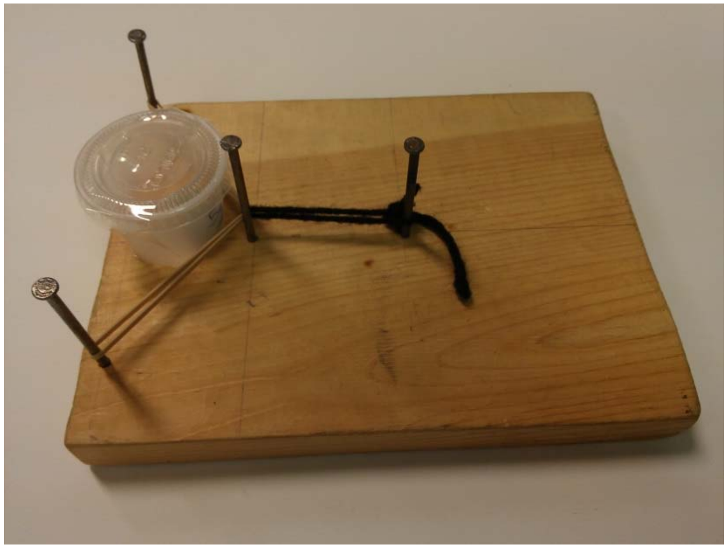
- Pull the rubber band(s) back behind the third nail, and TIGHTLY tie the string into place, keeping the knot behind the fourth nail so it does not impede the cutting process. If you do this step correctly, there will only be ONE KNOT!
- Carefully move the rubber band so that it is now in front of the 3rd nail.

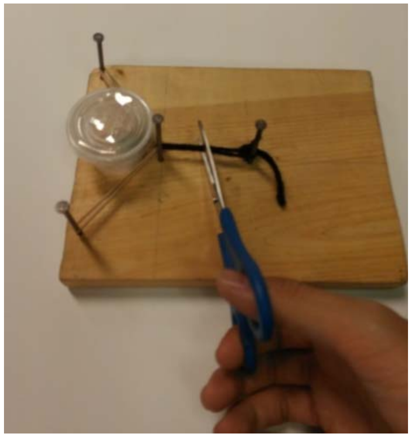




Procedure (Part I) - Varying the Mass

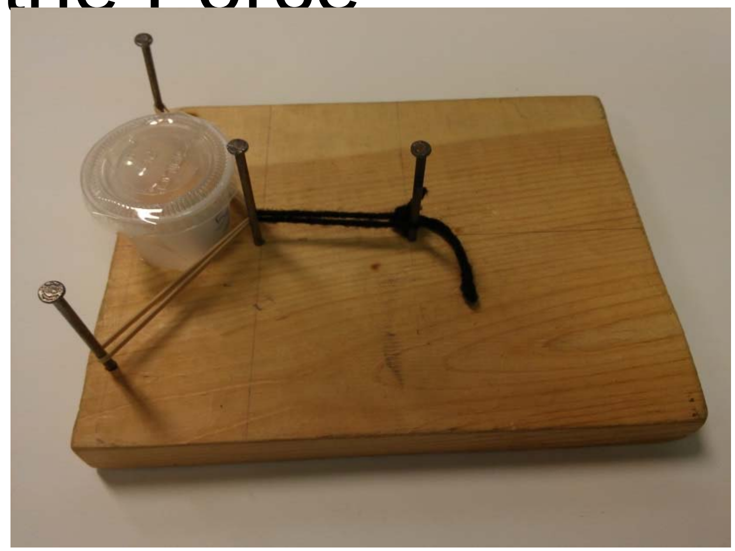
- Stretch one rubber band across the first and second nails, and complete the setup.
- Place the plastic cup labeled 5g into position.
- Use a pair of safety scissors to cut the string between the third and fourth nails.
- Measure the distance the projectile block traveled.
- Record your data into the table.
- Repeat steps 2-5 twice, using the same mass.
- Repeat steps 2-5 using the plastic cup labeled 10 and 20 g.
- Average the data and graph it.

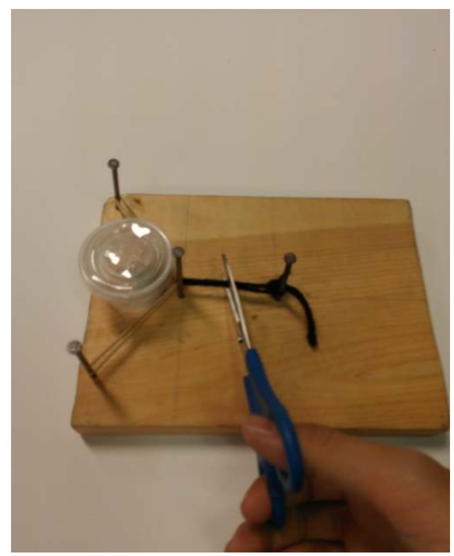




Procedure (Part I) - Varying the Force

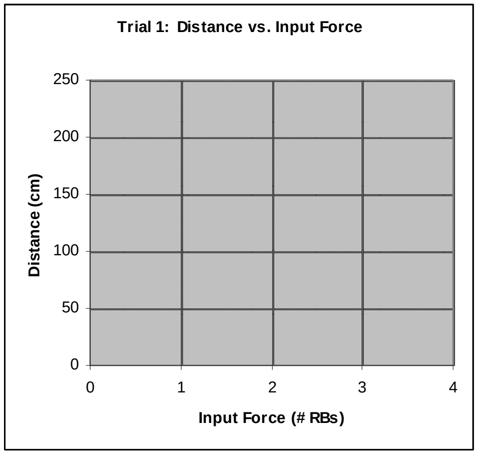
- Place the plastic cup labeled "10 g" in front of the 3rd nail, centered between nails 1 and 2, and snuggly against the angle of the rubber band.
- Use a pair of safety scissors to cut the string between the third and fourth nails.
- Measure the distance the plastic cup traveled.
- Record your data into the table.
- Repeat steps 2-5 using two rubber bands, then three rubber bands.
- NOTE: **Try to keep multiple rubber bands stacked evenly over one another for accurate fire power.**
- Also, try to **center the rubber bands to strike the middle of the projectile block upon firing.**

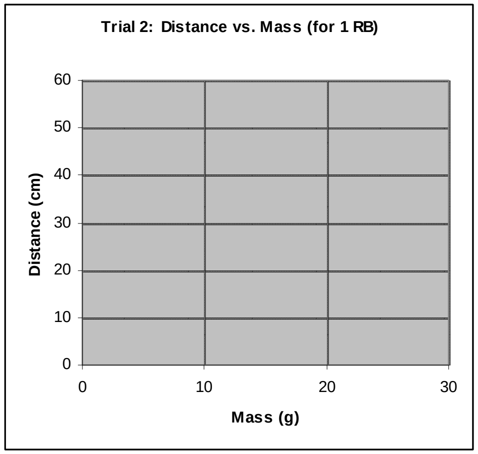




Graphing

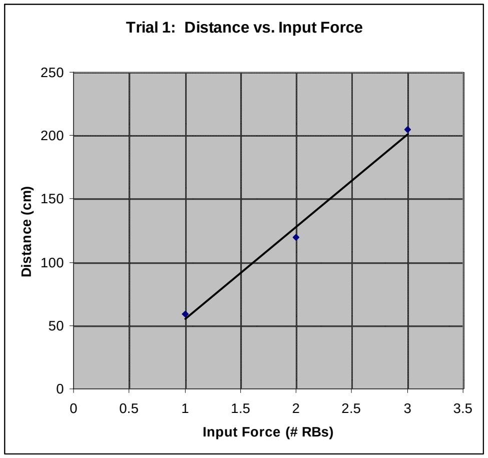
- Use the data from the tables to complete the graphs. For distance, use the averages.
- Draw a best-fit line for your points after they are plotted.

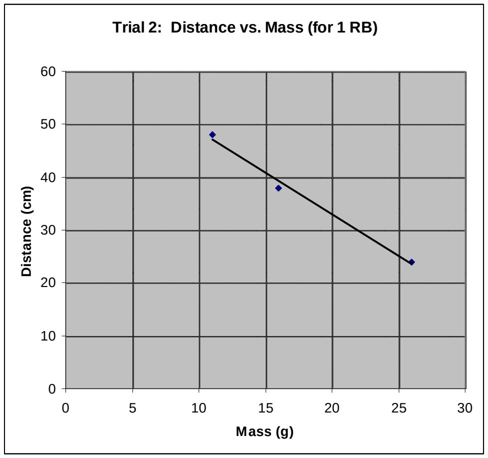




Sample Graphs and Questions

- Look at the graphs. What can you infer about the relationship between increasing input force with constant mass? about increasing mass with constant input force?
- What happened to acceleration in each part of the experiment?
- How did you use distance traveled as a factor to make your prediction before the experiment?
- How is distance a factor in Newton's Second Law of Motion?
- BONUS: Newton's First Law of Motion states that an object in motion will remain in motion until another force acts upon it. Your projectile block is the object in motion. What force acts on the bottle cap to stop it?





Conclusions

- From the linearity of the graphs, students will see that as input force increases and mass is held constant, then the distance the plastic cup travels increases as well.
- When the mass increases and the input force is held constant, the distance traveled by the plastic cup will decrease.
- Distance is a factor in acceleration, which is measured in (m/s^2).
- Mass and input force both affect the distance the cap is able to travel.
- The last question regarding Newton’s First Law of Motion refers to friction. Friction is the force that slows or stops objects from being in motion. Air resistance could also be a correct answer, but in this particular experiment, air resistance, as well as friction, is neglected.
- The main idea is that stronger input forces will result in greater accelerations, while adding mass will result in smaller accelerations.