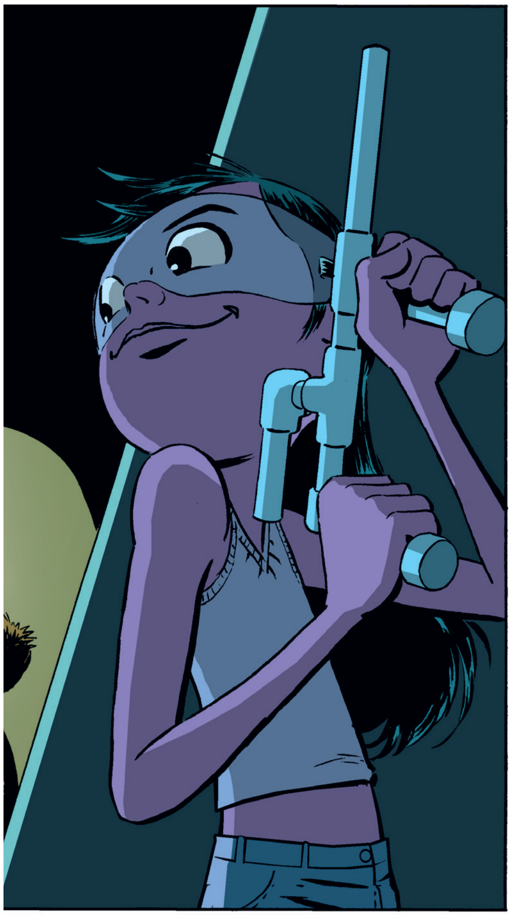
HOWTOONS: MARSHMALLOW SHOOTER!

ESTIMATED TIME: COMIC=5 MIN. STEM EXPLANATION=10 MIN. BUILDING & TESTING=20 MIN.



- **PROJECT DESCRIPTION:**
  A PVC pipe mini-marshmallow shooter.

- **OBJECTIVE:**
  This project examines the laws of motion, kinetic vs potential energy, mechanical energy and motion. It also introduces engineering design problem solving. Students read the comic and build their own marshmallow shooter, learn about the science, mechanics, and engineering while testing the shooter and then can even design their own.

- **CONTENT TOPICS:**
  Force, pressure, inertia, mass, velocity, transfer of energy, friction, kinetic vs potential energy, gravity, design, and engineering.

- **PREPARATION:**
  Using a ratcheting PVC cutter, cut PVC into (6) 3-inch pieces and (1) 6-inch piece per shooter. Place each material into own seperate bin.

MATERIALS (PER SHOOTER):

- ☐ 24 INCHES OF 1/2" DIAMETER PVC PIPE
  CUT INTO SIX 3-INCH PIECES & ONE 6-INCH PIECE
- ☐ TWO 1/2" DIAMETER ELBOW JOINTS
- ☐ TWO 1/2" DIAMETER T-JOINTS
- ☐ TWO 1/2" DIAMETER END SLIP CAPS

YOU WILL ALSO NEED:

- A RATCHETING PVC CUTTER
- A BIG BAG OF MINI MARSHMALLOWS
- SAFETY GOGGLES FOR EVERY STUDENT
  (SEE PAGE 46 FOR HOW TO MAKE YOUR OWN)

COST OF MATERIALS:

AVERAGE COST PER SHOOTER = **$2**

• 10FT 1/2" PIPE = $1.95 • ELBOW JOINT = 28¢ PER JOINT • T-JOINT = 37¢ PER JOINT • END SLIP CAP = 34¢ PER JOINT

National Science Education Standards & Common Core Standards:

Grades: 4-5th: 4-ps3-1, 4-ps3-4, 5-ps2, ms-ps2-2, ms-ps3-1, ms-ps3-5, ms-ets1-2, ms-ets1-3, ms-ets1-4

Disciplinary Core Ideas: ps2.a, ps2.b, ps3.a, ps3.b, ps3.c

Science And Engineering Practices: planning and carrying out investigations, analyzing and interpreting data, constructing explanations and designing solutions, engaging in argument from evidence.

Crosscutting Concepts: cause and effect, energy and matter, structure and function.

Common Core Standards: ccss.ela-literacy.whst.6-8.2

How To Use This HOWTOON:

1. Read the comic with students.
(5 MINUTES)

When reading the comic, remind students that in comics information comes from images as well as text (and they way they work together), so they need to read both the pictures and the words. You can use the *Discussion Questions* (below) if desired.

2. Discuss the science and engineering principles involved in building and using marshmallow shooters.
(10 MINUTES)

Use *What's Going On?* to guide discussion about the science of marshmallow shooters with students.

3. Have students build shooters from the blueprint in the comic.
(10 MINUTES)

Provide students with precut pieces and have them build marshmallow shooters either individually or in small groups. Just push the pipe sections together -- no glue needed!

4. Demonstrate the science behind the shooters.
(15 MINUTES)

Hold onto the bag of marshmallows! Have students come up and test their shooters one-by-one as you hand them one marshmallow. Don't forget the safety goggles! As students shoot the marshmallows, reinforce the STEM principles. For example, when a student shoots without sealing her lips around he tube, discuss how air pressure affected her shot. When a student uses a weak breath, discuss how the concepts of force, mass, and inertia affected his shot. You can perform these demonstrations yourself, or have students perform them:

> **- *Air Pressure:*** Replace the mouthpiece of the shooter with long and short pieces of PVC pipe, blow a marshmallow through each and compare the results. Discuss how the length of the tube affects the speed and distance of the marshmallow and relate this to air pressure.
> **- *Inertia and Mass:*** Blow objects of different masses through the shooter (e.g., marshmallow, paper, marble) and compare the results. Discuss how mass affects the speed and distance of the objects.
> **- *Friction:*** Blow both wet and dry marshmallows through the shooter and compare the results. Relate this to the friction of the marshmallow against the pipe.

5. Have students use what they have learned to design, build, and test their own shooters.

Hand out project page to help students use the design process to design, build, and test their shooters. Don't forget the safety goggles! Have students test their shooters for distance, changing variables one at a time and recording data. They can then analyze the data from their testing and use their findings to improve their designs.

Reading Discussion Questions

- Why does Celine toss Tucker his goggles? *(Because she wants his eyes to be protected when she shoots marshmallows at him.)*
- Look at the blueprint that shows the parts of the marshmallow shooter and how they go together. What professions use blueprints? *(Architects, builders, engineers) Have you ever seen visual directions that show you how to build something? (e.g., LEGO, Ikea)*
- Work with a partner to analyze the blueprint. Can you point out each part in the materials list where it goes in the assembly? Where does the marshmallow get loaded in? Where do you put your mouth and blow? Where does the marshmallow come out?
- Look at the drawing in the center panel. This type of drawing is called a cutaway -- the artist drew it so that you can see what is going on inside the shooter, as if the front part had been cut away. What do the red arrows represent? *(The path of the marshmallow through the shooter.)*

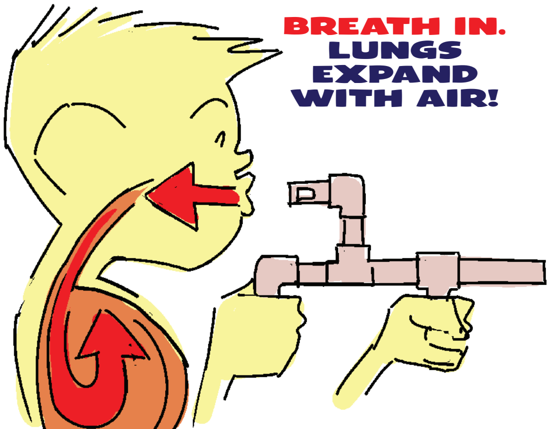
Assessment Options

• Have students try building shooters from each others' blueprints.
• Have students write an explanatory text detailing their design and building process and the science behind the decisions they made. (CCSS)
• Use the questions below to test understanding of the science behind the marshmallow shooters.

Assessment Questions

- Why does the marshmallow move?
- What happens when you push air through the shooter?
- What might happen if you pull air (suck in)?
- What is the force that causes the marshmallow to move?
- Which works better, a longer tube or a shorter tube? Why?
- Which would go further, a piece of paper, a marshmallow, or a marble? (the marshmallow. The paper does not have enough mass, the marble has too much).
- Why are fresh marshmallows better than stale or sticky?

What's Going On?

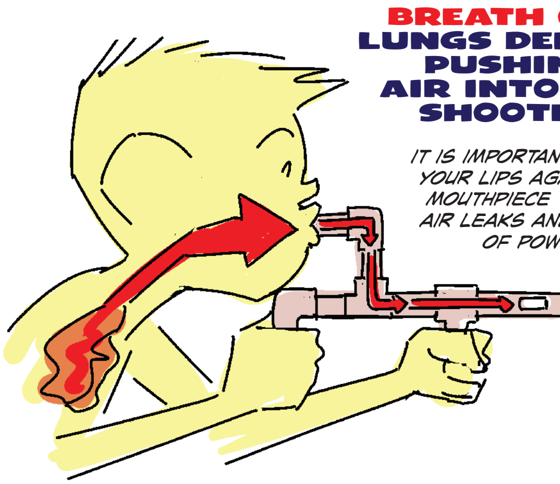


Force:

A PUSH OR A PULL THAT CAN MOVE AN OBJECT. THE MARSHMALLOW MOVES BECAUSE THE FORCE (PUSH) OF THE AIR IS APPLIED TO MOVE THE MASS OF THE MARSHMALLOW. A LONGER TUBE ALLOWS THE FORCE TO PUSH ON THE MARSHMALLOW FOR MORE TIME, AND GET IT MOVING FASTER WHEN IT LEAVES THE TUBE (AT WHICH POINT THE FORCE STOPS PUSHING).

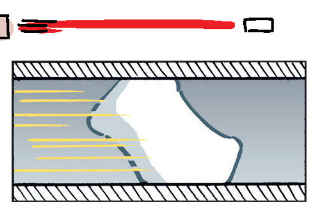
Newton's First Law of Motion:

AN OBJECT AT REST WILL REMAIN AT REST UNTIL ACTED UPON BY A FORCE, AND AN OBJECT IN MOTION WILL CONTINUE IN THE SAME DIRECTION UNTIL ACTED UPON BY A FORCE. THE MARSHMALLOW WILL REMAIN IN THE SHOOTER UNTIL YOUR BREATH FORCES IT OUT OF THE SHOOTER. ONCE YOUR BREATH FORCES THE MARSHMALLOW OUT OF THE SHOOTER, IT REMAINS IN MOTION WHILE BEING ACTED UPON BY OUTSIDE FORCES – FROM HITTING THE TARGET OR AN OBJECT, AND BEING PULLED TO THE GROUND BY GRAVITY.



Inertia:

A MORE MASSIVE OBJECT HAS A GREATER TENDENCY TO RESIST CHANGES IN ITS STATE OF MOTION. A MARSHMALLOW HAS MORE MASS THAN A BALL OF PAPER, SO IT TAKES MORE FORCE TO GET THE MARSHMALLOW MOVING. BUT ONCE IT'S MOVING, THE MARSHMALLOW ALSO TAKES MORE FORCE TO SLOW IT DOWN.



Friction:

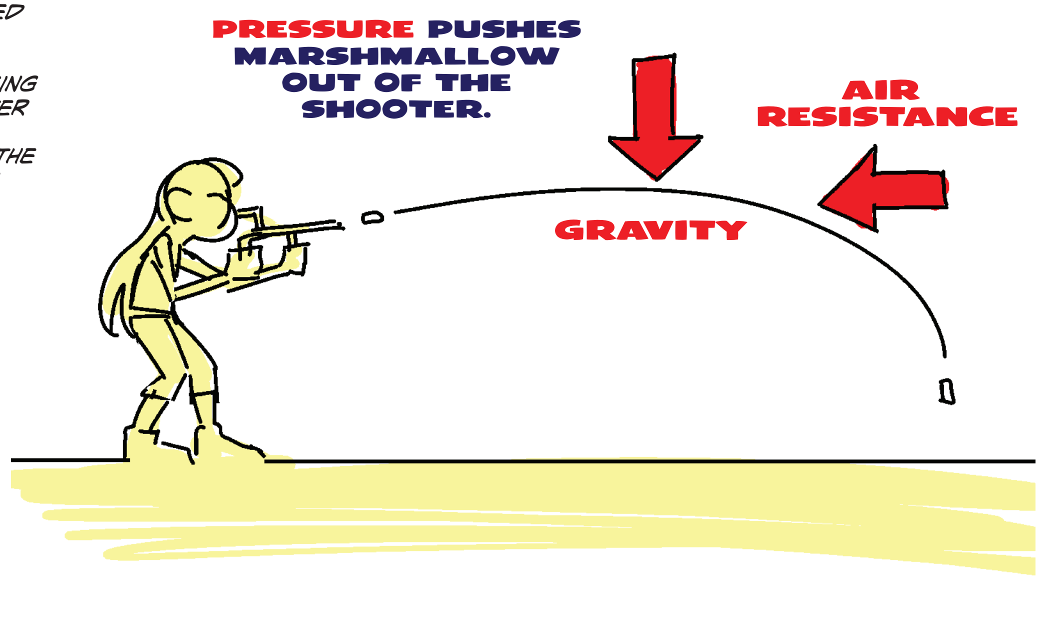
FRICTION IS A FORCE THAT SLOWS THINGS DOWN. ROUGHER SURFACES CREATE MORE FRICTION THAN SMOOTH SURFACES. MARSHMALLOWS WORK BEST IN THE SHOOTER WHEN ***FRESH*** AND COVERED WITH A LAYER OF POWDERED SUGAR, WHICH CREATES ***LESS FRICTION.***

Pressure:

A MEASURE OF THE "SQUEEZEDNESS" OF A GAS OR LIQUID, WHICH CAN PRODUCE A FORCE ON A SOLID OBJECT. THE MARSHMALLOW SHOOTER IS LIKE A GAS TANK, WHERE THE AIR PRESSURE BUILDS UP (SQUEEZES IN) AND PRODUCES THE FORCE THAT PUSHES THE MARSHMALLOW OUT.

Newton's Second Law of Motion:

ACCELERATION IS PRODUCED WHEN A FORCE ACTS IN A MASS. THE GREATER THE MASS (OF THE OBJECT BEING ACCELERATED) THE GREATER THE AMOUNT OF FORCE NEEDED (TO ACCELERATE THE OBJECT). THE BIGGER THE BREATH OF AIR THAT IS USED, THE FURTHER THE MARSHMALLOW WILL GO.



Newton's Third Law:

FOR EVERY ACTION THERE IS AN EQUAL AND OPPOSITE REACTION. AS YOUR BREATH PUSHES THE MARSHMALLOW AWAY FROM THE SHOOTER, IT ALSO PUSHES THE SHOOTER AWAY FROM THE MARSHMALLOW -- A VERY SMALL "RECOIL." IF YOU WERE ON A SKATEBOARD, YOU MIGHT EVEN START TO MOVE A LITTLE.

Design Your Own:

The Design Process:
The design process is a series of steps that engineers and designers use to help them make good products.

Design Cycle:
IDENTIFY → DESIGN → BUILD → TEST

IDENTIFY (Research & Define the Problem);

DESIGN (Brainstorming, Sketch, & Choose a Direction)

In the world of work, many people are a part of the design cycle. Engineers explain phenomena and develop solutions. Product designers make ideas functional. Artists/draftsmen communicate ideas. It takes all these people working together, brainstorming, planning, testing, and refining, to make a great product.

Draw It Up:
Using the blueprint in the comic as a model, draw a design for your shooter. Remember to list all the needed materials and show how they go together. Clear communication is key! Someone else should be able to use your drawing to build a shooter just like yours.

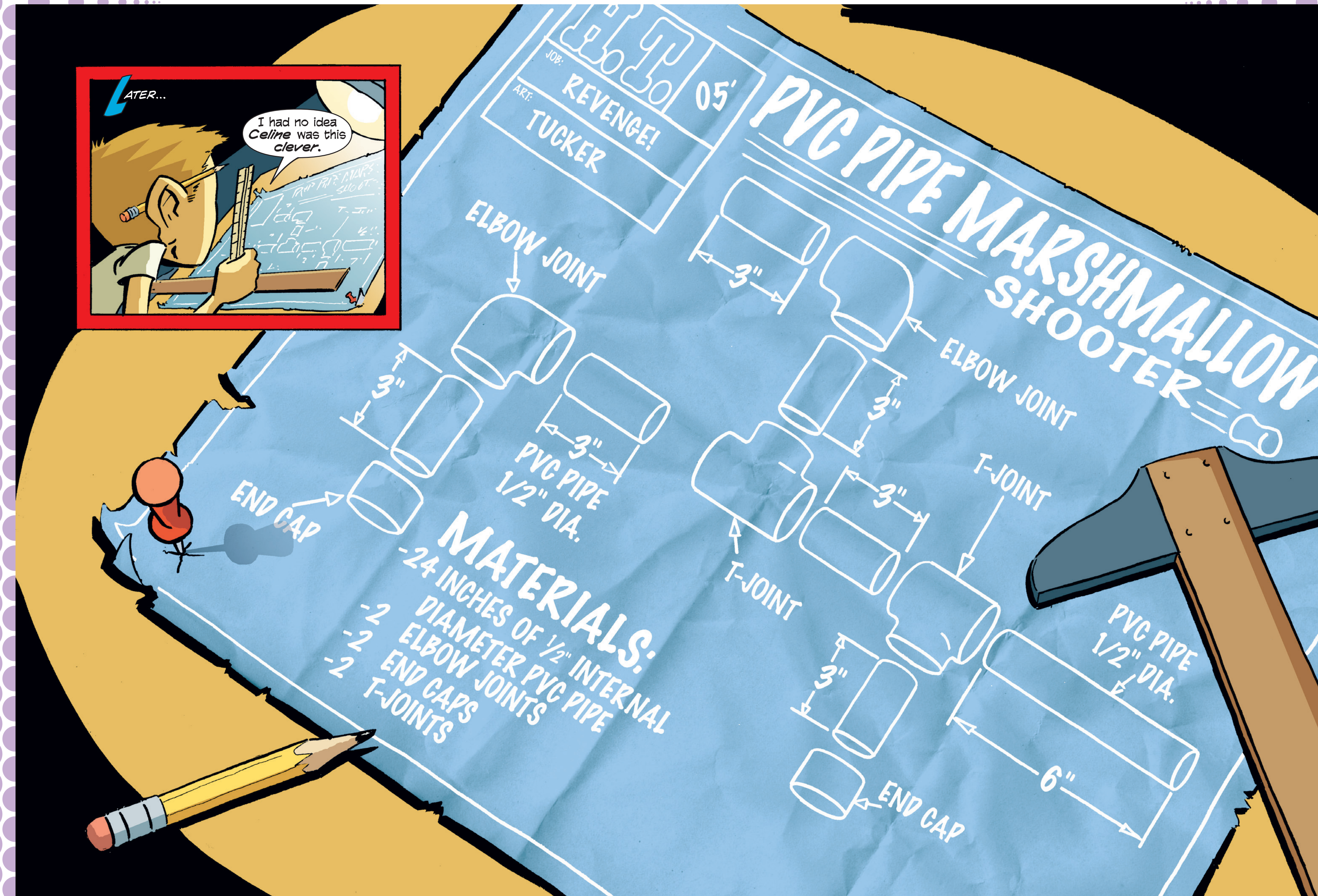
Form Follows Function:
When designing, keep in mind the purpose of the project--it has to ***work,*** not just look cool. For example, the original marshmallow shooter design has a bend in the tube so that it can have handles, making it easier to hold and position. Would this design work with something other than a marshmallow, like a dart? This design also allows the marshmallow to travel through 2 feet of pipe, an optimal amount to create the air pressure for long shots.

In the last panel of the comic, celine has a 5-barrel shooter. Draw a simple diagram of the airflow in the original shooter and in celine's 5-barrel design. Will celine's 5-barrel design work? It may look cool, but it won't work because air will escape out the extra four barrels and won't create enough pressure to shoot the marshmallow. Good design can improve function, but bad design hurts it.

Testing:
How will you evaluate your design? Decide on some criteria for success. You could design for the farthest shot, for ease of aim and use, or both. What other criteria will you use to determine success?

Once you've designed and built the first version of your own marshmallow shooter, test it out. Change one variable at a time and record data. Then, analyze your data and use what you learned to refine your design to make it better. Repeat until you're happy with your design.

Draw Time!


LATER...
I had no idea Celine was this clever.
JOB: REVENGE!
ART: TUCKER
05'
PVC PIPE MARSHMALLOW SHOOTER
ELBOW JOINT
3"
ELBOW JOINT
3"
3"
PVC PIPE 1/2" DIA.
3"
T-JOINT
T-JOINT
3"
END CAP
PVC PIPE 1/2" DIA.
6"
END CAP
MATERIALS:
-24 INCHES OF 1/2" INTERNAL DIAMETER PVC PIPE
-2 ELBOW JOINTS
-2 END CAPS
-2 T-JOINTS