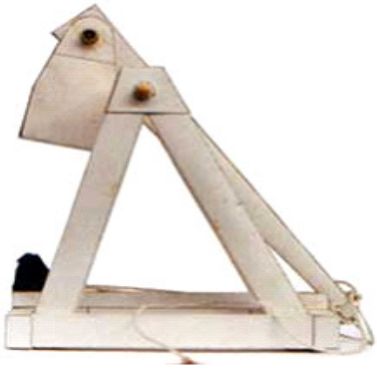
Name _____ Date _____ Period _____

Lab: Trebuchet

PHYSICS-CHAPTER 9: ENERGY

Background: A trebuchet is a siege engine that was employed in the Middle Ages either to smash masonry walls or to throw projectiles over them. It is sometimes called a "counterweight trebuchet" or "counterpoise trebuchet" in order to distinguish it from an earlier weapon that has come to be called the "traction trebuchet", the original version with pulling men instead of a counterweight.

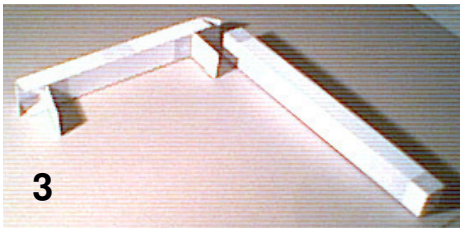


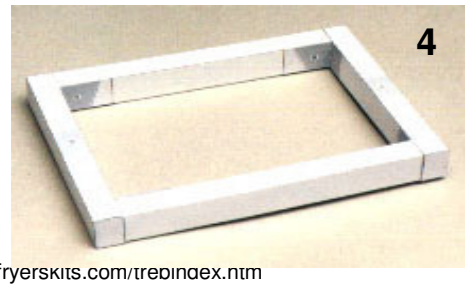
The counterweight trebuchet appeared in both Christian and Muslim lands around the Mediterranean in the twelfth century. It could fling up to three-hundred and fifty pound (140 kg) projectiles at high speeds into enemy fortifications. On occasion, disease-infected corpses were flung into cities in an attempt to infect or terrorize the people under siege—a medieval form of biological warfare. Traction trebuchets appeared in the Greek world and China in about the 4th century BC, and did not become obsolete until the 16th century, well after the introduction of gunpowder. Trebuchets were far more accurate than other medieval catapults.

Purpose: A trebuchet is a excellent model to demonstrate the Law of Conservation of Energy. After competing the model of your trebuchet, you will experiment using different amounts of weight in your trebuchet and record the changes in range produced.

Materials:

- (7) printed template sheets on card stock
- (2) 6-7 mm dowels or pencils
- (1) paper clip
- String
- 6 cm (2.5 inches) square of cloth
- Cutting board
- Straight edge (ruler)
- Scissors, craft knife
- Pliers
- Needle and thread
- Clear glue





Procedure:

Part 1: Making the Base

1. Cut out and fold parts 1, 2, 3, 4

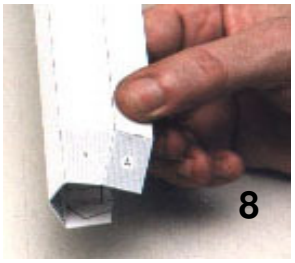
2. Glue cross hatched areas to parts numbered. Glue into 4, 4 sided long boxes.

3. Glue 1 and 2 together at right angles.

4. Complete 4 sided frame

Taken from Fryer's Kits: http://web.archive.org/web/20041204073720/www.fryerskits.com/trebindex.htm

Part 2: Making Uprights



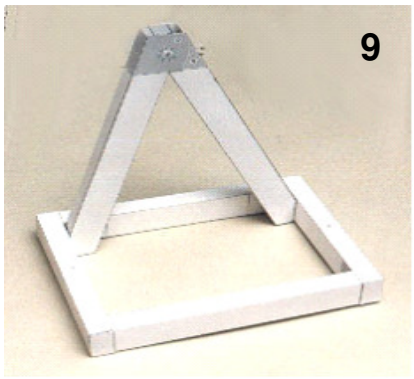
5. Cut out, score parts 5, 6, 7, and 8.

6. Roll paper lengths (parts 9, 10) 4-5 times around a cylindrical pencil so that it is a tight but not stuck, glue.

7. Put paper tubes against pivit holes and score around them.and cut radial lines up to score mark

8. Fold and glue parts 5, 6, 7, and 8. On each upright two small tabs must be glued

9. Glue to base

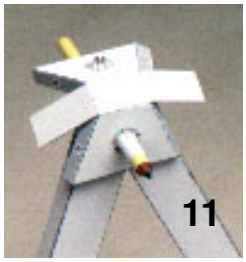


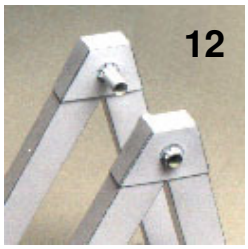
10. Fit paper tube part 9 with pencil into holes on upright parts 5, 6. Fit flaps inside. Repeat on other upright

11. Cut pivit holes as on uprights. Cut out and fold 11, 12 and fit on top of uprights ,flaps folded out.

12. Position first then take apart, glue and fit. Flaps and paper tube should stick out on the outside 5 mm (1/4 inch).

13. Cut out, fold and glue 13, glue to base

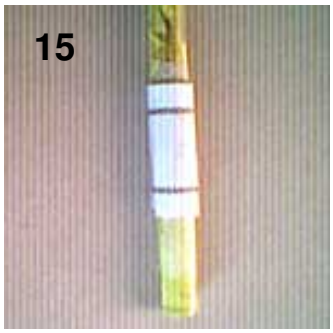


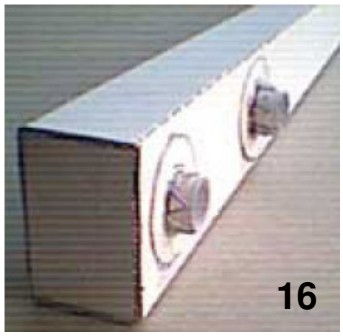


Part 3: Making the Swinging Arm

14. Fold (part 14) first 3 folds inwards and glue, rest of folds go opposite way and glue.

15. Wrap a pencil with 3 layers of tape and wrap part 15 around pencil, glue and press into swinging arm. Glue parts 16 and 17 in place.





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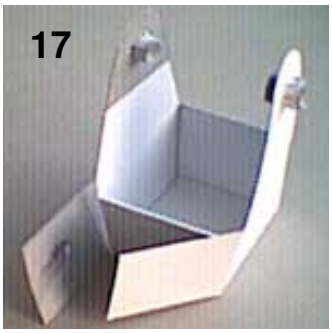
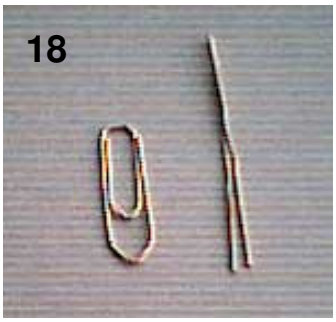
16. Do same with parts 18, 19 and 20. Fit and glue part 21.

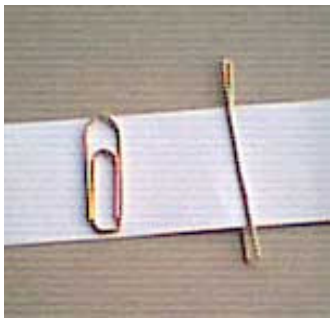
17. Cut out and fold cradle part 22, roll parts 23 and 24 around pencil, fit in holes with tabs sticking out and glue. Glue parts 25 and 26 in place with tabs sticking out.



Part 4: Making the Hook and Sling

18. Straighten a paper clip and bend double. Cut strip of paper 15 mm (5/8 inch) less in width than the paper clip.

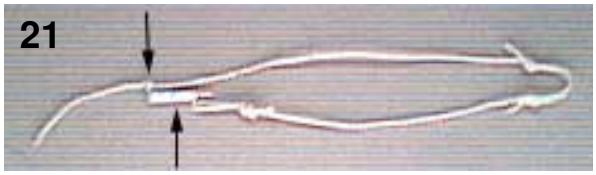




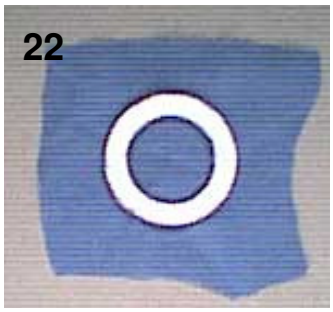
19. Roll paper around paper clip to a width shown that gives it a push fit into end of swinging arm. Allow 10 mm at looped end and 5 mm at other end, bend and pinch the 2 ends onto paper.

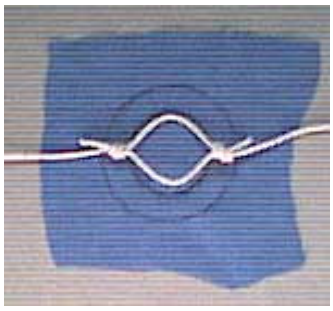
20. Knot the strings like this. Distance shown on paper.

21. and this, with paper clip shown by arrow. The knot shown by arrow should be further from the end of the loop by the length of the paper on the paperclip.



22. Cut out paper ring and draw edges on piece of thin cloth. Sew string onto cloth, starting with the knots and then half way along loop. The loop of the string should be a little smaller than the inner circle on the cloth which, when hem is sewn down will form a pouch.





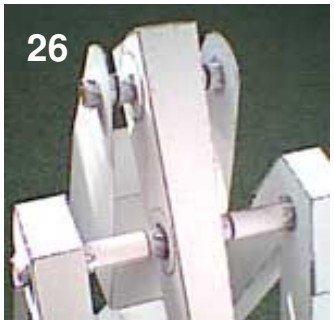
23. When paperclip part 27 is pressed in after knot on slingshot part 28

24. The loop is placed over paperclip, the pouch should be level and hang evenly, adjust if necessary.

25. Cut dowel or pencil to length shown

26. Fit pencils and assemble. Both cradle and swinging arm should swing freely

Part 5: Setup

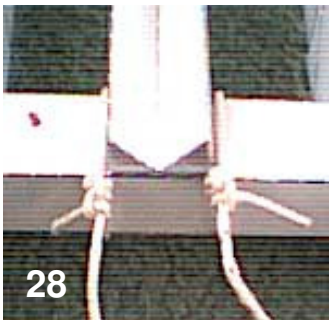


27. Fill cradle with weight, coins work well

28. The trigger is made up of one short and one long length of string tied on to the frame of the trebuchet as shown in picture. Tie a single bow knot. The longer string with the bow in it, and pull from side that it is tied to. Load with projectile

29. The grape, use something soft, fired from a trebuchet can travel 10 m (30 feet) or more and not always in the direction you thought it would. Always stand to the side.

30. Pull string slowly, make sure the trebuchet is not pulled out of position. The trajectory of the projectile can be altered by bending the paper clip up will give lower trajectory. Finally glue paper clip into swinging arm. Look at completed model to help you.



The completed trebuchet should look like the photo to the right. Experiment with differing amounts of weight in the swinging basket and also with different projectiles.

Part 6: Testing your Trebuchet

1. Roll up a small amount of clay and make a projectile between 1-2 cm in diameter. Weigh with scale. Mass of clay = _____ g

2. Start with 20 pennies of weight in your swinging basket. Before you put them into the basket, weigh them on a triple beam scale and record. Weight of 20 pennies = _____ g

3. Measure the distance traveled at least 3 times and record the average distance (range) of your projectile. Average range w/ 20 pennies = _____ meters

4. Add 20 more pennies to the basket. Weight of 40 pennies = _____ g

5. Measure the distance traveled at least 3 times and record the average distance (range) of your projectile. Average range w/ 40 pennies = _____ meters

6. Add 20 more pennies to the basket. Weight of 60 pennies = _____ g

5. Measure the distance traveled at least 3 times and record the average distance (range) of your projectile. Average range w/ 60 pennies = _____ meters

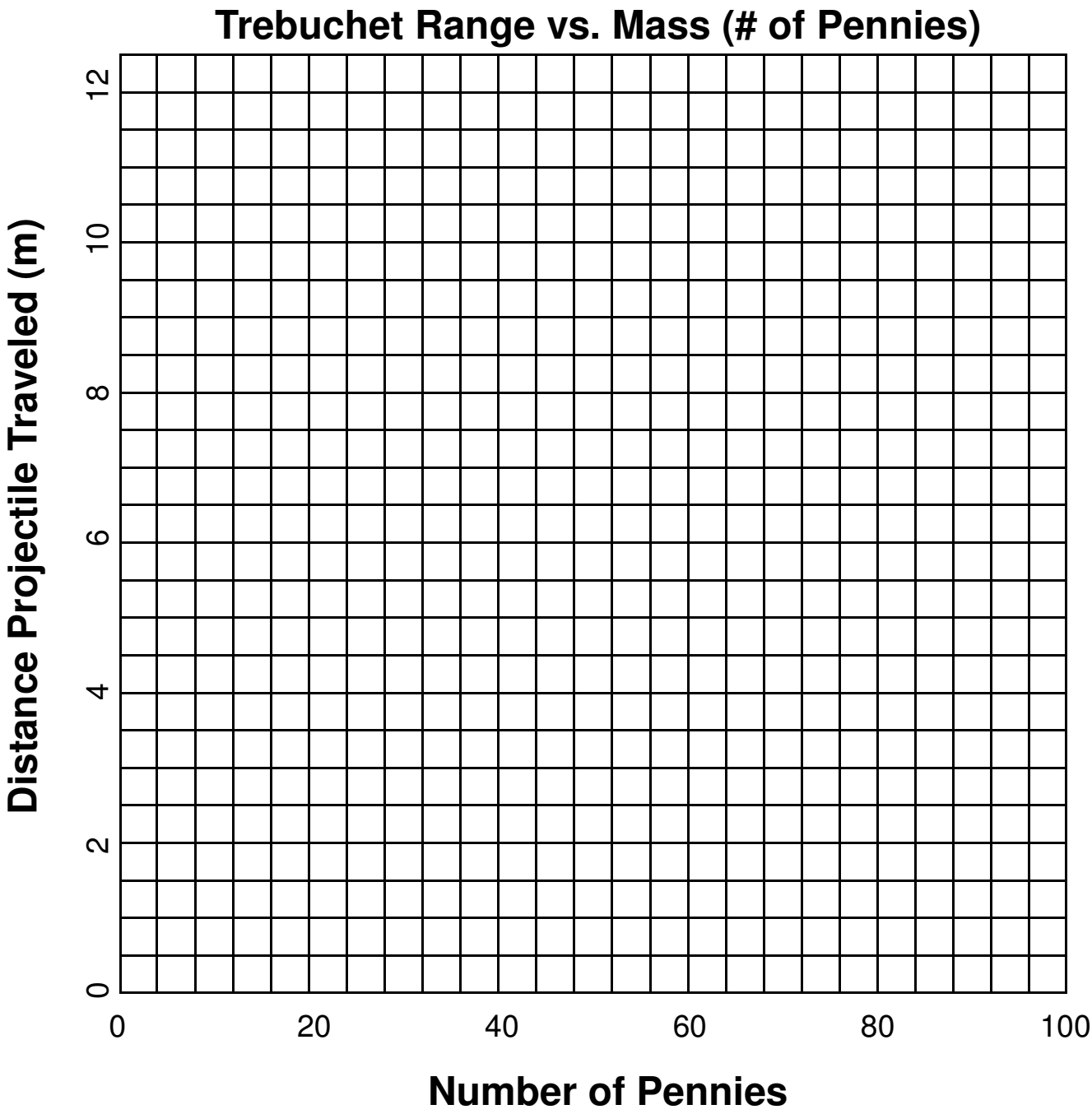
Conclusion Questions:

1. Use the data you collected utilizing the different amount of mass in the swinging basket and graph your results below. Extrapolate your data out to a mass of 80 and 100 pennies. According to your graph, how far should the trebuchet have launched your projectile with the following masses.

a. 80 pennies = _____ meters

b. 100 pennies = _____ meters

2. Try it again with 80 and 100 pennies. Did you results match you prediction? If not, why? Explain



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3. What supplied the energy to propel the projectile with your trebuchet?

4. What type(s) of energy was this initial energy transformed into when you launched your projectile?

5. How does this demonstrate the Law of Conservation of Energy?

6. Was all of the gravitational potential energy converted into kinetic energy? How might you check?

7. A trebuchet works by using the mechanical advantage principle of leverage to propel a stone or other projectile much farther and more accurately than a catapult, which swings off the ground. Explain what is meant by mechanical advantage.

8. How do you think you could improve the performance (increase the range) of your trebuchet?

7. What effect do you think doubling the length of the lever arm on the trebuchet would do to the range of your projectile? Explain

9. What do you think doubling the mass of your projectile have on it's range? Explain

Try it and check.

10. The trebuchet is often confused with the earlier torsion siege engines. The main difference is that a torsion siege engine (examples of which include the onager and ballista) uses a twisted rope or twine to provide power, whereas a trebuchet uses a counterweight. How does the twisted rope supply energy to launch a projectile? What is this energy called?