Background

In modern times, the word catapult can be used to describe any machine that hurls a projectile. This can include a sling shot used to hurl pebbles, a machine that launches airplanes off aircraft carriers or even a watch that flings BBs! There are several different kinds of catapults - the Greeks & the "ballista", the Romans & the "mangonel" or "onager", or the French & the "trebuchet". Contrary to popular belief, cats were not used as projectiles in ancient times. Cats were extremely rare in areas where the catapult was mainly used. In medieval times the "trebuchet" was actually used to catapult dead humans into castles & fortresses to spread diseases.

For your information, both catapults & ballistas work by storing tension either in twisted ropes or in a flexed piece of wood (in the same way an archery bow does, but on a larger scale). On the other hand, a trebuchet consists simply of a pivoting beam & a counterweight that rotates the beam through an arc.

Task

Your task is to (a) build a simple "catapult" with a rat trap that uses marshmallows (or similar soft objects) as projectiles & then (b) perform a series of calculations & measurements to determine the efficiency of your catapult.

Limitations

1. The teacher will provide you with all the necessary material to build your catapult.
2. You will be given two periods of class-time to (a) build your catapult & (b) perform your measurements/calculations. Depending upon time, a third period may be assigned to write-up your report (but don't count on it).

Process

1. Form groups of 2 (or 3) & build your catapult with the materials provided. Your teacher will demonstrate how you are to build it. You will need these construction instructions later so pay attention! **NOTE: If you choose to work in a group of 3 there will be additional work - see instructions below.**
2. Perform the measurements & calculations outlined in 3 (b) to (e).
3. Prepare a written report (pen & single-sided) that includes the following categories & calculations (C) or measurements (M):
   (a) a description of how the catapult was constructed
   - list of materials & measuring equipment/probeware
   - instructions including diagrams and/or photos to aid construction
     Hint: these instructions should be written in brief yet precise numbered format (much like a recipe) in third person past tense (ie do not use personal pronouns like I, we, or you)

   (b) an overview of the physics
   - the angle (β) the catapult arm makes with the horizontal at the time of release (M)
   - the launch angle (θ) of the projectile (C)
     Hint: θ is the angle at which the projectile is launched - this is measured with respect to the horizontal (assuming the projectile is released at 90° to the catapult arm draw a diagram & prove that $\theta = 90° - \beta$)
   - the average force (F_{avg}) applied to the projectile (M)
     Hint: use a force probe to measure the force at several points in the arc & then average these values (be sure to record the forces)
   - the distance (d) through which the force is applied (M&C)
     Hint: the path is an arc - measure the radius of rotation (r) & then use $d = 2 * \pi * r * \beta \div 360$
   - the mass ($m_{projectile}$) of the projectile (M&C)
     Hint: not only is the projectile being accelerated but so too is the arm so $m_{projectile} = m_{rat\ trap\ \&\ projectile} - m_{rat\ trap}$
   - the average acceleration (a_{avg}) of the projectile (C)
     Hint: $a_{avg} = F_{avg} \div m_{projectile}$
   - the average launch velocity (C)
     Hint: $v_{launch} = \sqrt{(2 \times d \times a_{avg})}$

   (c) a theoretical prediction for the performance of the catapult
   - the flight range (C)
     Hint: $r_{flight} = v_{launch}^2 \times \sin 2\theta \div g$

   (d) an analysis of the catapult's performance
   - the range (M)
     Hint: measure the distance from where the projectile is launched to where it hits (do several trials & then average the distances - be sure to record the distances)

   (e) an evaluation of the catapult's performance
   - % difference between the calculated & measured range (C)

   (f) a discussion of the catapult
   - % differences (ie identify at least 6 errors - choose 3 - fully explain how you think each affected your results)
   - process (ie what worked, what didn't work & what would you do next time & why)

Checklist

☞ 2 STUDENTS	(a) to (e)
☞ 3 STUDENTS	same as 2 students + (f)

NOTE

① One report per group is expected. However, if you wish to work alone you may. If you have any difficulties with your partner let the teacher know immediately!

② Each calculation/measurement must include how it was measured/determined using GRESS. Your solutions MUST be done in good. Do NOT attach your rough work & call that your solution!

③ Any tests of the catapult must be carried out in a way that ensures absolutely no damage is done to people or furniture. Safety should always be a prime consideration in the building & testing of the "catapult".

④ A general rule of thumb for the calculations is 1 decimal place or 2 significant digits

FIZZIX CATAPULT REPORT

Student(s):

✔ = correct/present/good ✘ = wrong/absent/poor
0 = poor/not done 1 = good 2 = very good 3 = excellent

2 STUDENTS	(a)	CATAPULT CONSTRUCTION	
		• list of materials/equipment	❑
		• numbered steps	❑
		• diagrams/photos for each step of construction (3 diagrams/photos minimum)	❑ ❑ ❑
		• 3rd person & past tense	❑ ❑
		• detail	0 + 1 + 2 + 3
		PRESENTATION	
		• pen/computer & singled sided	❑ ❑
		• neat & organized (labels, easy to follow, ...	0 + 1 + 2
		• grammar & spelling (full & complete sentences, makes sense, ...	0 + 1 + 2
	(b)	OVERVIEW OF THE PHYSICS INVOLVED	
		• launch angle (M&C)	0 + 1 + 2 + 3
		• average force applied to projectile (M) (several trials performed & averaged)	0 + 1 + 2
		• distance through which force is applied (M&C)	0 + 1 + 2 + 3
		• mass of the projectile (M&C)	0 + 1 + 2
		• average acceleration of the projectile (C)	0 + 1 + 2 + 3
		• average launch velocity (C)	0 + 1 + 2 + 3
	(c)	THEORETICAL PREDICTION FOR PERFORMANCE	
		• range (C)	0 + 1 + 2 + 3
	(d)	ANALYSIS OF PERFORMANCE	
		• range (M) (several trials performed & averaged)	0 + 1 + 2
	(e)	EVALUATION OF PERFORMANCE (% DIFFERENCE)	
		• range (C)	0 + 1 + 2 + 3
		PRESENTATION (b-e)	
		• pen/computer & singled sided	❑ ❑
		• neat & organized (labels, easy to follow, ...	0 + 1 + 2 + 3
		TOTAL ☞	/45
3 STUDENTS	(f)	DISCUSSION	
		• 6 different errors identified (½ mark each)	0 + 1 + 2 + 3
		• 3 errors discussed fully 1 page minimum ☞	❑
		(2 marks each - errors identified & effects analyzed)	0 + 1 + 2 + 3 + 4 + 5 + 6
		• evaluation of process 1 page minimum ☞	❑
		(2 marks each - what worked, what didn't work, next time & why)	0 + 1 + 2 + 3 + 4 + 5 + 6
		PRESENTATION	
		• pen & singled sided	❑ ❑
		• neat & organized (labels, easy to follow, ...	0 + 1 + 2
		• grammar & spelling (full & complete sentences, makes sense, ...	0 + 1 + 2 + 3
		TOTAL ☞	/69

Comments