CATAPULTS

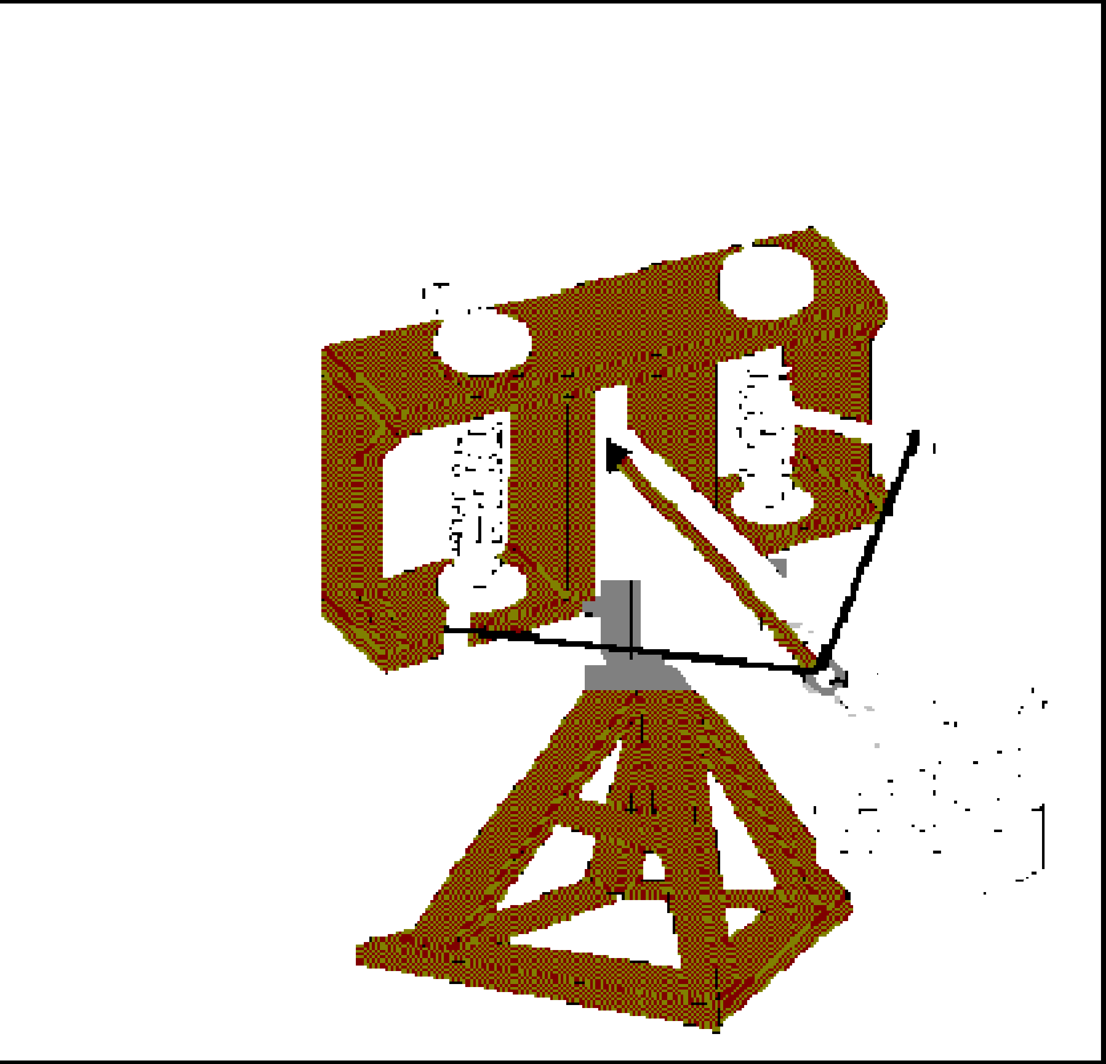
12 JAN 2011 – Date of Project Competition

Engineering Explorer Post 228

Types of Catapults

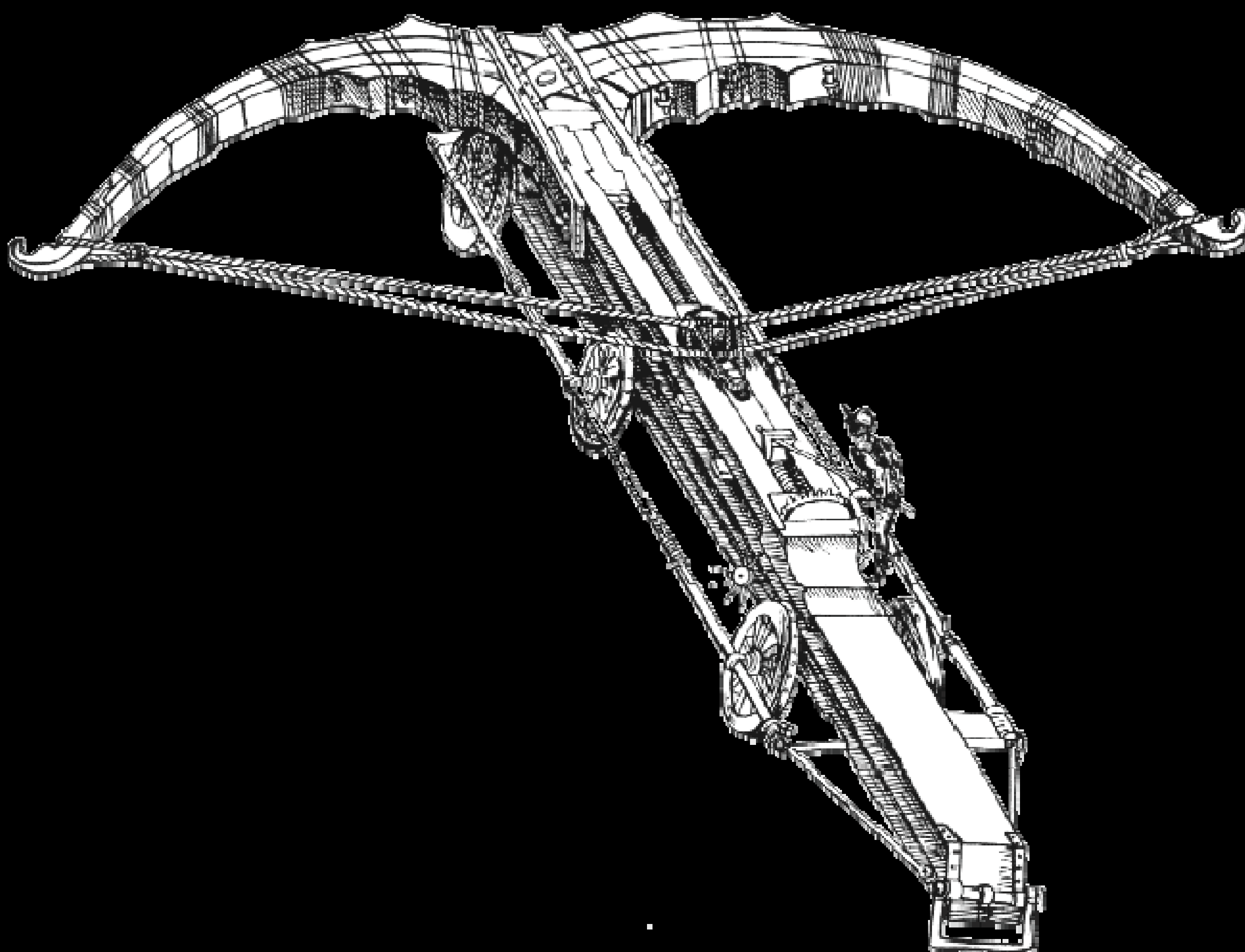
All this stuff is taken off of the internet so feel free to do some research for ideas

Balista

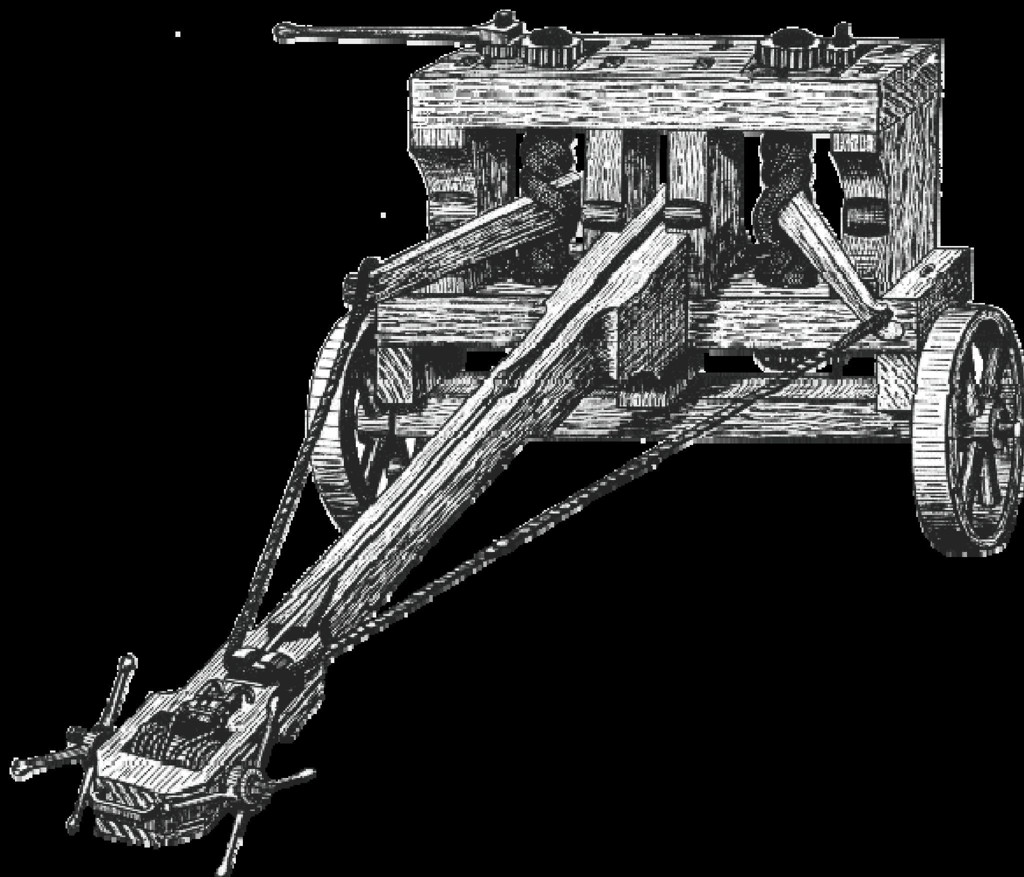


Ballista

Ballista

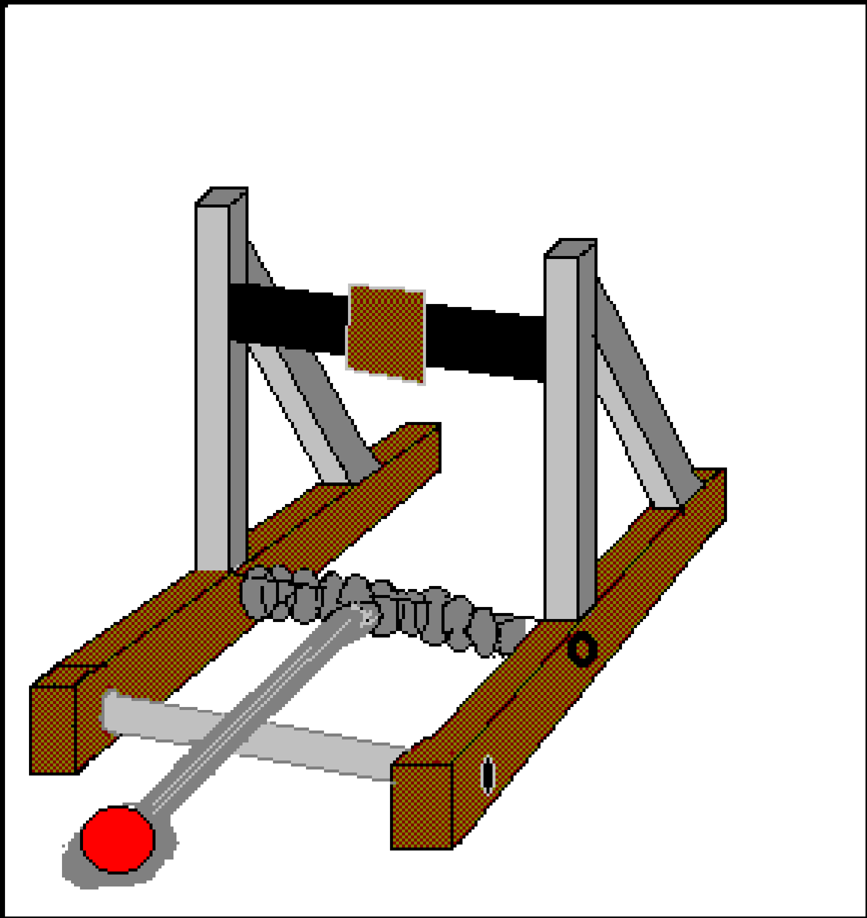


Ballista



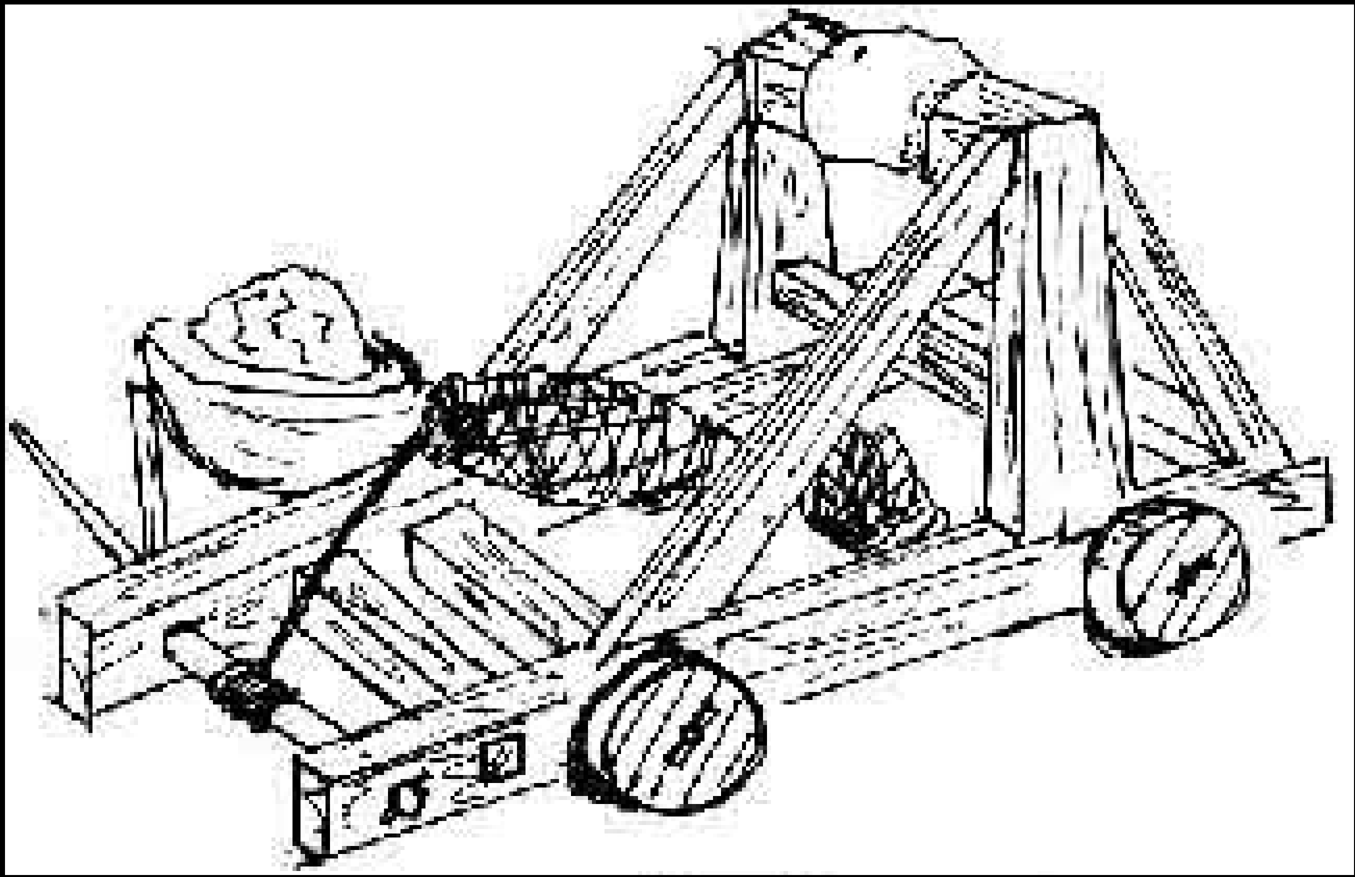
BOY SCOUTS OF AMERICA

Mangonel

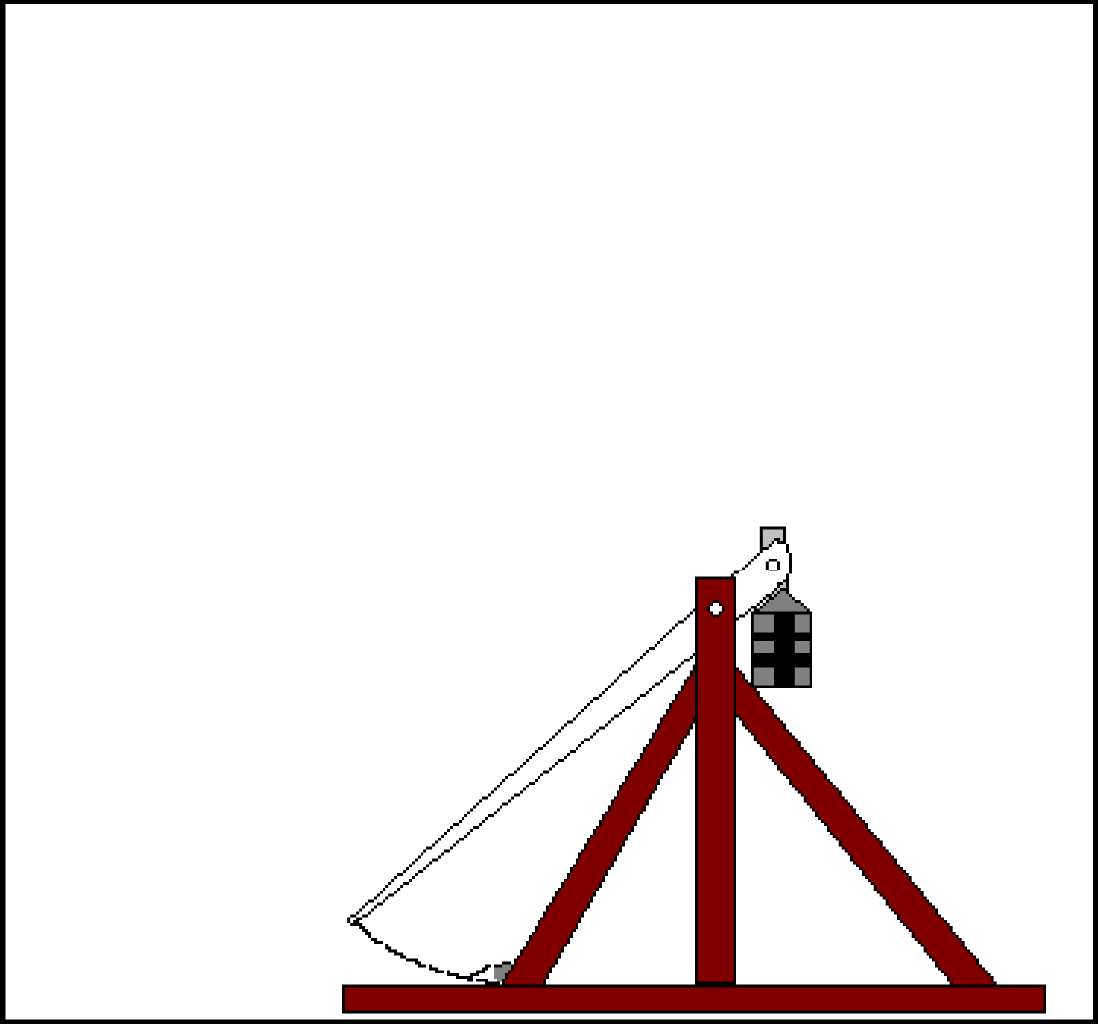


Mangonel

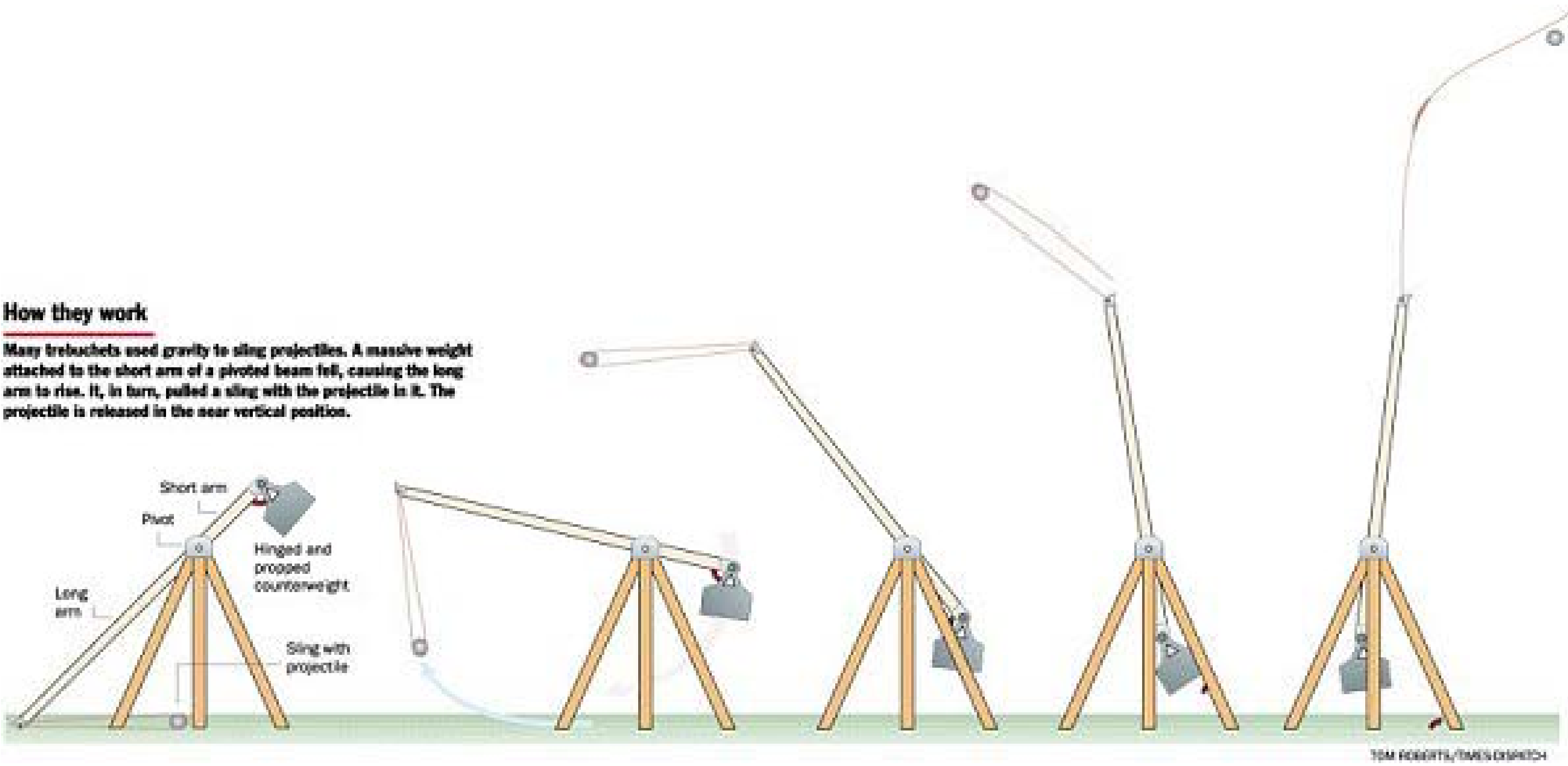
Mangonel



Counterpoise Trebuchet



Trebuchet Steps



Counterpoise Trebuchet

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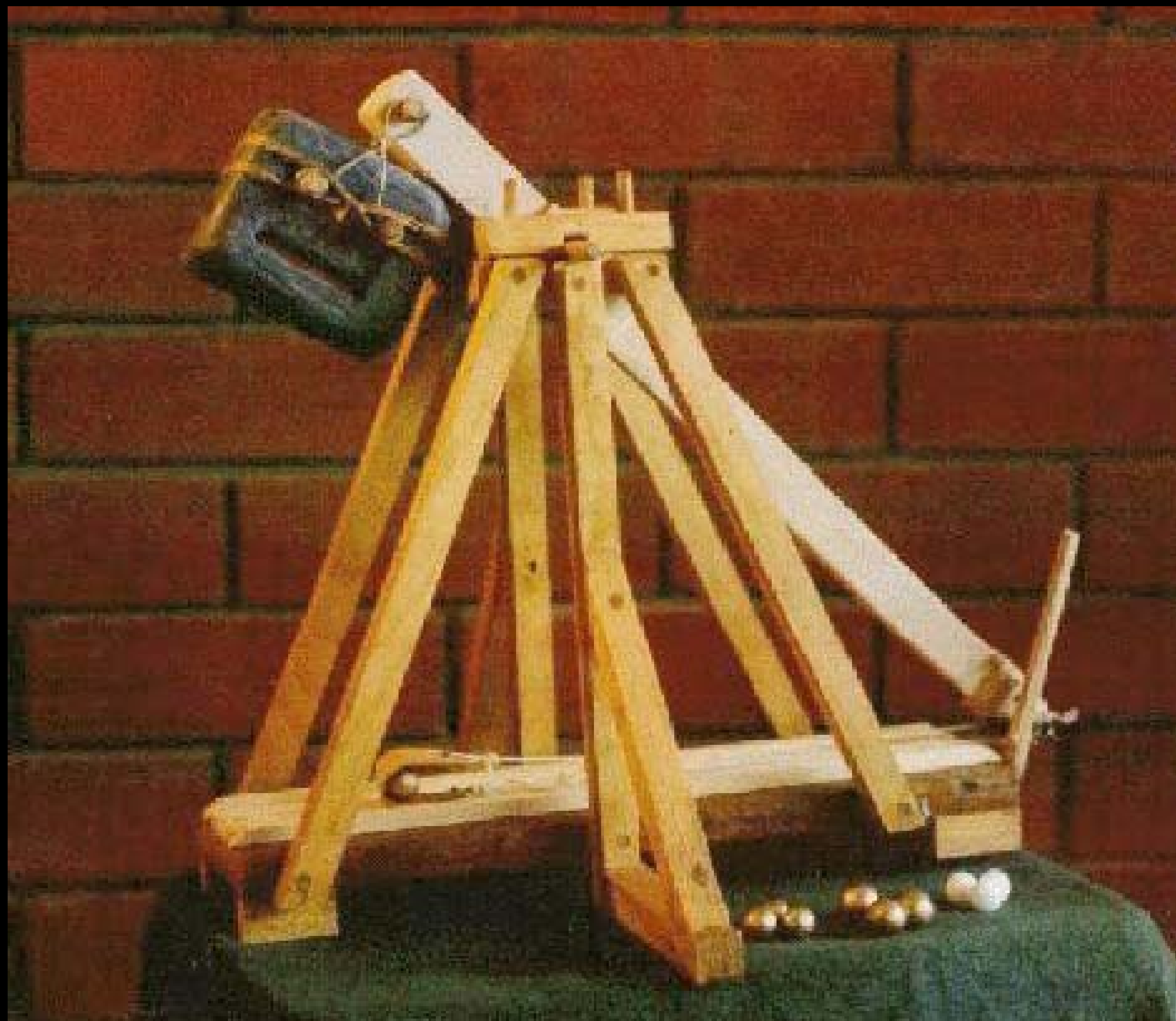
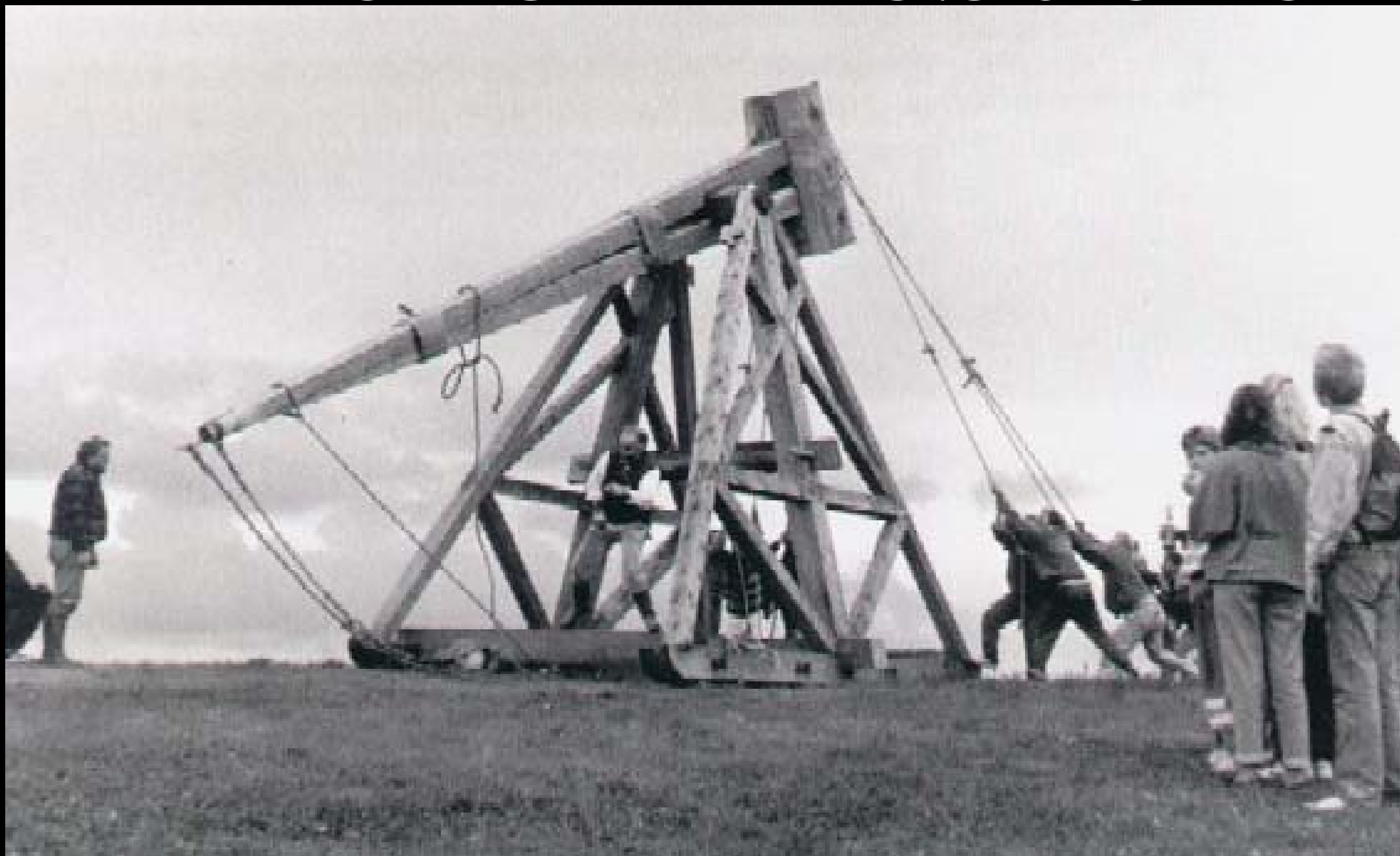
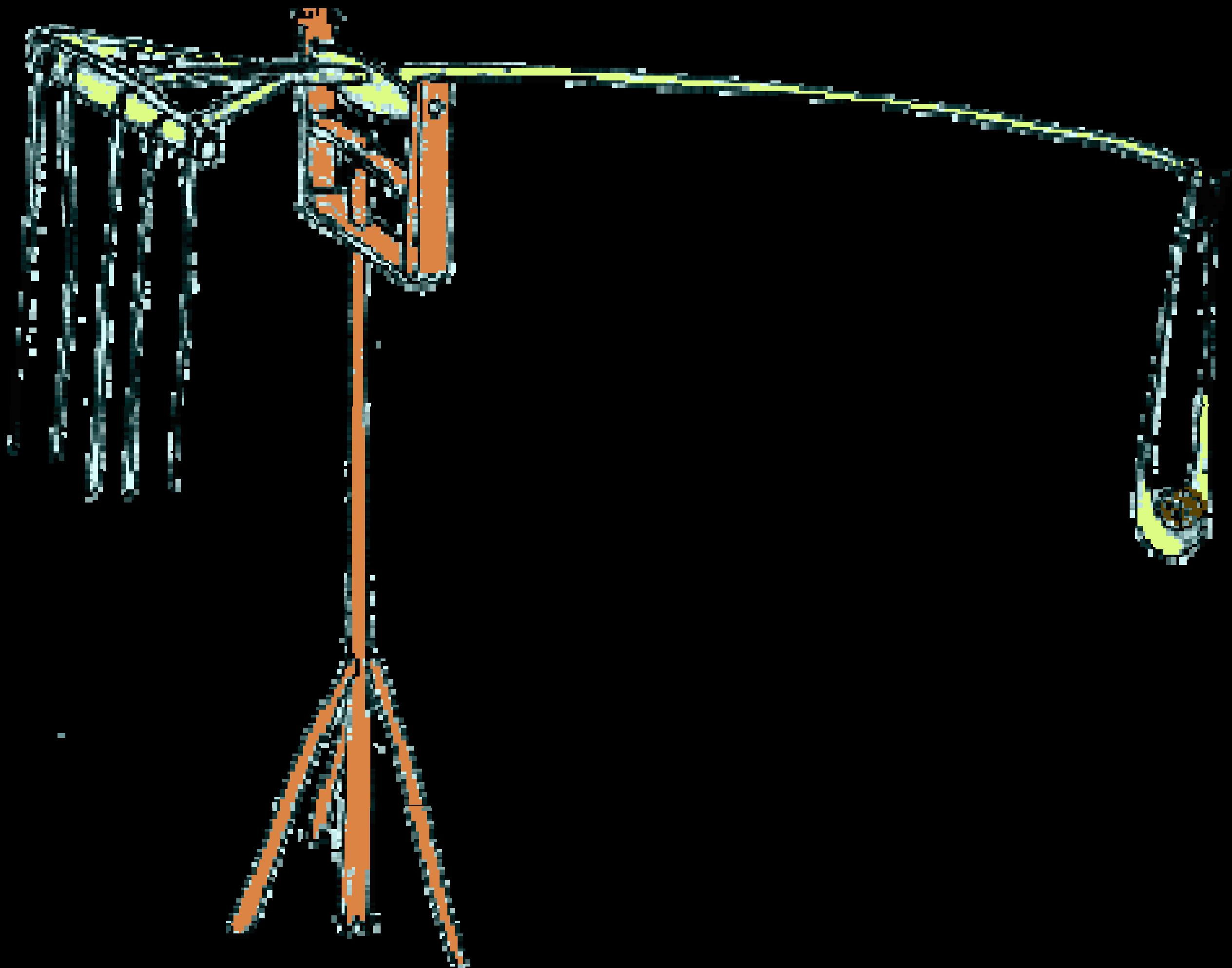


Traction Trebuchet

Traction Trebuchet



Traction Trebuchet



Trebuchet Tips

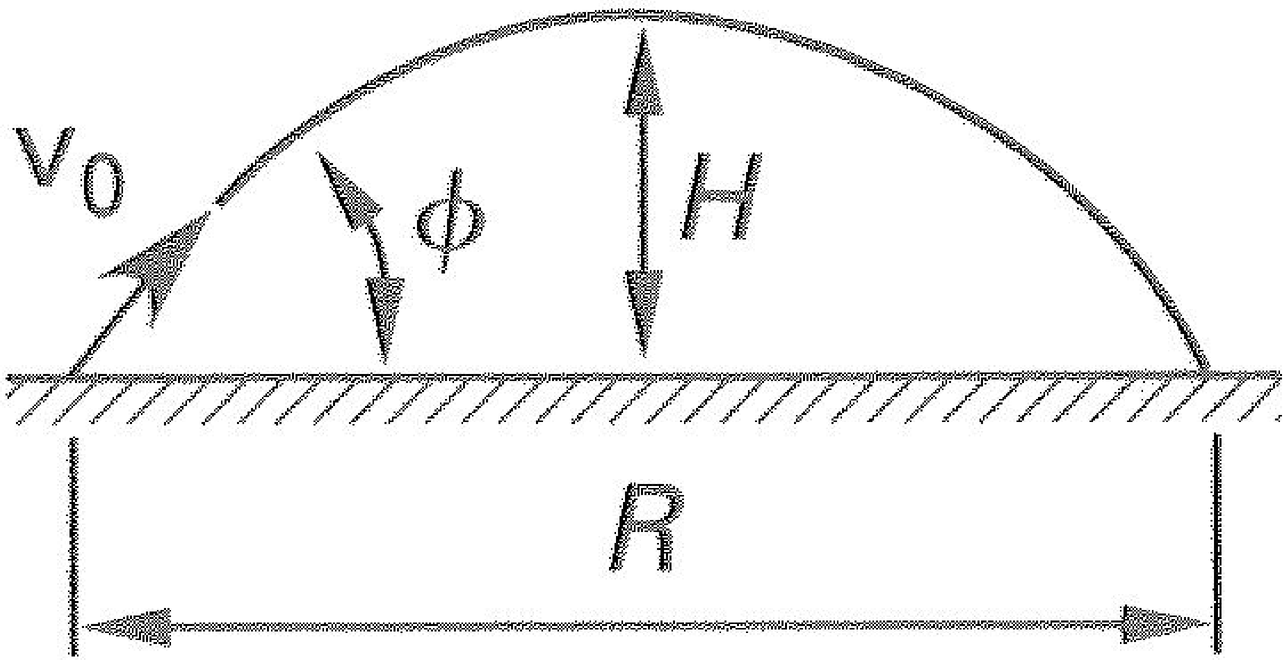
- If your trebuchet's release mechanism is the usual ring over a prong or hook, it is going to release the sling as soon as the angle between the sling ropes and the arm is straight enough for the ring to slip off the prong. You can adjust when the sling releases in a number of ways:

- **By setting the angle of the prong -** a more hooked prong will hold the sling loop longer than a straighter one.
  - ie a prong less hooked or in line with beam = earlier release = higher trajectory
    ... a prong more hooked or forward-pointing = later release = flatter trajectory

- **By changing the length of the cords that hold the sling pouch..**
  - If the sling is rotating around the end of the beam slowly, the beam will have time to swing through a bigger arc before the sling catches up to it. If the sling is rotating quickly, the release angle will happen earlier.
    A shorter sling will rotate faster than a long sling.
    ie short sling cords = fast sling rotation = earlier release = higher trajectory
    ... long sling cords = slow sling rotation = later release = flatter trajectory

- **By choosing the size of your shot..**
  - Another thing that influences when a sling releases is the force on it - a heavier projectile tends to pull the loop off the prong earlier than a lighter projectile does.
    ie heavy projectile = earlier release = higher trajectory
    .. light projectile = later release = flatter trajectory

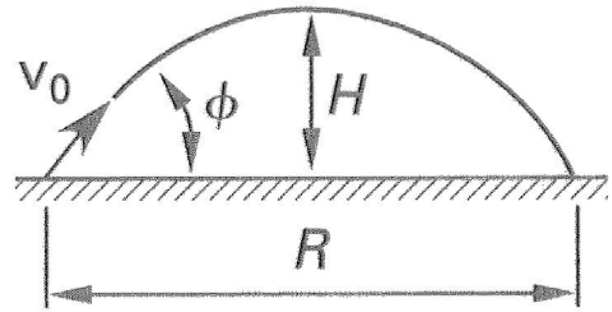
The Engineering Part



Vo is the initial velocity (mph or ft/s) achieved at launch, **R** is the total distance (feet) traveled, **H** is the height (feet) achieved and **Φ (phi)** is the angle (degrees) at launch.

This neglects air friction and assumes level launch and landing points.

Calculation

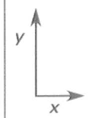
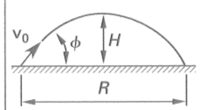
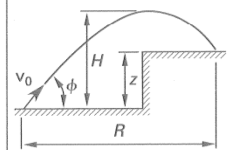
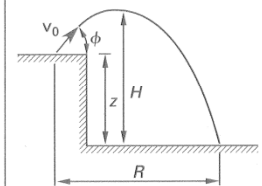
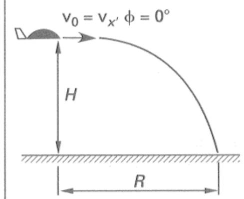


- Depending on what data we have we can predict the distance or height, and back-calculate to find Vo.
- Assuming the **Vo** is constant each time we launch, we can control the distance **R** by changing the launch angle **Φ**.

Calculation

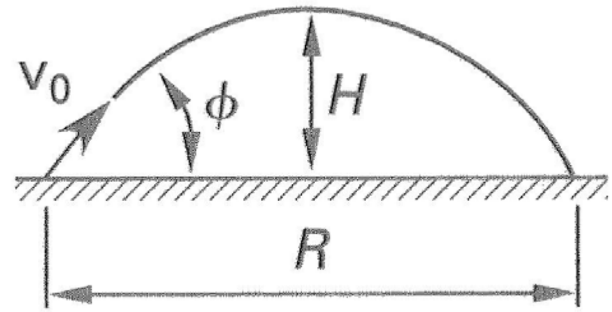
From this page in my Mechanical Engineering Reference Handbook select an equation that we can use.

Table 55.2 *Projectile Motion Equations*
(ϕ may be negative for projection downward)

	level target 	target above  (assuming projectile does clear the vertical rise)	target below  (assuming projectile does clear the edge of the vertical drop)	horizontal projection 
$x(t)$	$(v_0 \cos\phi)t$			$v_0 t$
$y(t)$	$(v_0 \sin\phi)t - \frac{1}{2}gt^2$			$H - \frac{1}{2}gt^2$
$v_x(t)$	$v_0 \cos\phi$			v_0
$v_y(t)$	$v_0 \sin\phi - gt$			$-gt$
$v(t)$	$\sqrt{v_0^2 - 2gy} = \sqrt{v_0^2 - 2gtv_0 \sin\phi + g^2t^2}$			$\sqrt{v_0^2 + g^2t^2}$
$v(y)$	$\sqrt{v_0^2 - 2gy}$			$\sqrt{v_0^2 + 2g(H-y)}$
H	$\frac{v_0^2 \sin^2\phi}{2g}$	$\frac{v_0^2 \sin^2\phi}{2g}$	$z + \frac{v_0^2 \sin^2\phi}{2g}$	$\frac{1}{2}gT^2$
R	$v_0 T \cos\phi$			$v_0 T$
	$\frac{v_0^2 \sin 2\phi}{g}$	$\left(\frac{v_0 \cos\phi}{g}\right)\left(v_0 \sin\phi + \sqrt{v_0^2 \sin^2\phi - 2gz}\right)$	$\left(\frac{v_0 \cos\phi}{g}\right)\left(v_0 \sin\phi + \sqrt{2gz + v_0^2 \sin^2\phi}\right)$	
T	$\frac{R}{v_0 \cos\phi}$			$\sqrt{\frac{2H}{g}}$
	$\frac{2v_0 \sin\phi}{g}$	$\frac{v_0 \sin\phi}{g} + \sqrt{\frac{(2)(H-z)}{g}}$	$\frac{v_0 \sin\phi}{g} + \sqrt{\frac{2H}{g}}$	
t_H	$\frac{v_0 \sin\phi}{g} = \frac{T}{2}$	$\frac{v_0 \sin\phi}{g}$		

Engineeri

Calculation

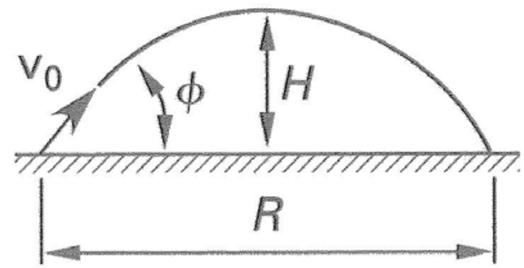


- We can measure **R** after landing and approximate phi between 0 and 90 degrees so we can calculate Vo using the equation.
- Using the equation (from the handbook)

$$R := \frac{V_o^{\,2} \cdot \sin(2 \cdot \phi)}{g}$$

Rearrange to solve for **Vo**

Calculation



Rearrange to solve for **Vo**

$$V_o := \sqrt{\frac{R \cdot g}{\sin(2 \cdot \phi)}}$$

Assume we measure

R= 10ft   and

Φ = 60 deg

- Plug in values and solve for **Vo** and we get

$$V_o = 19.3 \frac{ft}{s}$$

or

$$V_o = 13.1 mph$$

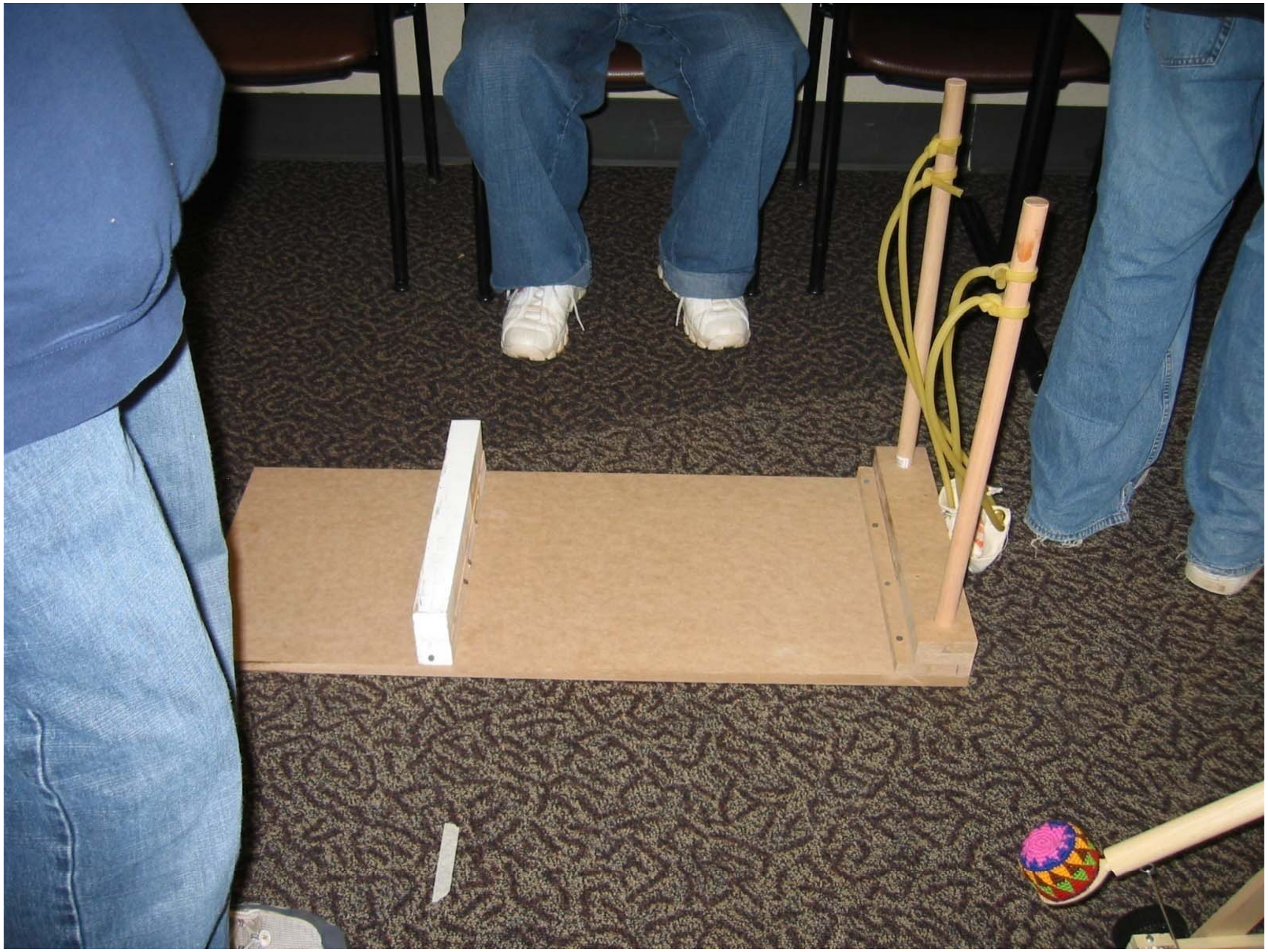
Why is this useful?

Next Meeting

- You will bring a catapult in that you make at home
- Purpose
  - Propel a standard ‘Hackey Sack’ with home-made catapult
  - Prizes given for
    - Distance
    - Style
    - Accuracy

Previous Years Examples

Previous Years Examples



Previous Years Examples

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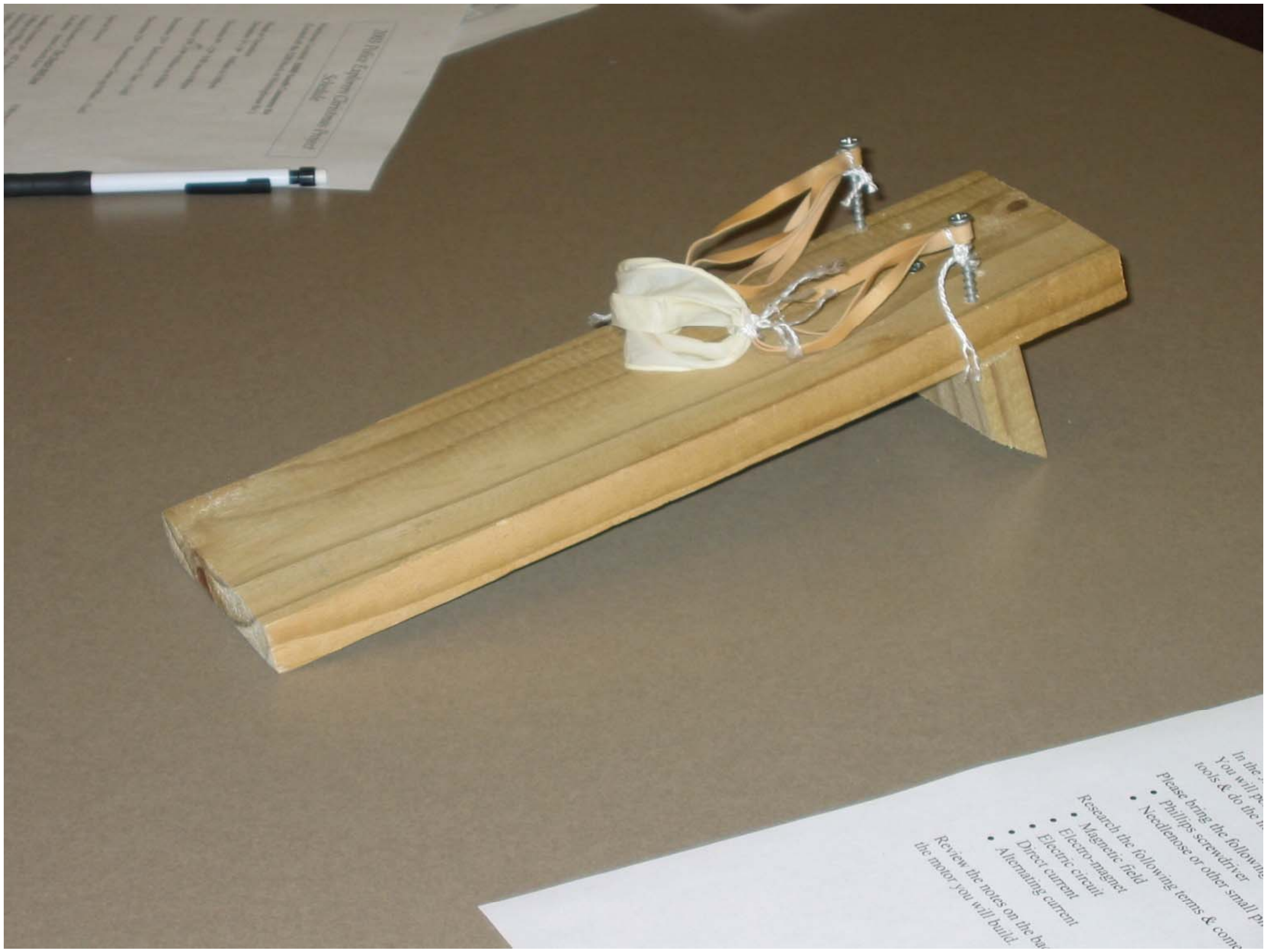

Previous Years Examples

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Catapults – 12 JAN 2008

- Requirements
  - Have Fun
  - Must fit in 2’ x 1’ x 2’ box (before launch)
  - Can be any type of catapult
- Competition
  - Distance
  - Accuracy

- Materials allowed
  - Small size wood, balsa wood, or equivalent
  - Steel Springs / Rubber Bands
  - Rope/Twine
  - Epoxy/Glue
- Materials *NOT* Allowed
  - Nails/Screws
  - Pre-made Kits
  - Plywood over ½” Thick
  - Dowel Rods over ¾” Diameter
  - Dimensional Lumber (1 x or 2 x)

No dollar limit, but reimbursement available for up to $20 with receipts.