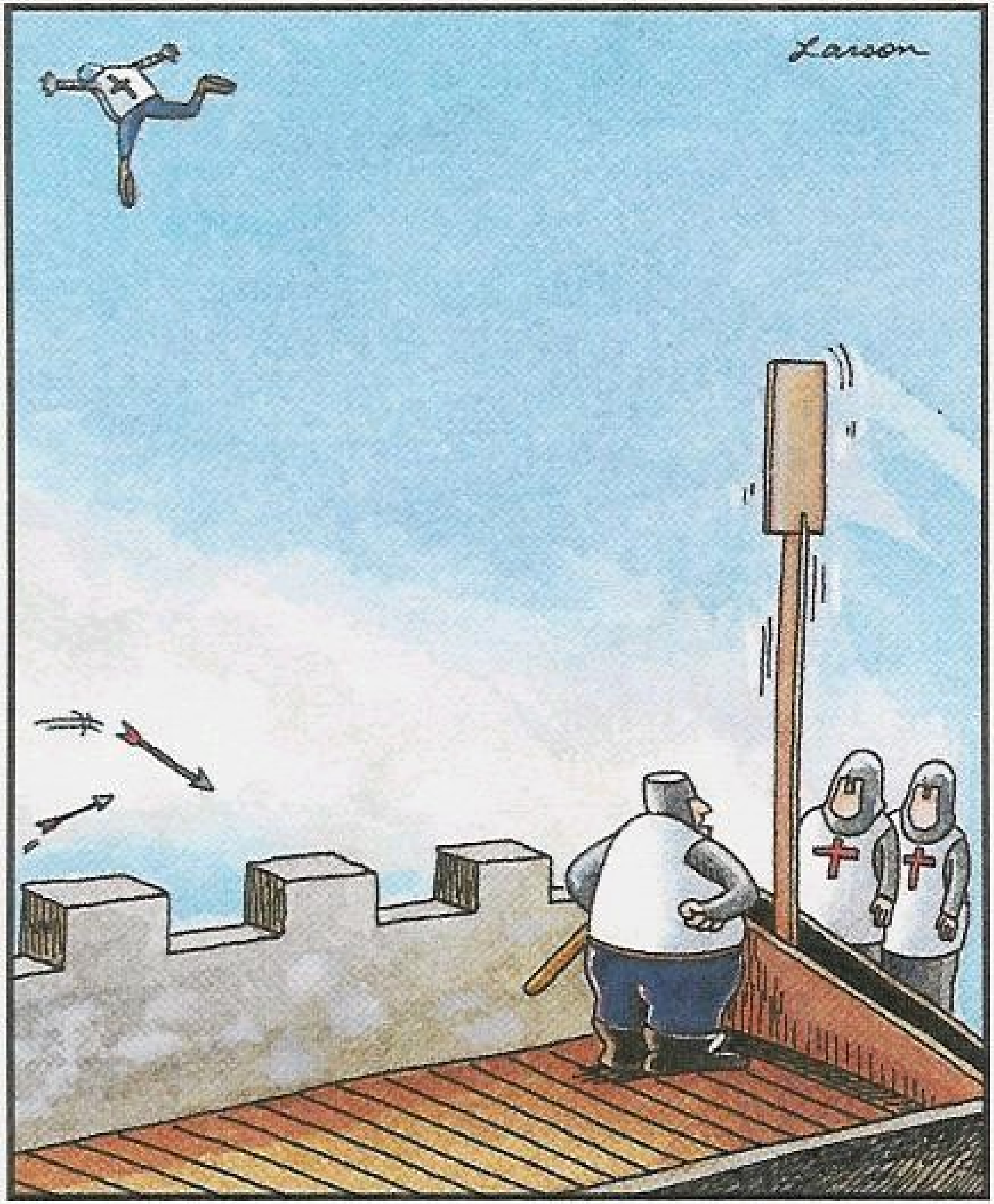
Do you know where you are?

- The missile knows where it is at all times. It knows this because it knows where it isn't. By subtracting where it is from where it isn't, or where it isn't from where it is (whichever is greater), it obtains a difference, or deviation. The guidance subsystem uses deviations to generate corrective commands to drive the missile from a position where it is to a position where it isn't, and arriving at a position where it wasn't, it now is.
- Consequently, the position where it is, is now the position that it wasn't, and it follows that the position that it was, is now the position that it isn't. In the event that the position that it is in is not the position that it wasn't, the system has acquired a variation, the variation being the difference between where the missile is, and where it wasn't. If variation is considered to be a significant factor, it too may be corrected by the GEA. However, the missile must also know where it was.
- The missile guidance computer scenario works as follows. Because a variation has modified some of the information the missile has obtained, it is not sure just where it is. However, it is sure where it isn't, within reason, and it knows where it was. It now subtracts where it should be from where it wasn't, or vice-versa, and by differentiating this from the algebraic sum of where it shouldn't be, and where it was, it is able to obtain the deviation and its variation, which is called error.

Projectiles

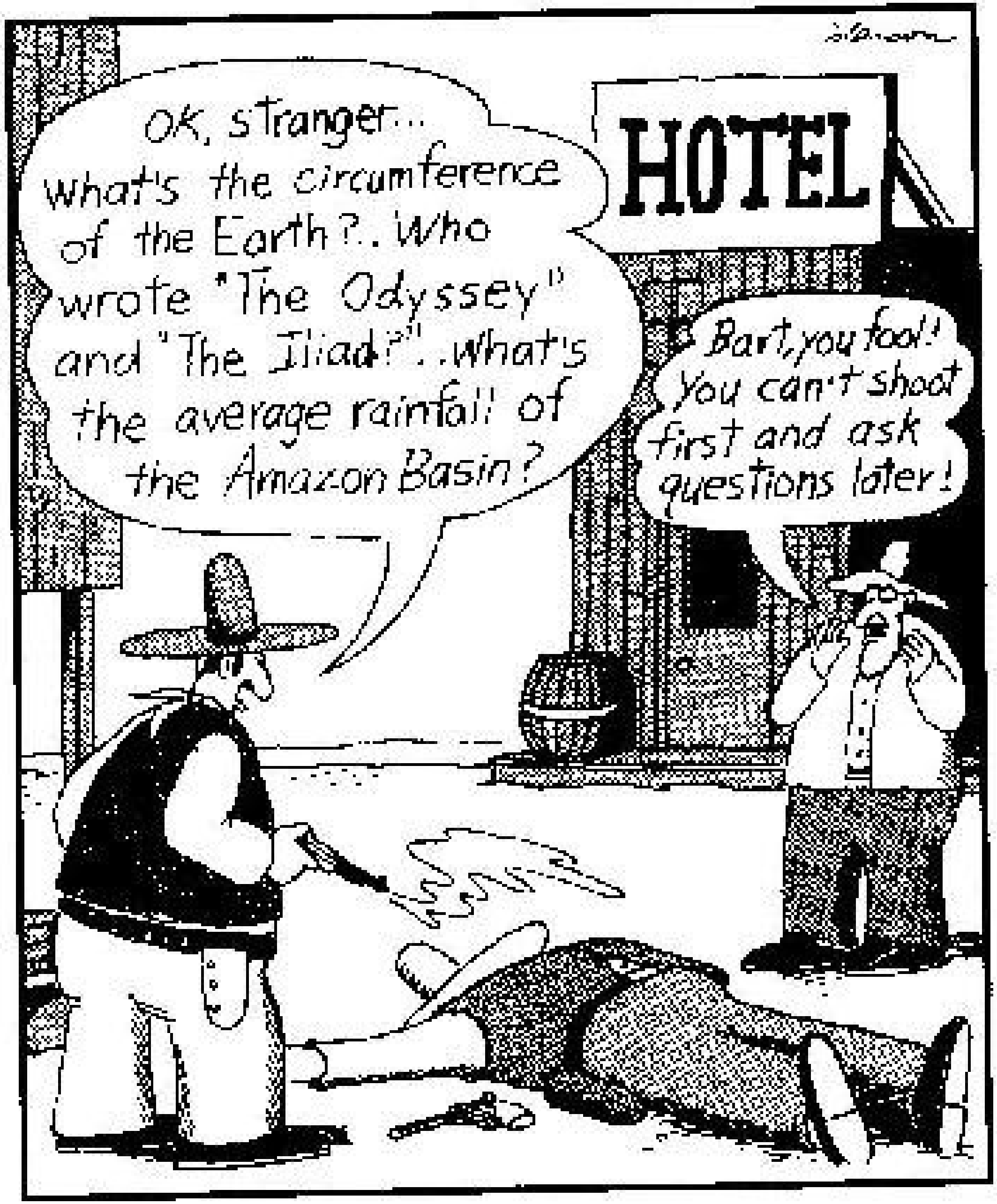
Any object in free fall



"I told you guys to slow down and take it easy or something like this would happen."

Yes, even you!

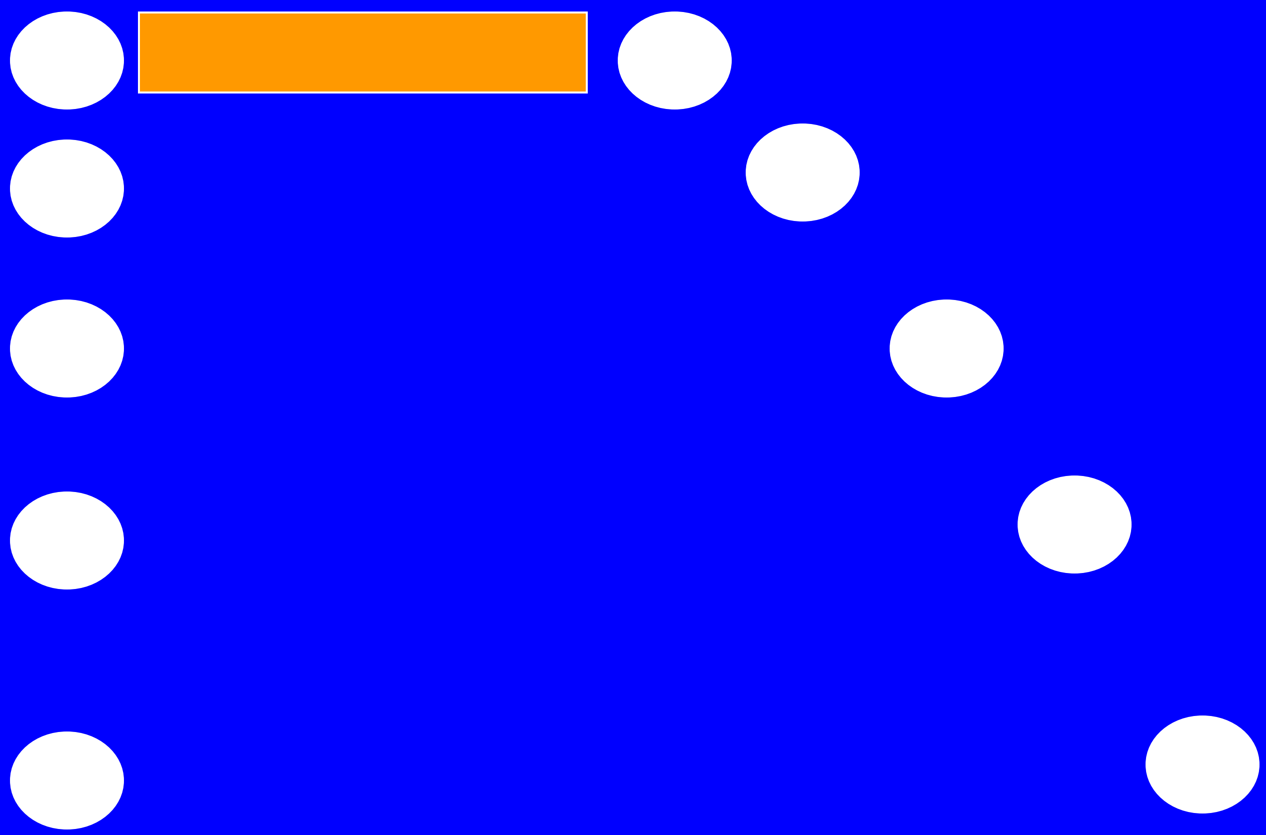
- Even a hockey puck?


HOTEL
OK, stranger... what's the circumference of the Earth?.. Who wrote "The Odyssey" and "The Iliad?"..What's the average rainfall of the Amazon Basin?
Bart, you fool! You can't shoot first and ask questions later!


That's right folks, free falling right here! Step right up gents step right up! It's all free folks it's all free!
GRAND CANYON

X and Y directions

- Which hits the ground first?



Should they hit at the same time?

- We want to know if the horizontal component affects the vertical component
- We would like to treat a 2-dimensional projectile question as two separate 1-dimensional problems
  - A constant velocity horizontal problem, and
  - A free fall problem in the vertical direction
  - The only connection between the two would be time

Step 1: take a video

- Record meter stick for scale, dots for every frame while it is in free fall
- How do we know we can treat H and V separately? Look at the graphs!
- We should see a straight line for x vs t
- We should also see a straight line for Vy vs t

Step 2: output the video data to email

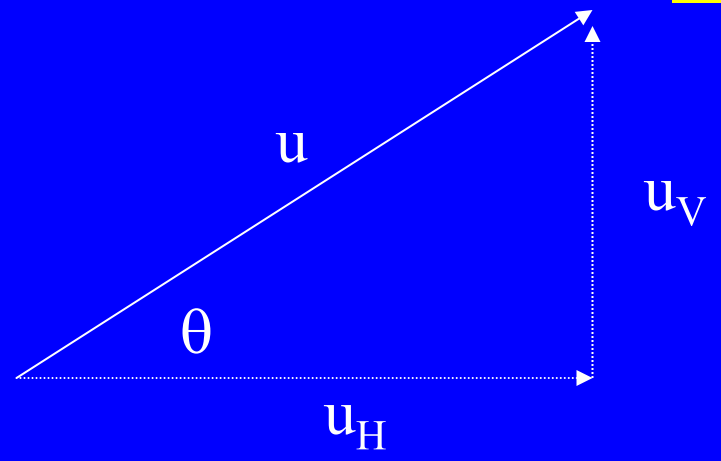
- Open the data in a spreadsheet
- Do a graph of:
  - Horizontal position vs time
    - Use the slope to find u_H
  - Vertical velocity vs time
    - Use the slope to find g
    - Use the y-intercept to find u_V
    - Use the components to find initial velocity

What new formulas do we use?

- There are two new formulas for projectiles, but these come directly from SohCahToa:

$$\boxed{u_H = u\cos\theta}$$

$$\boxed{u_V = u\sin\theta}$$

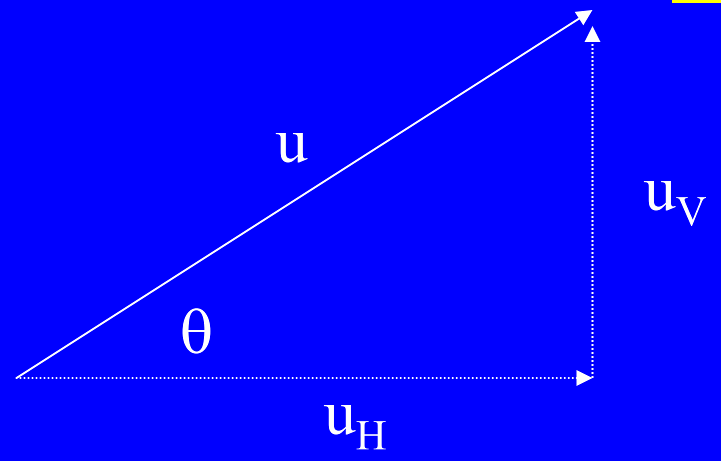


Ex 1: find the horizontal and vertical components

- a) A line drive hit at 35 m/s and 7º
- b) A 3 pointer thrown at 13 m/s and 42º
- c) A kill spiked at 24 m/s and -22º

$$u_H = u\cos\theta$$

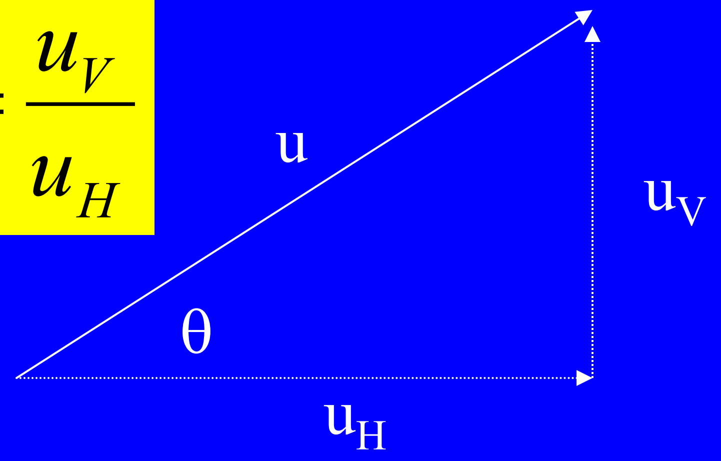
$$u_V = u\sin\theta$$



Ex 2: find the initial velocity

- a) A snowball thrown at 5 m/s vertically and 23 m/s horizontally
- b) A package thrown down at 13 m/s from an airplane cruising at 85 m/s

$$\tan\theta = \frac{u_V}{u_H}$$



$$u = \sqrt{u_V^{\,2} + u_H^{\,2}}$$

What formulas do we use?

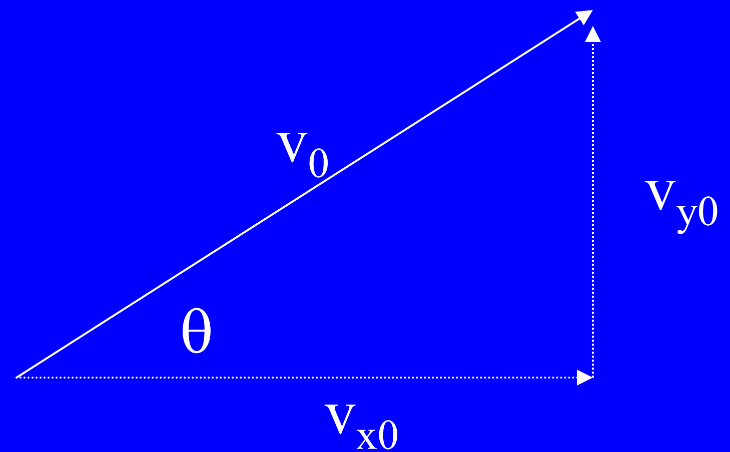
- There are no new formulas for projectiles, we use the same ones we've been using all along:

$$\boxed{v = u + at}$$

$$\boxed{s = ut + \tfrac{1}{2}at^2}$$

Since the x and y directions do not affect each other, we can solve them separately!

x	y
$u_x = u\cos\theta$	$u_y = u\sin\theta$
$v_x = u_x + \cancel{at}$	$v_y = u_y + gt$
$s_x = u_x t + \cancel{\frac{1}{2}at^2}$	$s_y = u_y t + \frac{1}{2}gt^2$



Special Cases

- Horizontal Launch: $u_y=0$
- Vertical launch: $v_x=0$
- Level ground landing: $v_y=-u_y$
- Max Height $v_y=0$

Ex 1: A student runs off a 10m cliff at 8.5 m/s

a) How far from the bottom does he land?

x	y
$v_x = 8.5 \, {}^{m}\!/_{s}$	$u_{y0} = 0$
$s_x = u_x t$	$s_y = \cancel{u_y t} + \frac{1}{2} g t^2$
$x = 8.5 m/s \cdot 1.43 s$	$t = \sqrt{\frac{2 s_y}{g}}$ $\quad t = \sqrt{\frac{2(-10m)}{-9.8 m/s^2}} = 1.43 s$

Variables:

- $g = -9.8 m/s^2$
- u= 8.5 m/s
- ϴ= 0°
- sx= ?
- $s_y = -10m$

$$x = 12m$$

Ex 2: A golf ball rolls off a 0.92m table at 2.5 m/s
a) How far from the bottom does it land?

x	y
$u_x = 2.5 \, {}^{m}\!/\!_{s}$	$u_y = 0$
$s_x = v_x t$	$s_y = \cancel{u_y t} + {}^{1}\!/\!_{2} g t^2$
$x = 2.5 m/s \cdot 0.43 s$	$t = \sqrt{\dfrac{2y}{g}}$

$$t = \sqrt{\frac{2(-0.92m)}{-9.8m/s^2}} = 0.43s$$

$$x = 12m$$

Variables:

- $g = -9.8 m/s^2$
- u= 2.5 m/s
- $s_x = ?$
- $s_y = -0.92m$

Ex 2: A golf ball rolls off a 0.92m table at 2.5 m/s
a) How far from the bottom does it land?

x	y
$u_x = 2.5 \, {}^{m}\!/\!_{s}$	$u_y = 0$
$s_x = v_x t$	$s_y = \cancel{u_y t} + {}^{1}\!/\!_{2}\, g t^2$
$x = 2.5 m/s \cdot 0.43 s$	$t = \sqrt{\dfrac{2y}{g}}$

$$t = \sqrt{\frac{2(-0.92m)}{-9.8 m/s^2}} = 0.43 s$$

Variables:

- $g = -9.8 m/s^2$
- $u = 2.5$ m/s
- $s_x = ?$
- $s_y = -0.92m$

$$x = 12m$$

Ex 3: Cody hits a tennis ball horizontally at 33 m/s
How high did he hit it from, if it lands 18 m away from him?

x	y
$u_x = 33 \, m/s$	$u_y = 0$
$s_x = v_x t$	$s_y = \cancel{u_y t} + \frac{1}{2} g t^2$
$t = \dfrac{s_x}{v_x}$	$s_y = \frac{1}{2}\left(-9.8 m \cdot s^{-2}\right)\left(0.51 s\right)^2$

$t = 18m \div 33m \cdot s^{-1}$

$s_y = -1.46m$

$t = 0.55s$

- $g=-9.8 m/s^2$
- $u = 33$ m/s
- $s_x = 18$ m
- $S_y = ?$

Ex 4: Evan throws some baby bok choy from the top of the Burj Dubai up at 15 m/s. Where will it be in 12 s?

x	y
	$u_y = 15 m \cdot s^{-1}$
	$s_y = u_y t + \frac{1}{2} g t^2$
	$s_y = 15 \cdot 12 - 4.9(12)^2$

$$s_y = -525m$$

Variables:

- $g=-9.8 m/s^2$
- u= 15 m/s
- t=12s
- s_y=?

Ex 5: Duncan throws a watermelon horizontally at 12 m/s
a) How far from the base of the 22 m cliff does it land?

x	y
$u_x = 2.5 \, {}^{m}\!/\!{}_{s}$	$u_y = 0$
$s_x = v_x t$	$s_y = \cancel{u_y t} + \frac{1}{2} g t^2$
$x = 2.5 m/s \cdot 0.43 s$	$t = \sqrt{\frac{2y}{g}}$

$$t = \sqrt{\frac{2(-0.92m)}{-9.8m/s^2}} = 0.43s$$

Variables:

- g=-9.8m/s^2
- u= 2.5 m/s
- s_x= ?
- s_y=-0.92m

$$x = 12m$$

Ex 6: Sean throws a dummy horizontally at 8.5 m/s How high did it start if it travels 3.2 m horizontally?

x	y
$u_x = 2.5 \, {}^{m}\!/\!{}_{s}$	$u_y = 0$
$s_x = v_x t$	$s_y = \cancel{u_y t} + {}^{1}\!/\!{}_{2} g t^2$
$x = 2.5 m/s \cdot 0.43 s$	$t = \sqrt{\frac{2y}{g}}$

$$t = \sqrt{\frac{2(-0.92m)}{-9.8 m/s^2}} = 0.43 s$$

Variables:

- $g=-9.8 m/s^2$
- u= 2.5 m/s
- s_x= ?
- s_y=-0.92m

$$x = 12 m$$

Finish Test Yourself p. 43 q's 1-8

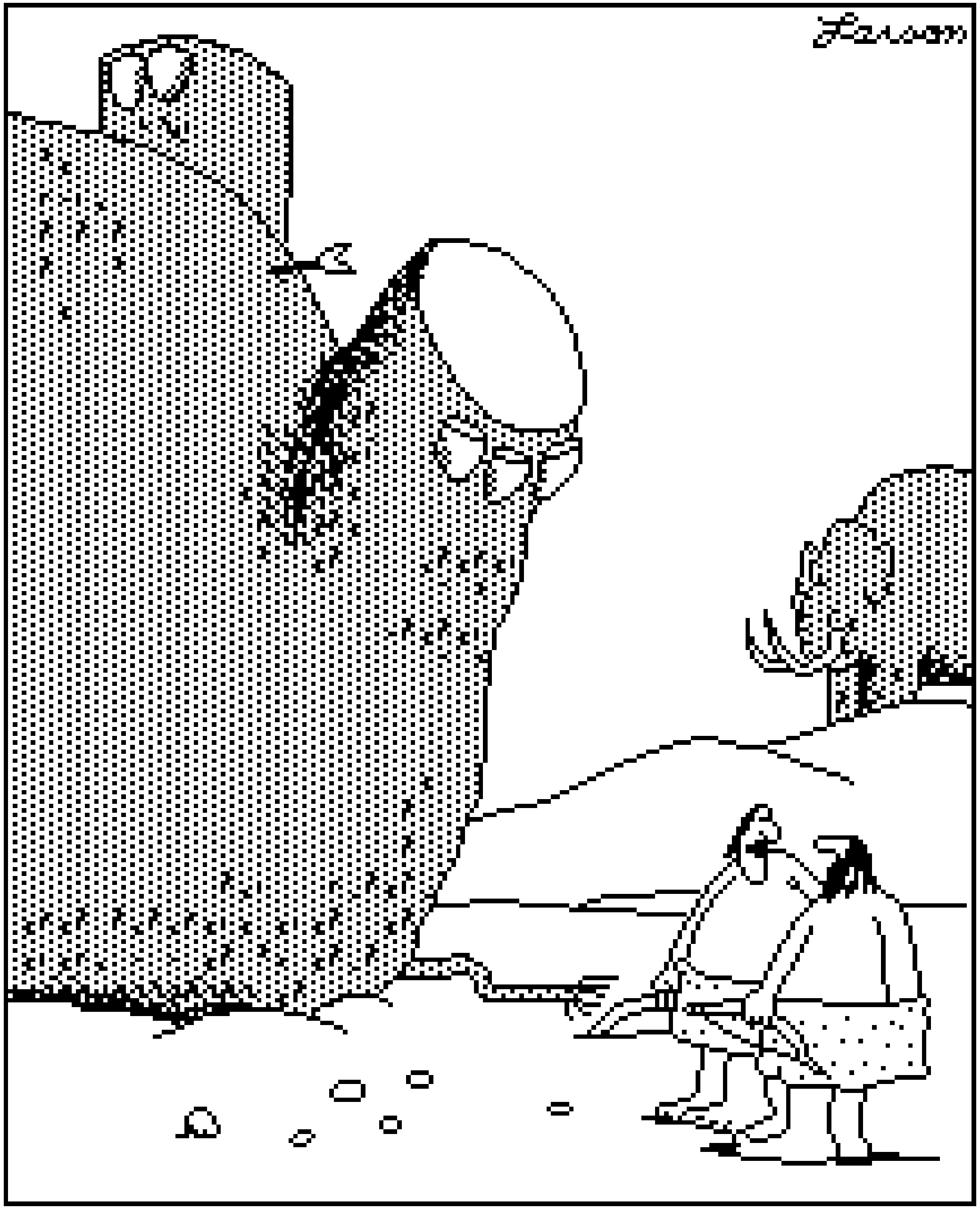
#TIAPQD

#RIATD

Start Bridge design

Popsicle stick bridge

- Your mission, should you choose to accept it, is to:
  - Team up with no more than two other students
  - Build a bridge spanning 20 cm, out of no more than 25 popsicle sticks and 20 g white glue
  - Incorporate the testing beam into the design
  - Show up on November 7 to test (AKA destroy) your bridge



"Maybe we should write that spot down."

The original Calcululer!