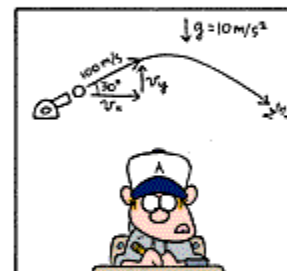
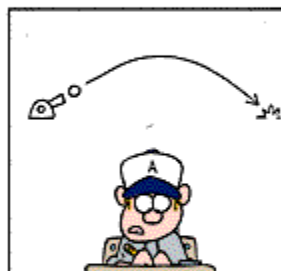
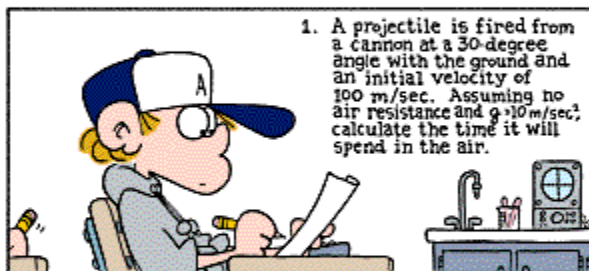
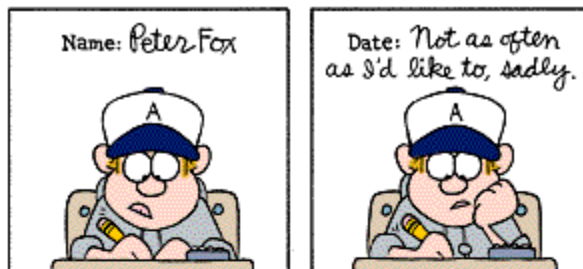


PROJECTILE MOTION : A creative approach or How to kill a Monkey

reference: onlinephys.com

FoxTrot

BILL AMEND



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part 1: FREE-FALL

- What do you know about Galileo Galilei ? (check: <http://onlinephys.com/giants.html>)

- What is Free-Fall ? What is the acceleration due to gravity ? (in m/s and in feet/s)

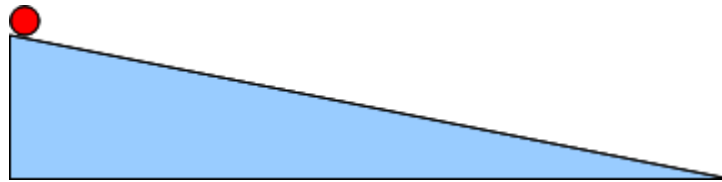
http://www.youtube.com/watch?v=5C5_dOEyAfk

- Why do you think Galileo used inclined plane to study motion instead of dropping masses from the Tower of Pisa ? (this is a legend). (Why was it easier to study the relationship between acceleration, speed and distance when you use inclined plane).

- Working with inclined plane, Galileo discovered an odd numbers pattern. Here is the experiment.

Fill the blanks.

The Ball is released from rest and rolls down the ramp. The friction is so small that you can forget about it.



Galileo observes that after 1 second the ball covers **1m**, then during the following second, the ball covers **3m**, Then **5m** during the next second , then ____, then ____, then ____. Draw the different positions of the ball on the above drawing. (0.5 cm = 1m)

Then you can fill the table :

time	0	1	2	3	4	5	6	7	8
Total distance covered	0	1	1+3=4						

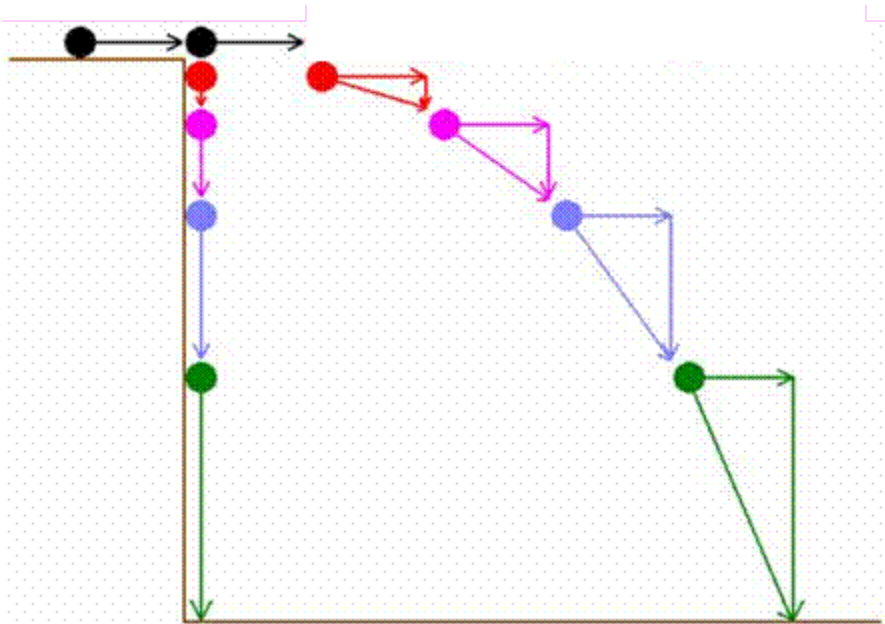
His conclusion was : if an object accelerates, the total distance covered is proportional to the _____ of the time. Newton later derived the formula $d = \frac{1}{2}at^2$ with a the acceleration.

If the object is free falling then acceleration = a = _____ m/s/s or _____ ft/s/s.

The formula becomes: $d = \frac{1}{2}at^2$ (if h in meters and a in m/s/s) or $d = \frac{1}{2}at^2$ (if h in feet and a in ft/s/s). We suppose the object falls with no initial speed. d is the distance covered.

PART2: HORIZONTAL and VERTICAL COMPONENTS of a projectile. KILL THE MONKEY

Another thing that Galileo discovered is that the vertical and the horizontal components of a projectile is independent of each other. This is not an intuitive result. Comment the picture below:



Discuss and then watch this animation :

<http://www.upscale.utoronto.ca/GeneralInterest/Harrison/Flash/ClassMechanics/TwoBallsGravity/TwoBallsGravity.html>

watch or do this experiment:

<http://www.youtube.com/watch?v=qErh402eJgI>

Use a ruler and what you learnt to answer the following questions. Use $d = \frac{1}{2} (10) t^2$ or $d = 5t^2$

Refer to the first drawing below. A person drop a ball from a cliff. Friction can be neglected. Draw the position of the ball at 1 second interval. In the second situation, a person throws a ball horizontally. The position of the ball in the absence of gravity is shown. Draw the position of the ball when the force of gravity acts on it.

Refer to the second drawing. A bad guy, who happens to like baseball, wants to kill a monkey in a tree. If the monkey stays still and if there is no gravity the ball will follow a straight line. I draw the ball positions in that case for the first 4 seconds. (1second elapsed between 2 positions of the ball).

Now suppose $g = 10\text{m/s/s}$ and use a scale: $0.5\text{cm}:5\text{m}$

(hint: it means divide by 5 and multiply by 0.5 or $d = 0.5 t^2$ in cm)

Draw the new positions of the ball for the first 4 seconds.

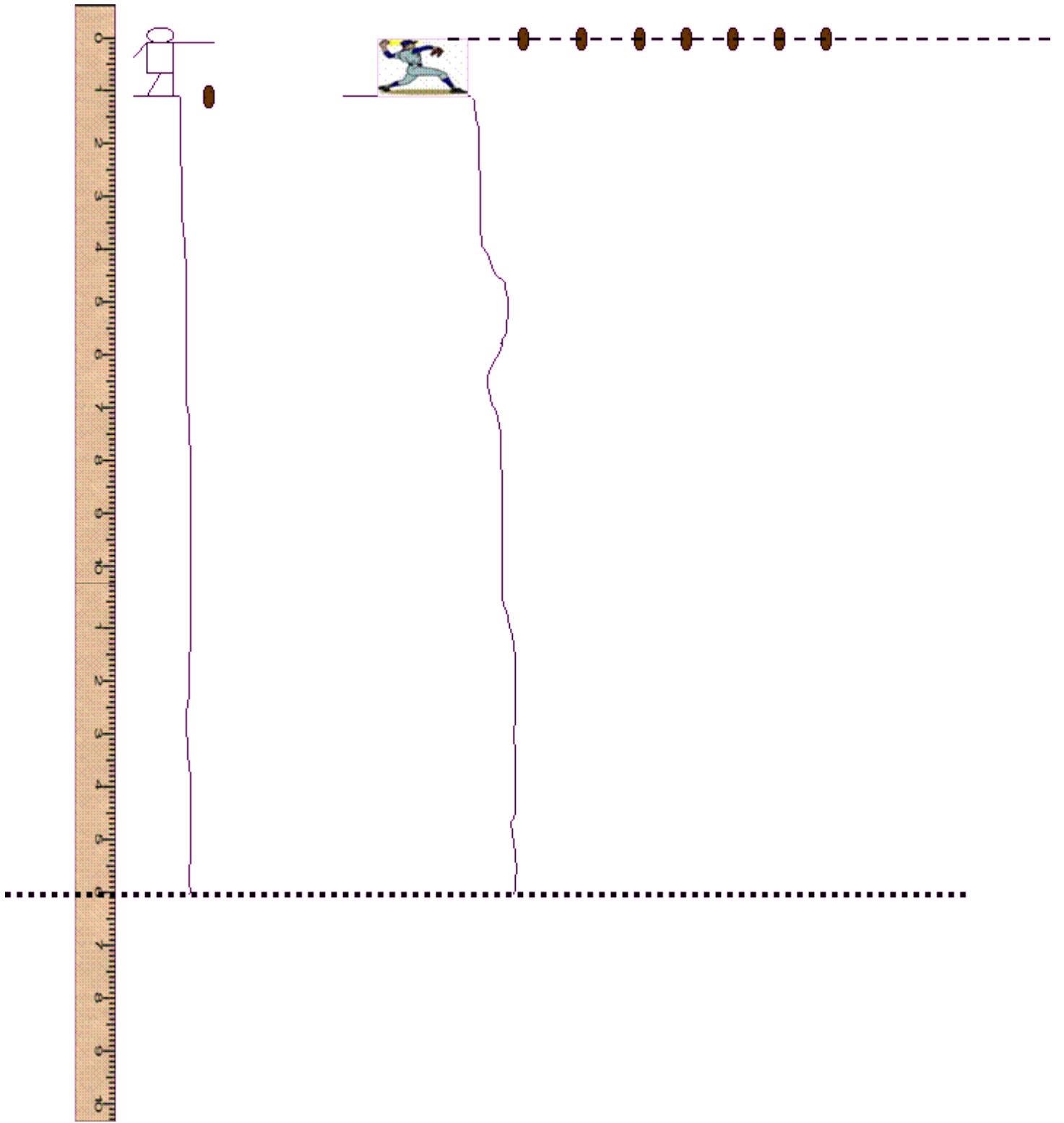
If the monkey stays still, will it die ?

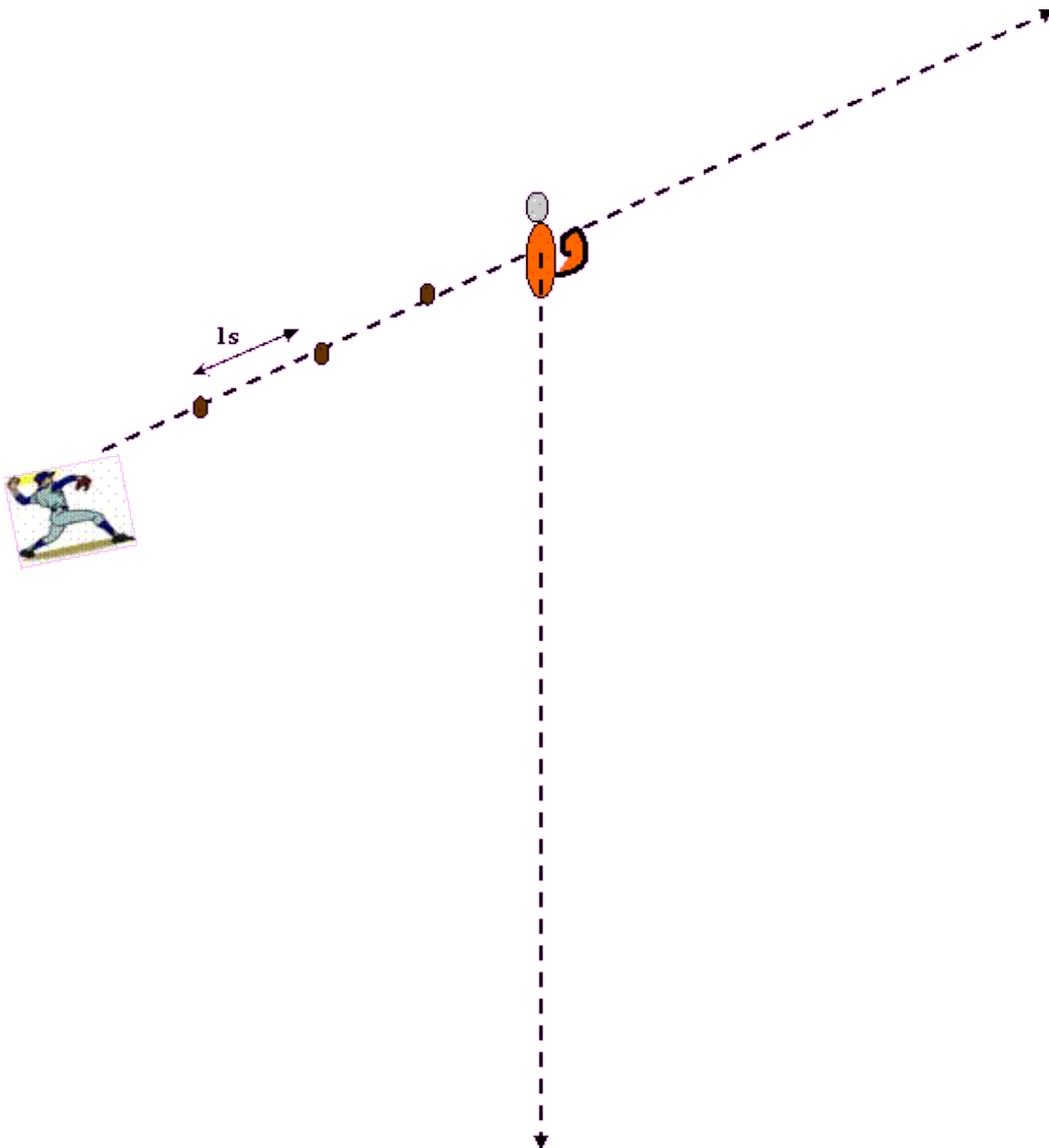
Now, as soon as the ball leaves the hand of the dude, the monkey let go the branch. (he got scare). The monkey falls. (the monkey and the ball start the motion at the same time). Will the monkey die ? Can you show that ?

There is now another monkey in the same tree, at the same distance from the bad baseball player who is ready for another shot. The monkey is smart. (took Physics 101 at the jungle college). He thinks "I am going to stay still, so the ball will miss me". What the bad guy should do to reach his goal ? (in case he also took physics 101)

What did you neglect in this thought experiment ? How does it relate to the bullet shape. Here is the animation:

<http://www.upscale.utoronto.ca/GeneralInterest/Harrison/Flash/ClassMechanics/MonkeyHunter/MonkeyHunter.html>





If a canon was placed on a mountain and if enough speed is given to the canon ball, what will happen to the ball? See: http://highered.mcgraw-hill.com/sites/dl/free/0072482621/59233/5_3.htm

PART3: The Maths

The shape of the trajectory of a projectile is a _____. In standard form the equation of the parabola is $y = ax^2 + bx + c$ (it is called a _____ equation) The coefficient a, b, c will determine the shape of the parabola. (x,y) represents the coordinates of the projectile in a frame of reference of your choice.

Note that y can be negative and so is x.

What is a frame of reference ?

a, b, c are constant coefficient for a given motion and will depend on the initial conditions of the throw.

a, b, c will be determined by :

Check with this applet and play with it.

http://galileo.phys.virginia.edu/classes/109N/more_stuff/Applets/ProjectileMotion/jarapplet.html

Playing with the applet find the angle that will give you the largest x. (the range) . angle = _____

With the Applet shoot at 20 degrees and at 70 degrees (keep other parameters the same).

Conclusion?

What if you choose 60 and 30 ?

What is the pattern ?

You get the equation of the parabola by playing with the parametric (the variable is the time) equations :

$y = \frac{1}{2} g t^2 + V_{oy} t + y_0$ for the motion along vertical **and** $x = V_{ox} t$ for motion along horizontal

$g = -$ _____ (for x and y in meters) or $-$ _____ (for x and y in feet)

note that g is what we call a **vector**. It is an object with a _____ and a _____.

Refer to the drawing below.

V_0 is the initial velocity of the projectile . It is a vector too. It has 2 components V_{ox} and V_{oy} .

V_{oy} is _____ V_{ox} is _____.

y_0 is _____.

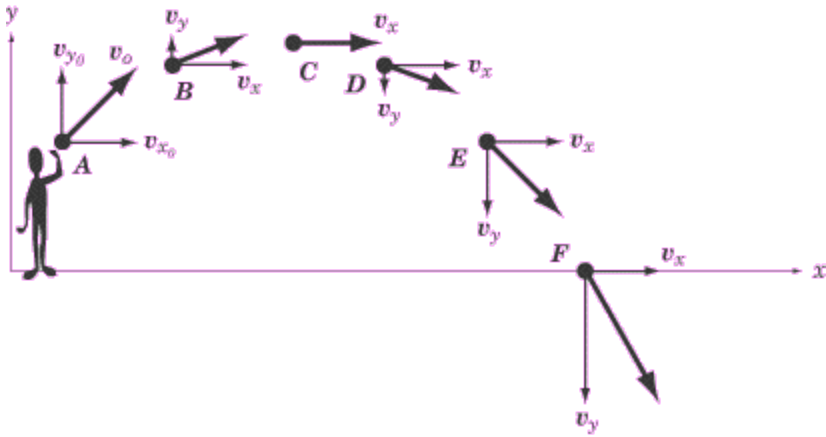
Let's call (V_{ox}, V_{oy}) the components of the initial velocity V_0 .

If the arrow below represents the initial velocity V_0 , draw V_{ox} and V_{oy} .

The angle of shooting is given by : $\tan(\text{angle}) =$

Label the angle of the drawing.

Let's call y_0 the initial height . Below trace y_0 and trace the frame of reference. Label the angle of shooting.



APPLY YOUR SKILLS :

Playing with kinematics you can show:

$$y = 0.5 g / V_{ox}^2 x^2 + V_{oy}/V_{ox} x + y_0 \text{ with } g = -10\text{m/s/s (for x and y in meters) or } -32\text{ft/s/s (for x and y in feet)}$$

This is a quadratic equation in standard form : $y = ax^2 + bx + c$

Some Algebra:

In our case $a < 0$ which means the parabola is curved _____.

$x = -b/2a$ is the x-coordinate of the maximum (vertex). Y_{max} is easy to get by _____.

c is the _____. In our case $c =$ _____

How to find the x-intercepts ? What do they represent ? Why only x-intercept is of interest ?

TRY THAT : In a College book (Blitzer, college Algebra) you read:

A football is kicked and the nearest defensive player is 6 feet from the point of impact with the kicker's foot. The height of the of the punted football can be modeled by :

$$f(x) = -.01x^2 + 1.18x + 2$$

where x is the ball 's horizontal distance , in feet, from the point of impact with the kicker's foot.

A) The acceleration due to gravity is - 32 ft/s/s.

By " staring " at the equation find the :

- initial height of the foot ball ?

- initial horizontal speed ?

- initial vertical speed ?

- angle of shooting ? (hint: $\text{tangent}(\text{angle of shooting}) = V_{oy}/V_{ox}$)

B) what is the maximum height of the punt and how far from the of impact does it occur ?

(hint: find the vertex with $x_{max} = - b/2a$)

C) How far must be the nearest defensive player, who is 6 feet from the kiker's point of impact, reach to block the punt ?

(hint: find height for $x=6$)

D) If the ball is not blocked by the defensive player, how far down the field will it go before hitting the ground ?

(hint: find the x-intercepts. pick the one that makes sense)

E) Graph the function that models the football's parabolic path. You can check with a graphic calculator.

TRY THAT: In the same book, a problem mention a projectile shot at an angle of 65 degrees. Its height in feet can be modeled by:
 $g(x) = -0.04x^2 + 2.1x + 6.1$

A) check if the angle is indeed 65 degrees.

Find initial vertical speed

initial horizontal speed

initial height

B) Find the maximum height , to the nearest tenth of a foot., of the shot and how far from its point of release does this occur.

C) What is the shot maximum horizontal distance, to the nearest tenth of a foot, or the distance of the throw.