

Parabolic Path of Action



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Animation
Physics



Parabolic Arcs

When gravity is the only force, the path of action is a *parabolic arc*.

Path of action of a bouncing ball is a parabolic arc.



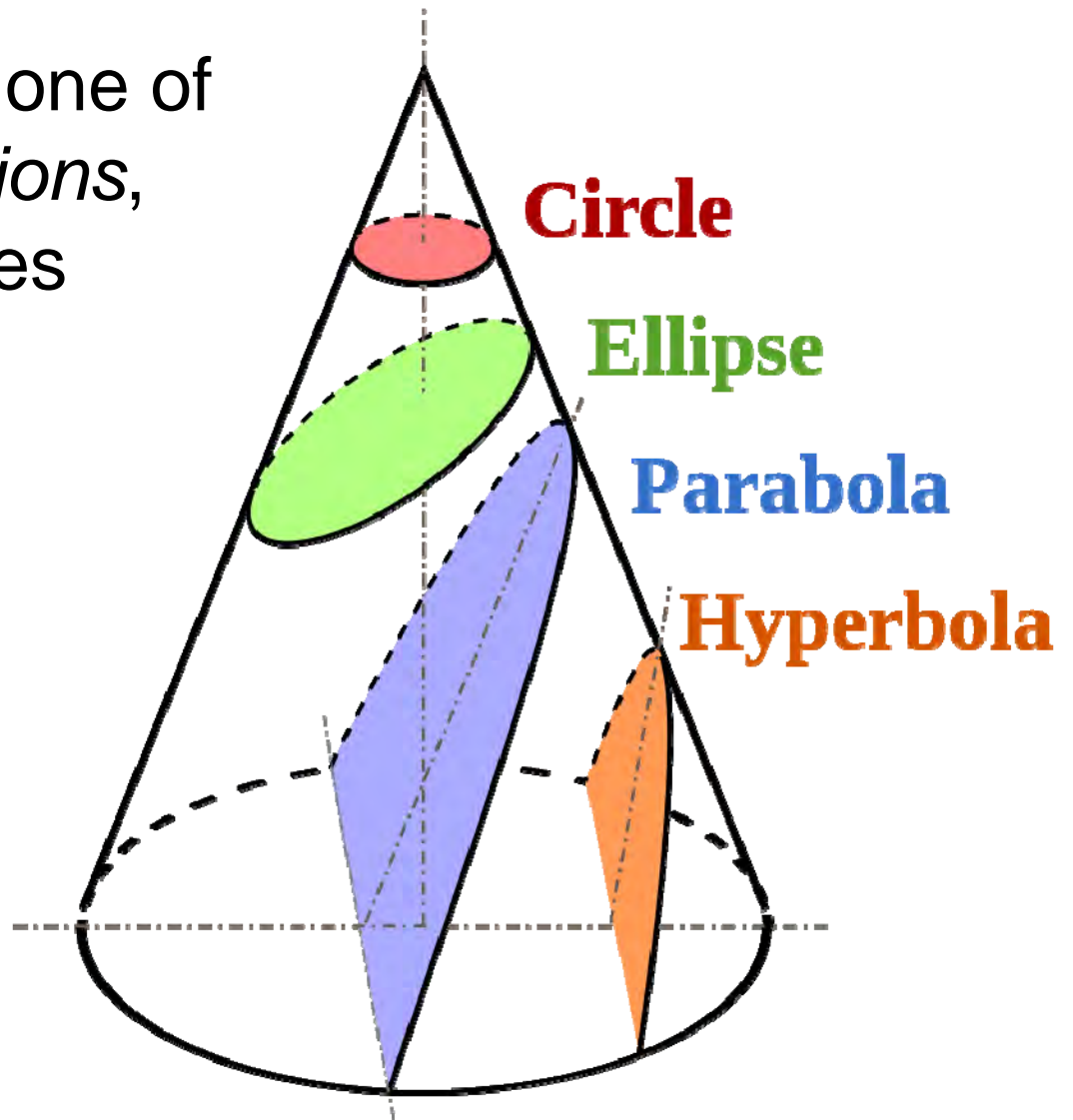
Water stream



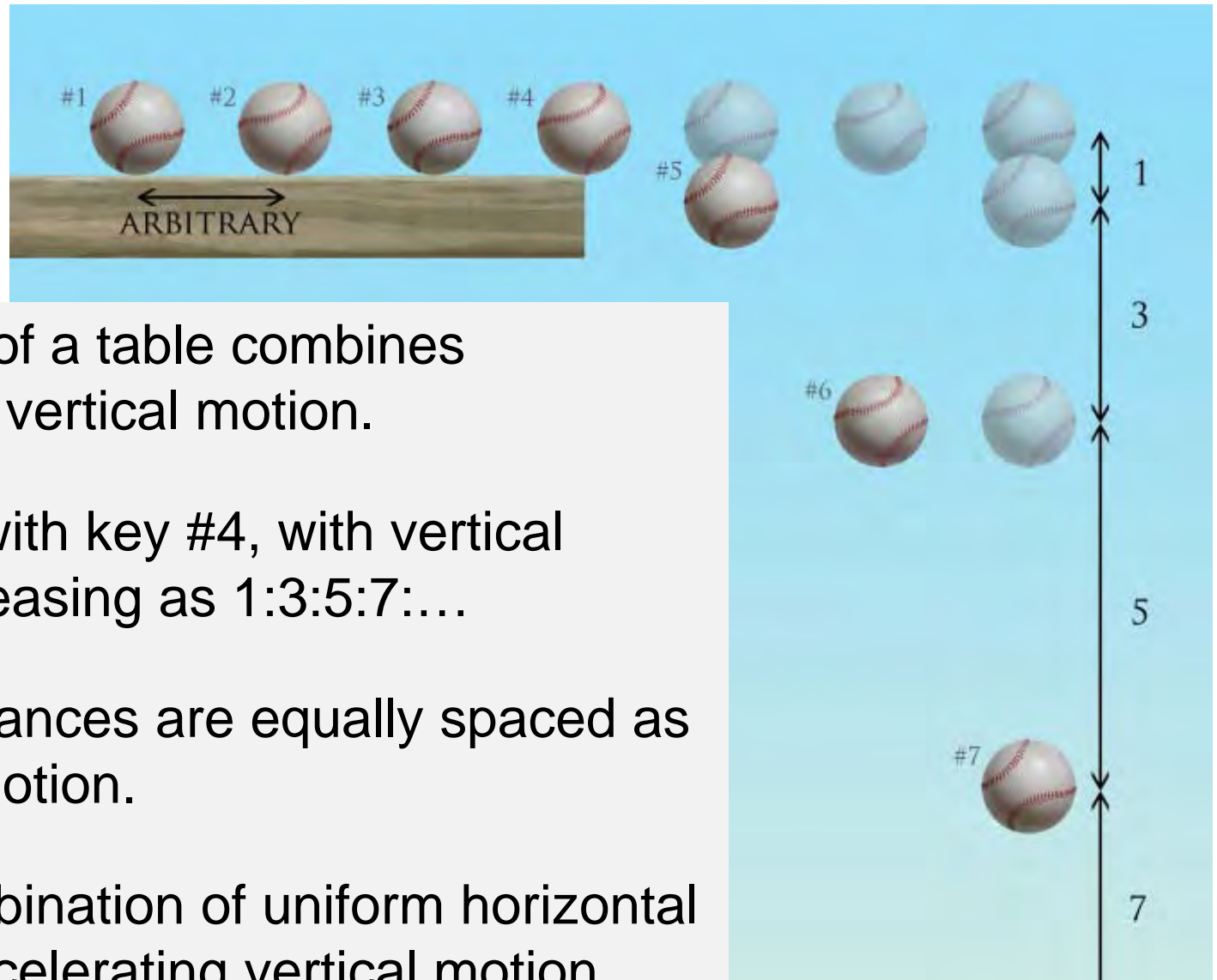
Conic Sections

Parabolic arcs are one of the four *conic sections*, which are the curves you get when you slice a cone.

The hyperbola looks similar to a parabola but it rarely occurs as a path of action.



Moving & Falling



Ball rolling off of a table combines horizontal and vertical motion.

Falling starts with key #4, with vertical distances increasing as 1:3:5:7:....

Horizontal distances are equally spaced as with uniform motion.

Arc is the combination of uniform horizontal motion and accelerating vertical motion.

Rolling off a Table

Ball Drop closeup
with horizontal movement

Speed: 120 frames per second

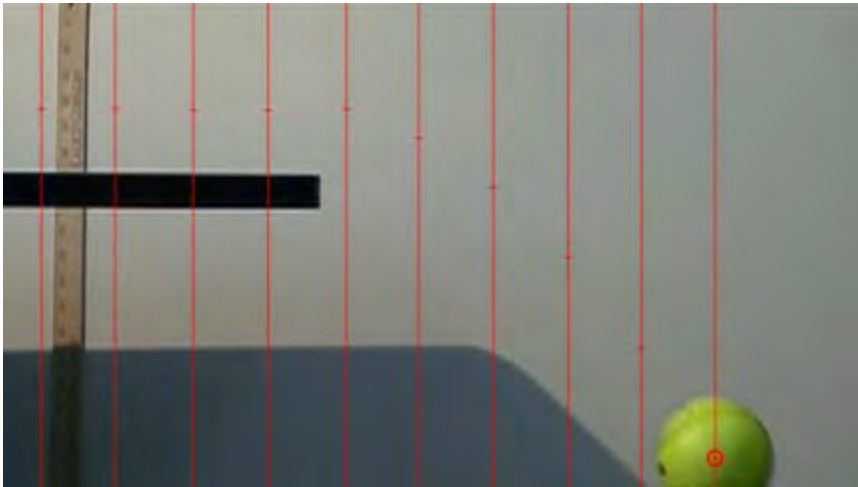
Size: Softball - $3 \frac{3}{4}$ inches

www.AnimationPhysics.com

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

Rolling off a Table, Tracked

Video tracking, frame-by-frame, shows that the horizontal motion stays uniform as the vertical motion slows out.

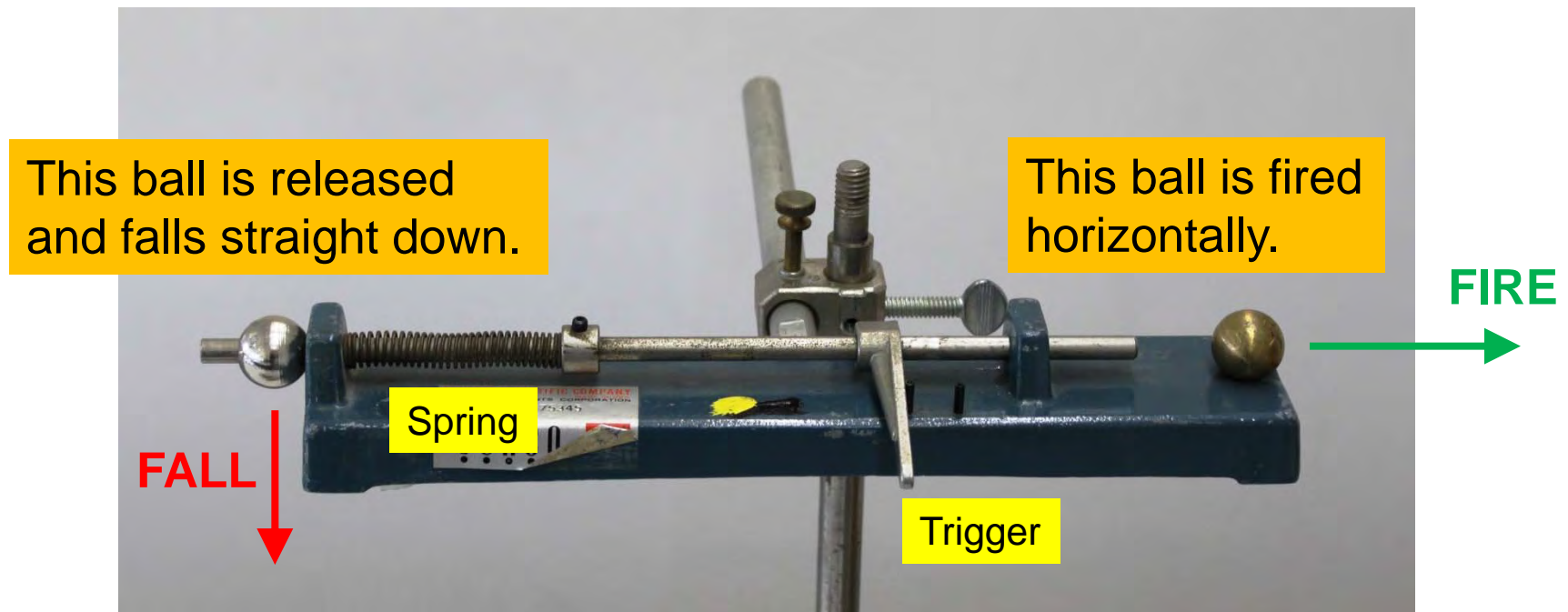


Uniform motion
(Horizontal)



Slowing out
(Vertical)

Demo: Fall and Fire

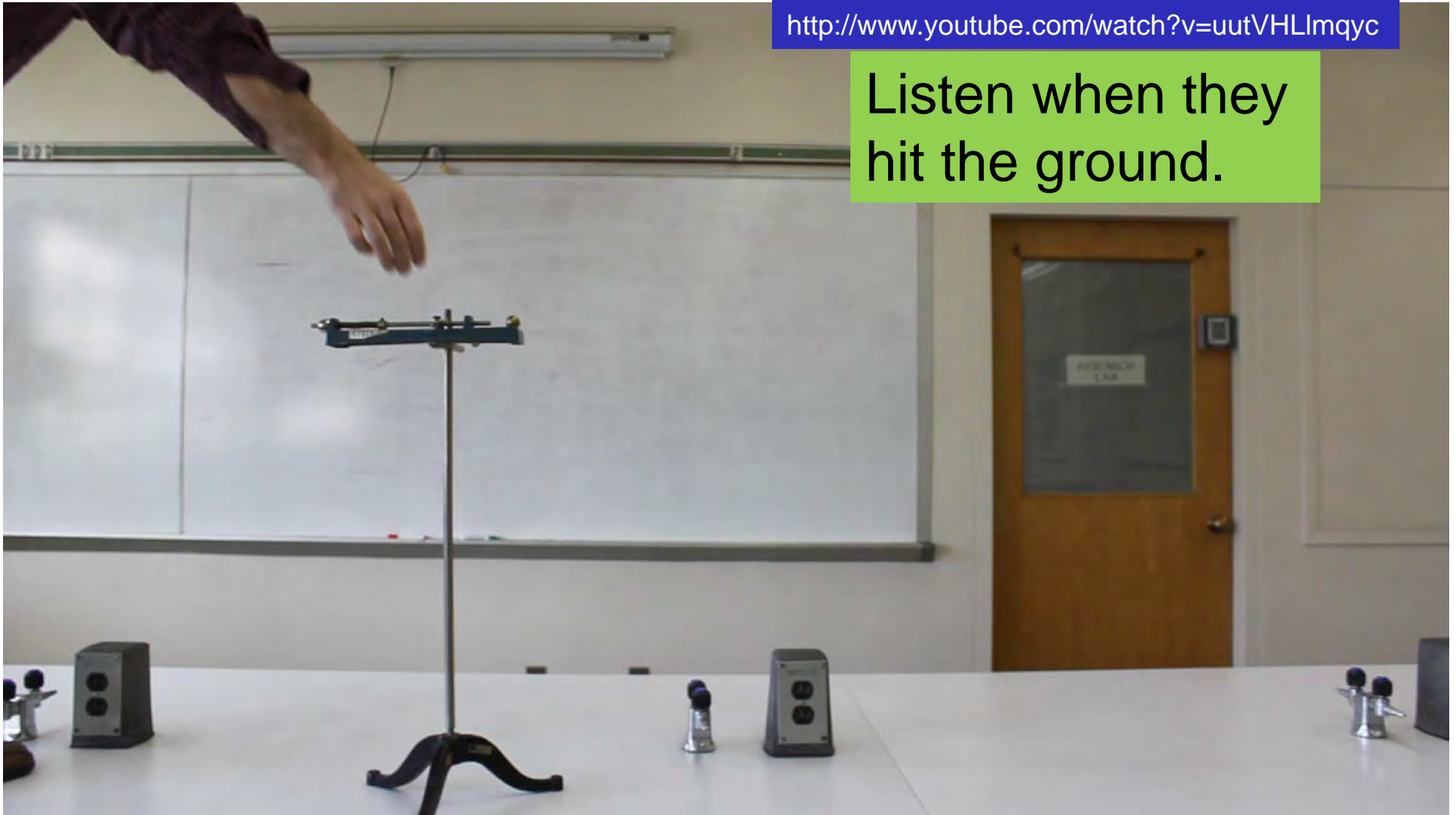


This apparatus is designed to release the ball on the left, which falls straight down, as it *simultaneously* fires the ball on the right, shooting it horizontally.

Demo: Fall and Fire

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

Listen when they
hit the ground.

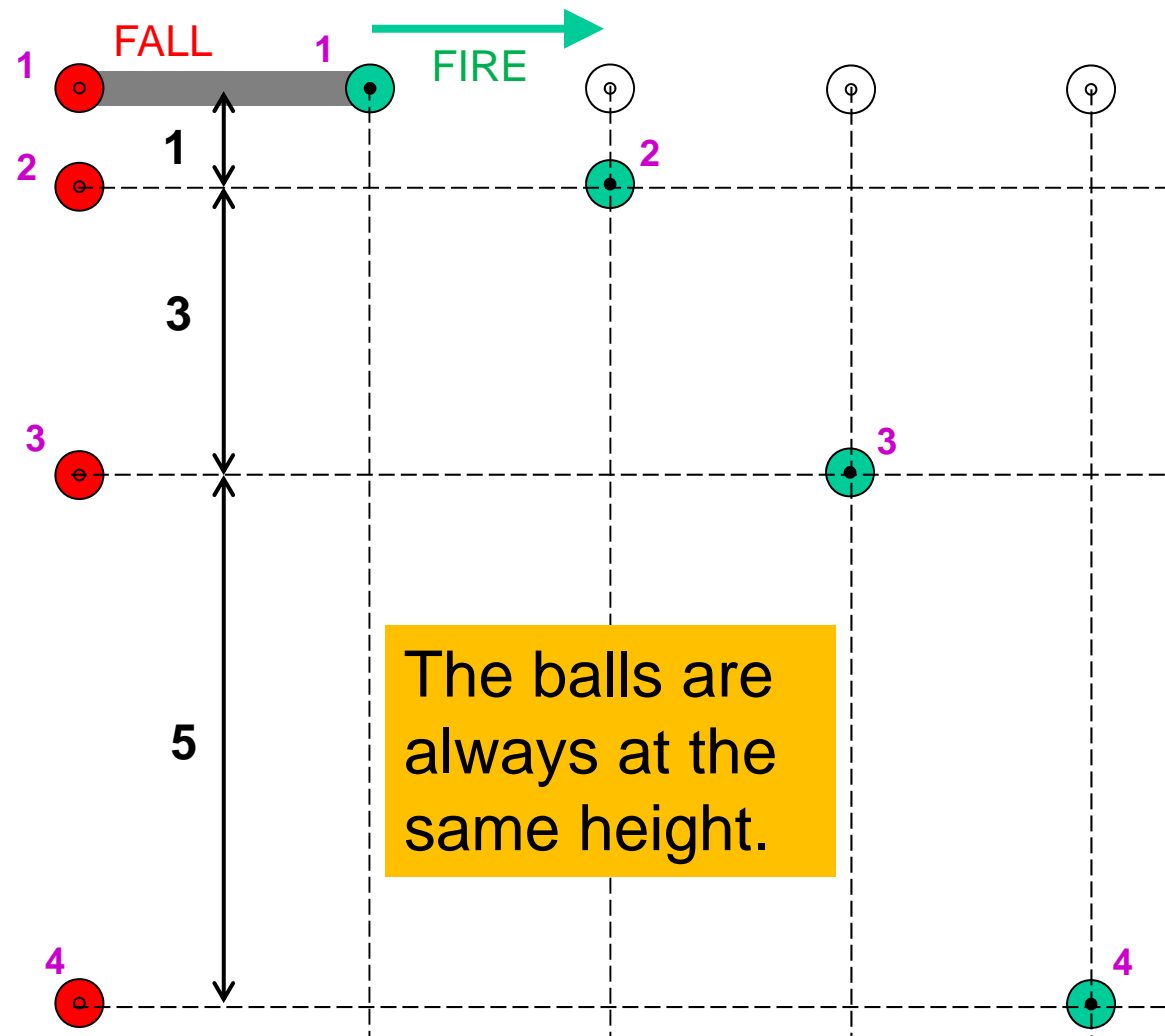


Demo: Fall and Fire

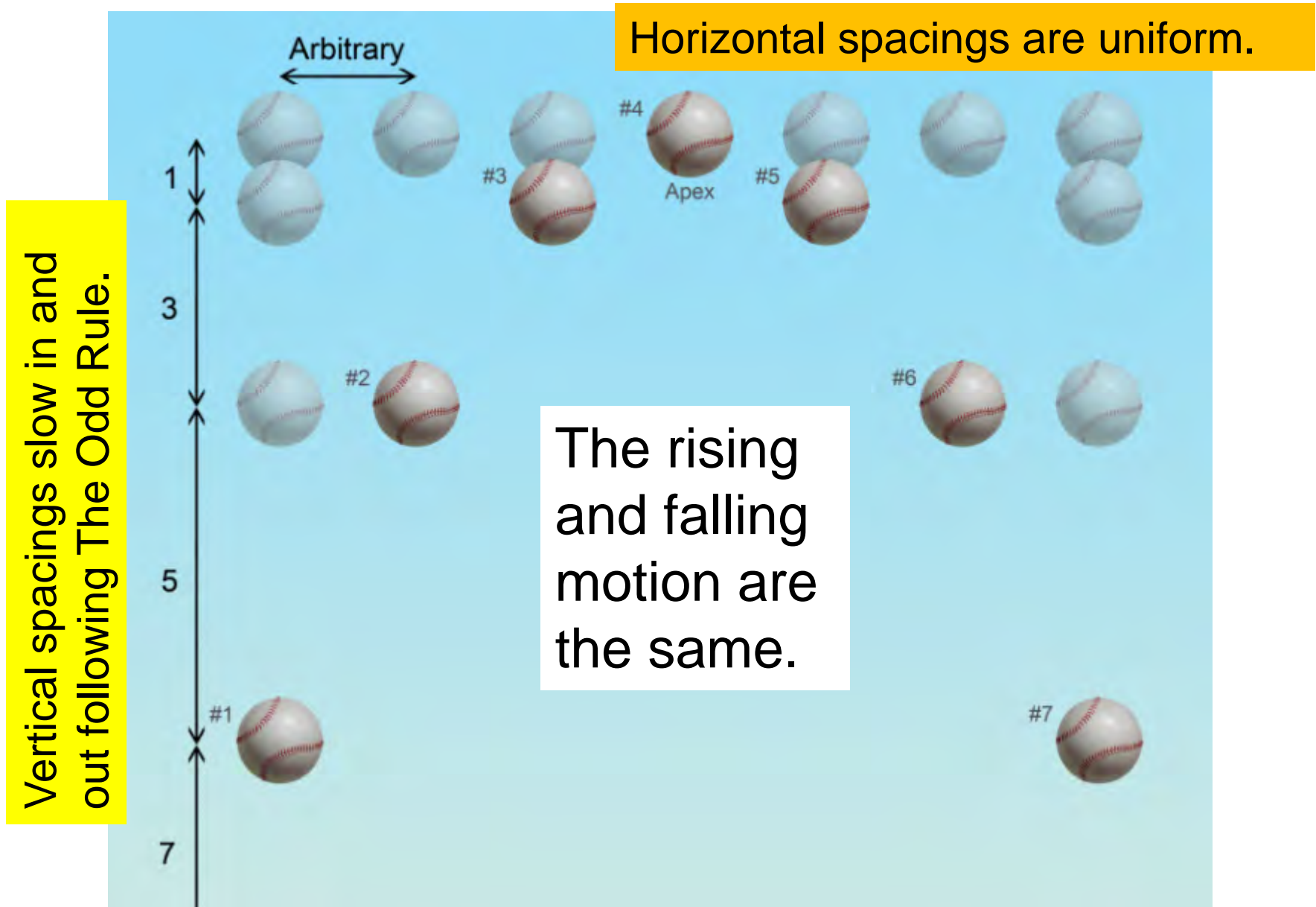
One ball is released and falls straight down.

Other ball is fired horizontally.

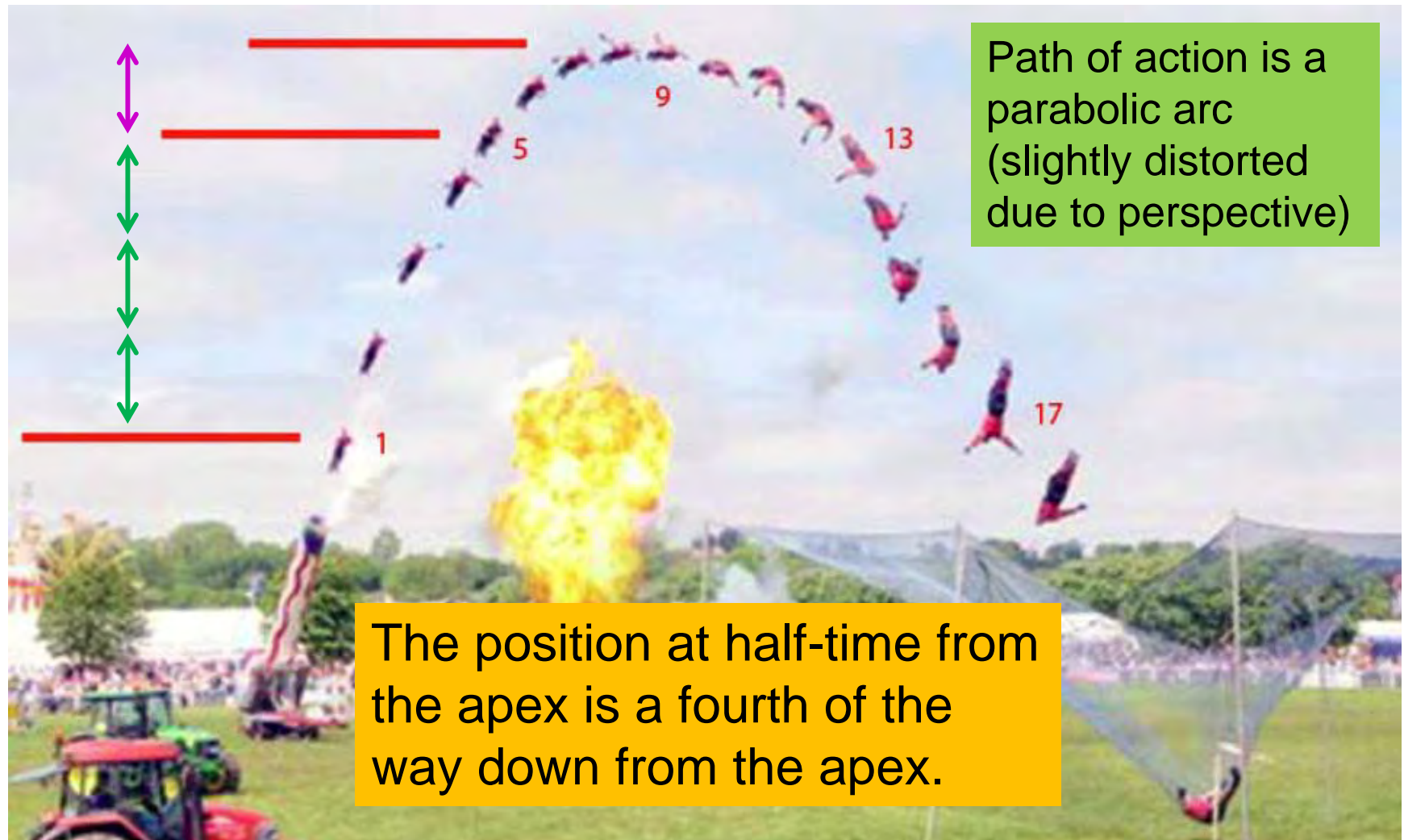
Hit the ground at the same time.



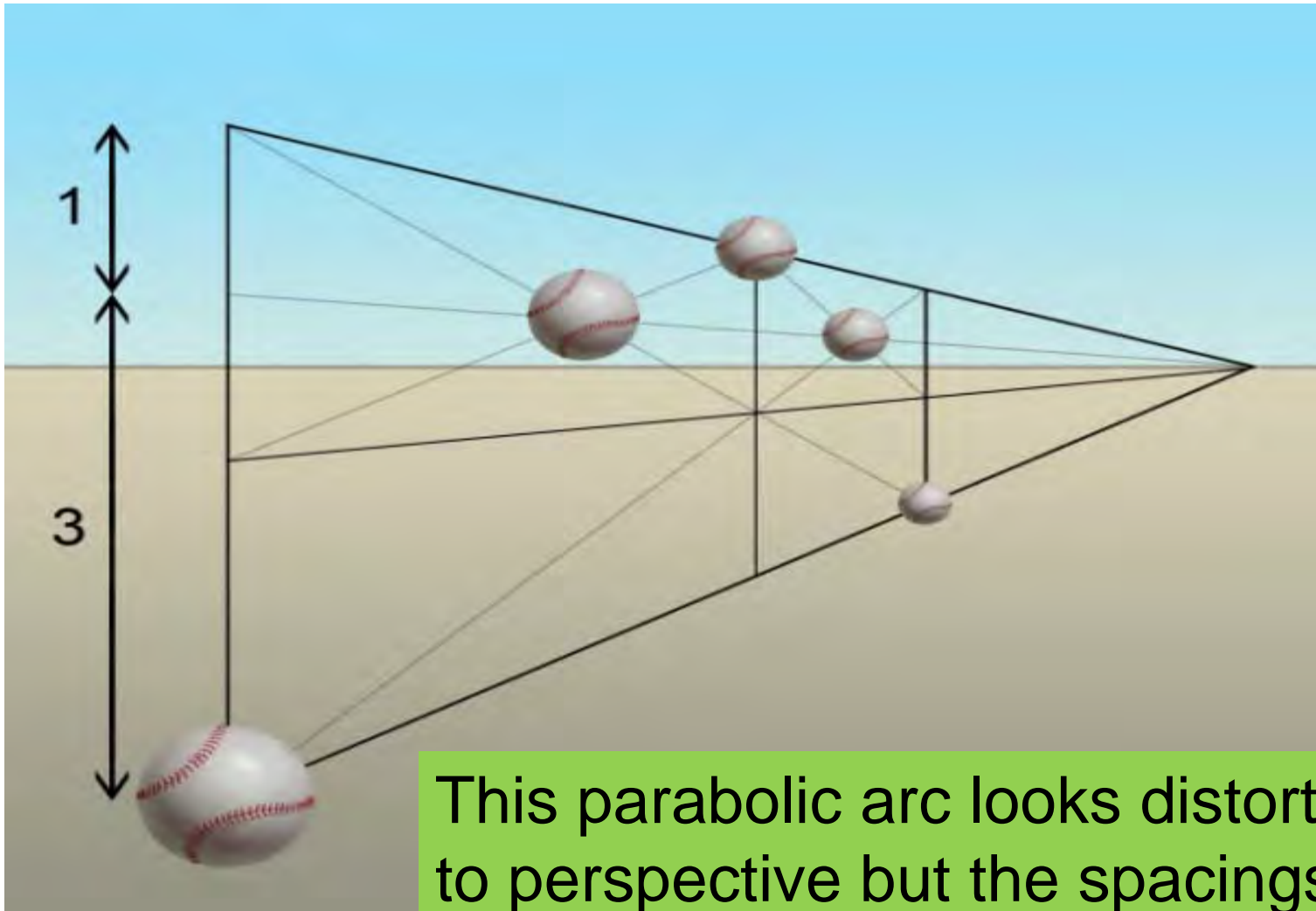
Full Parabolic Arcs



Fourth Down at Half-time



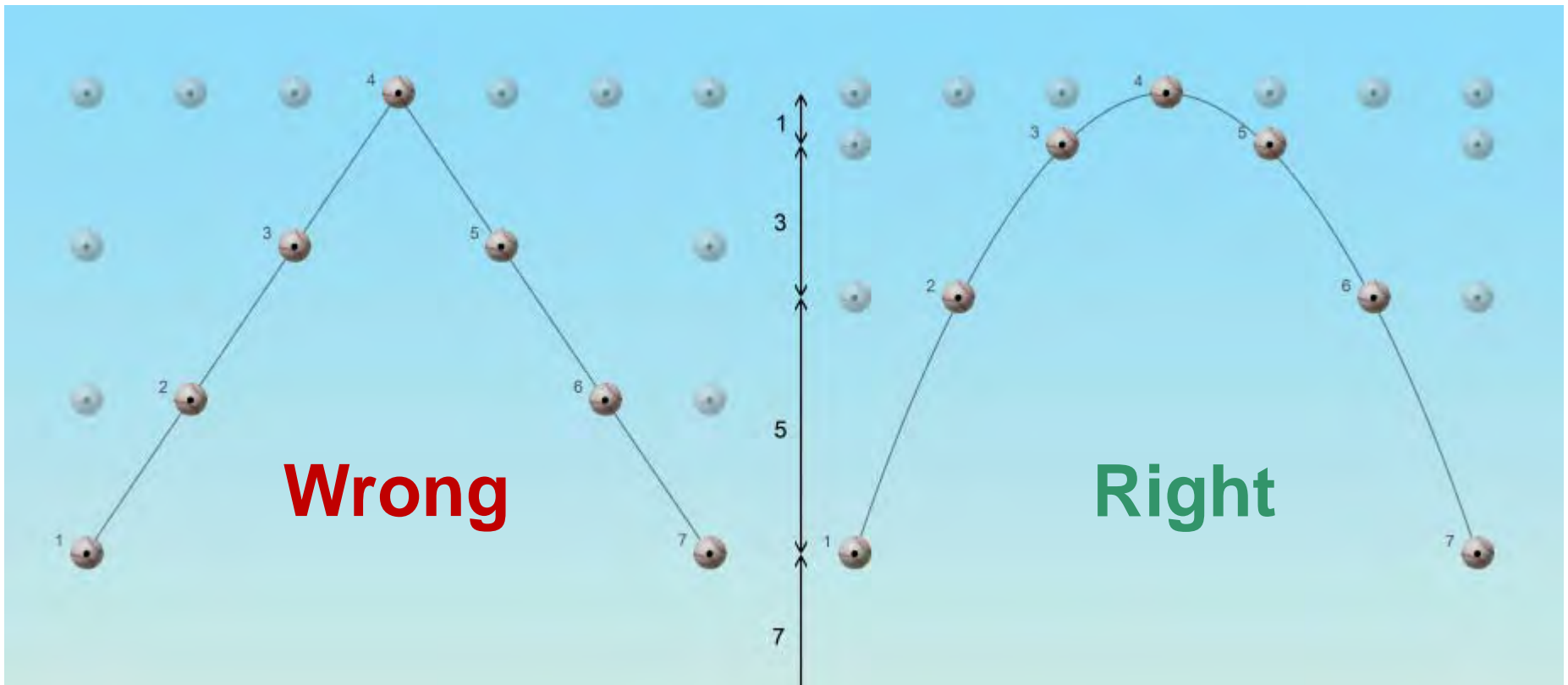
Arcs in Perspective



This parabolic arc looks distorted due to perspective but the spacings follow the same rules as for arcs in profile.

Common Errors in Arcs

Most common error in arcs is making them too straight.

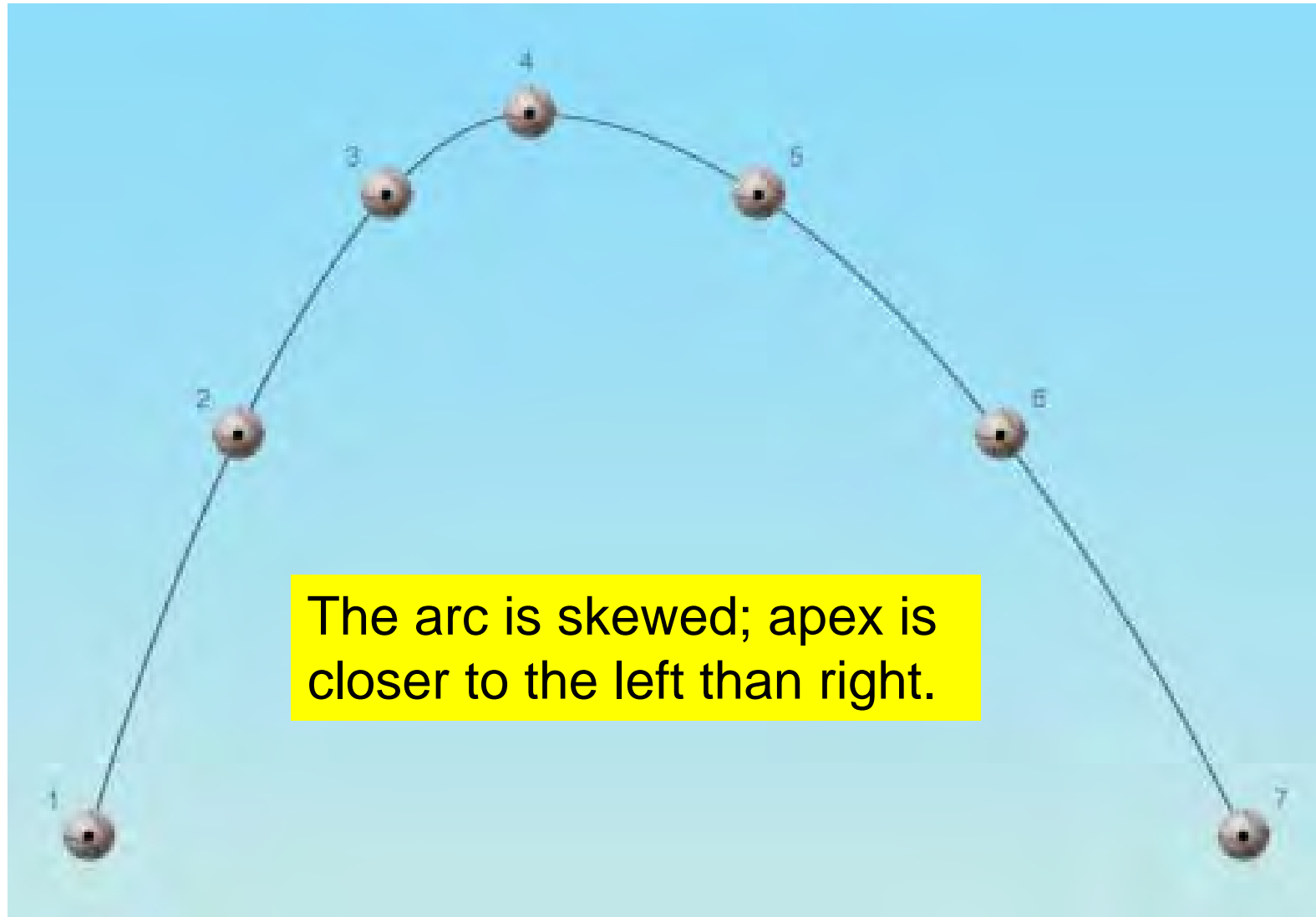


This example is exaggerated to make the error obvious.

Nacho Libre (2006)



Asymmetric Arcs

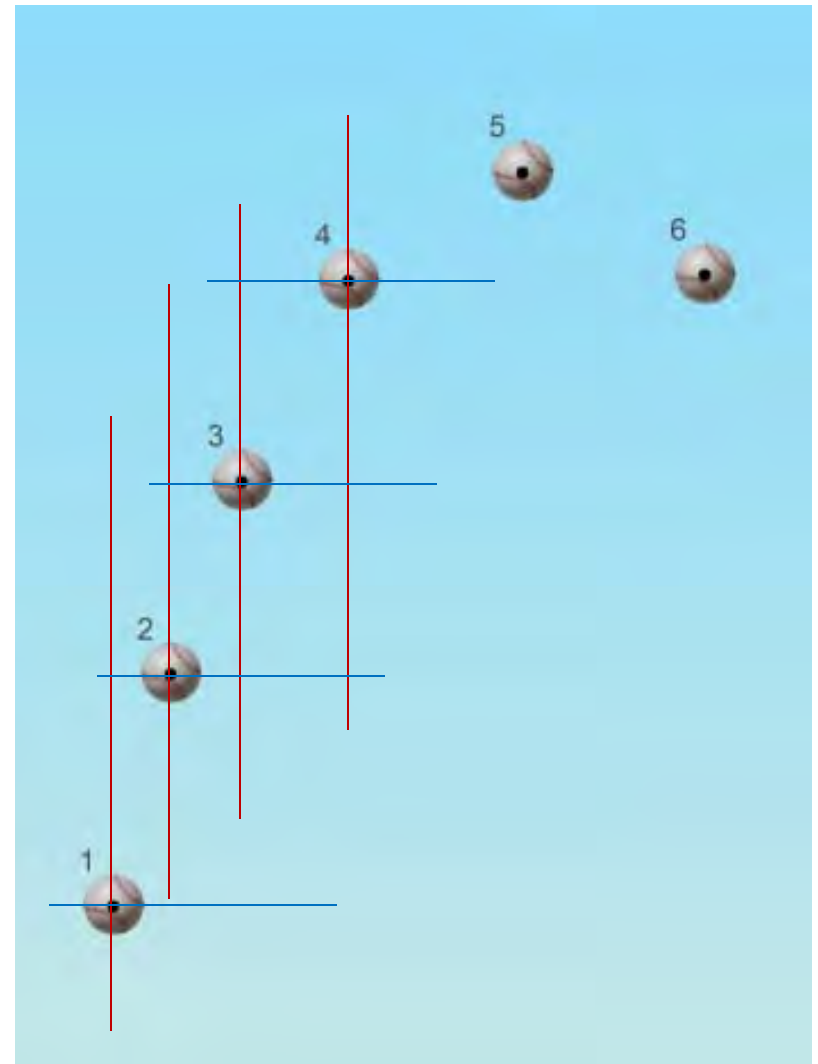


Path of Action and Spacings

The path of action for these drawings is roughly shaped like parabolic arc.

The spacings of these drawings are **not** physically accurate since:

- Horizontal spacings not constant and uniform.
- Vertical spacings do not slow into the apex.



Summary

- When gravity is the only significant force the path of action is a parabolic arc.
- For a parabolic path of action the horizontal spacings are constant and uniform.
- The vertical spacings are the same as for simple falling motion (i.e., The Odd Rule, Fourth Down at Half-time).
- Two common errors are: Making the arc too straight; Not having the apex centered.
- Path of action can have the right shape but the timing and spacing can still be wrong.