Circular Arcs: Tipping Motion

National Science Foundation
WHERE DISCOVERIES BEGIN

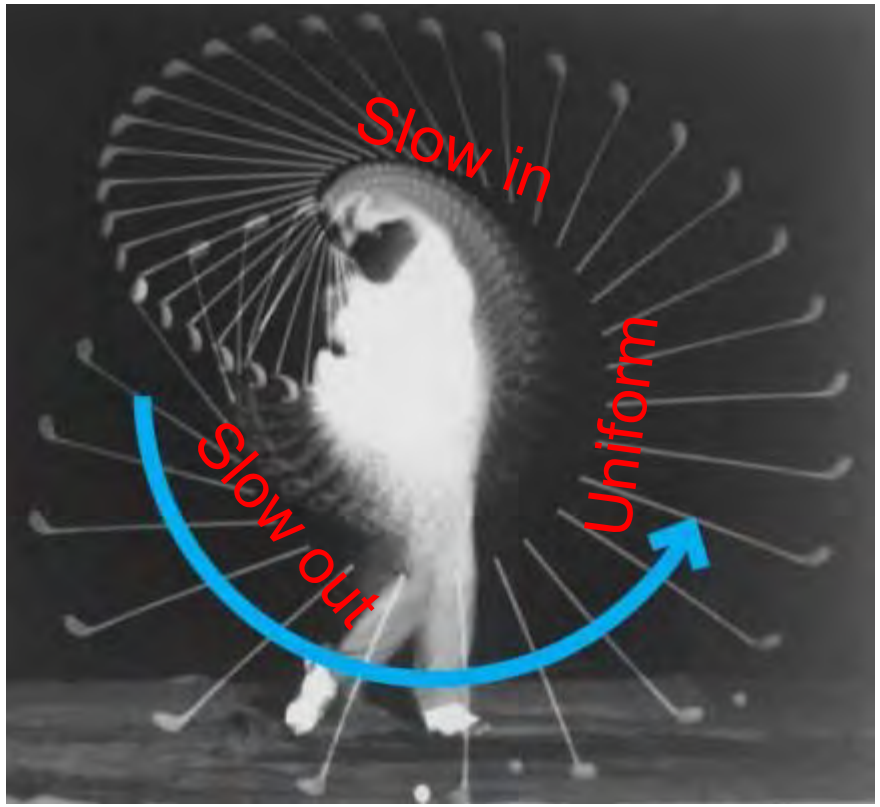
Animation
Physics

Timing & Spacing on Circular Arcs

A circular arc is a simple path of action but the timing may be complex and textured.

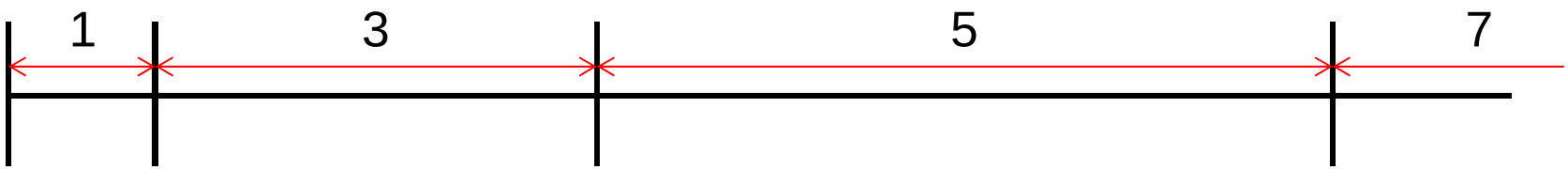
In this golf swing the motion:

- Slows out (accelerates) to hit the ball
- Uniform after the hit
- Slows in as the swing finishes follow-through

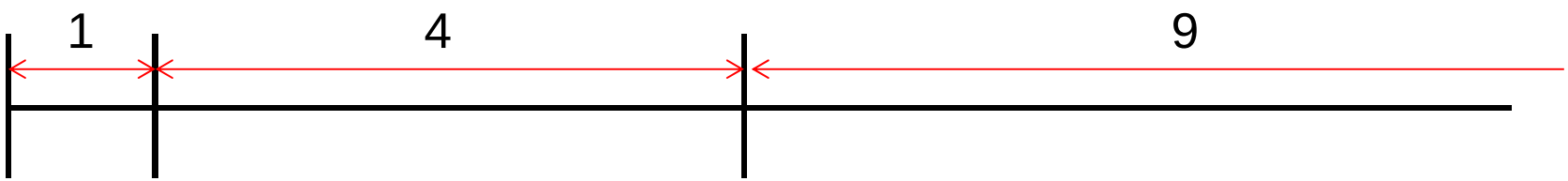


Texture in Timing & Spacing

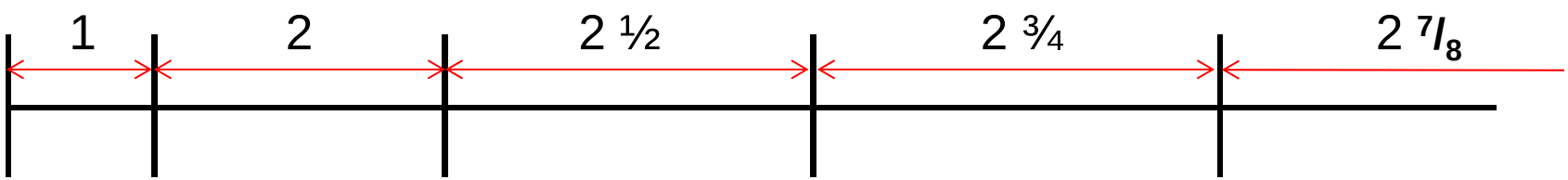
Odd Rule Spacing



More Textured Spacing



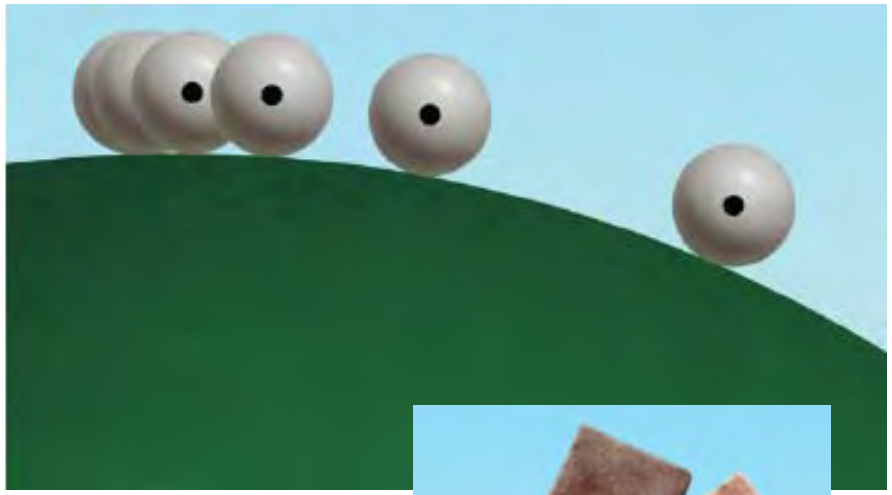
Less Textured Spacing



Non-Uniform Circular Motion

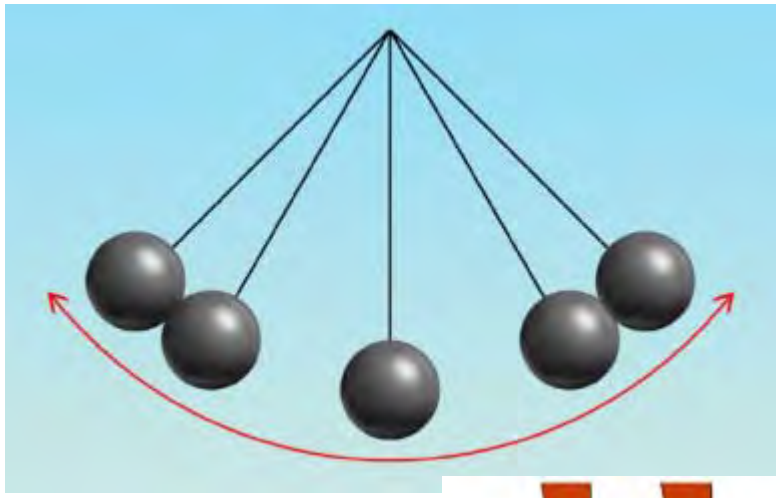
Two basic types of circular arcs, tipping and swinging have timing and spacing with different textures.

Exponential Spacing



Example:
Tipping over

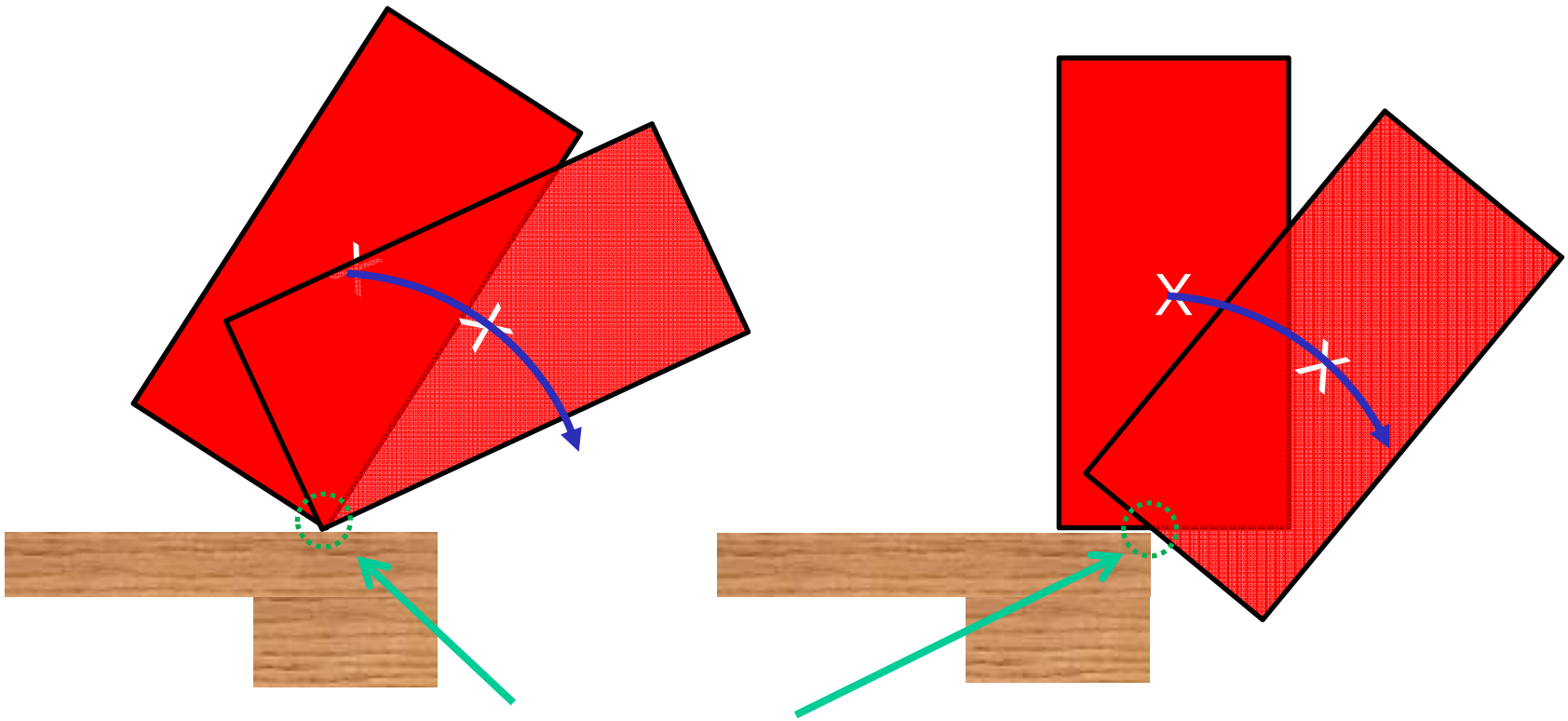
Sinusoidal Spacing



Example:
Stride in
walking

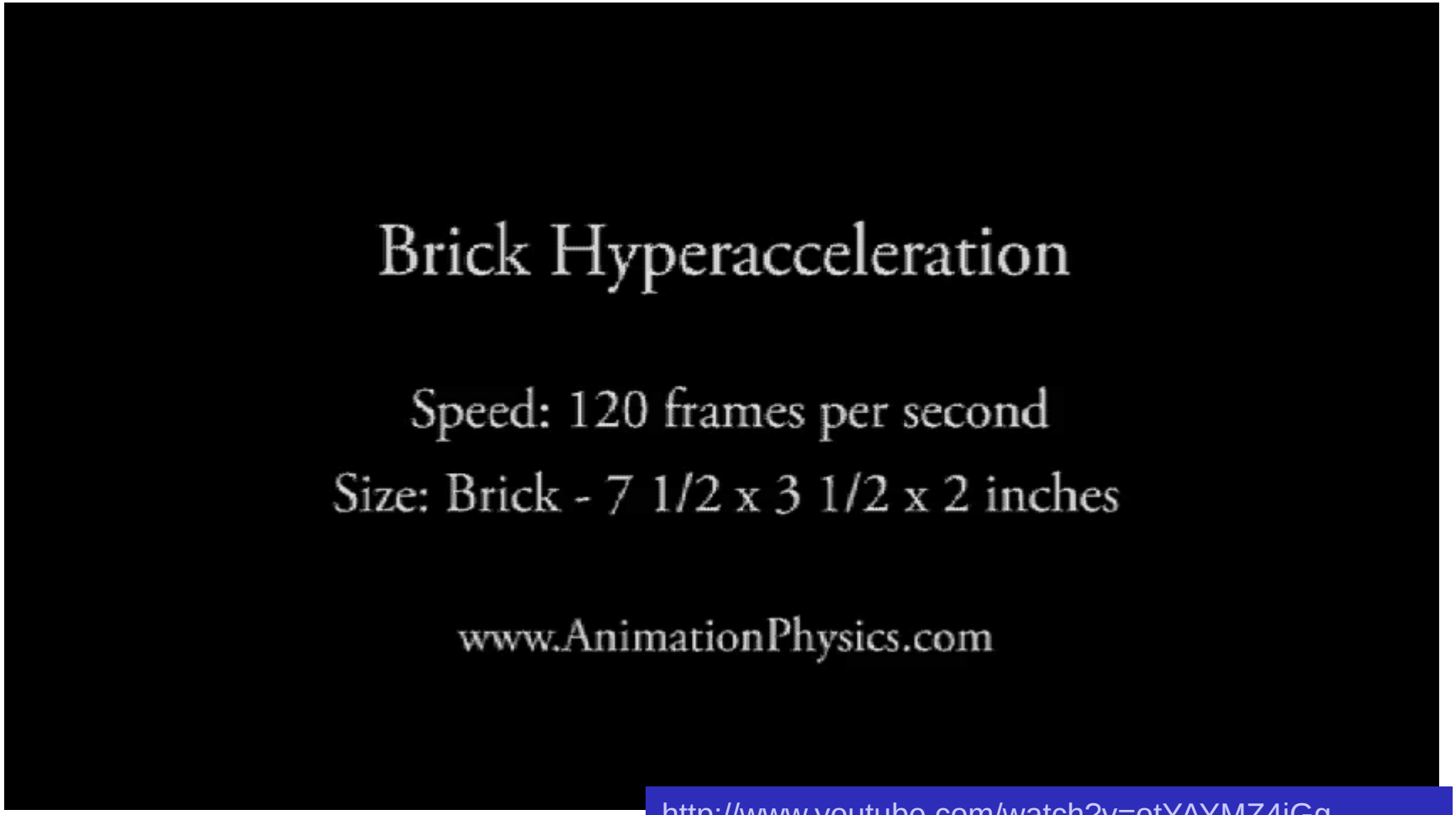
Tipping Rotation

A brick rotates about a point as it tips; that point is the center of a circular arc.



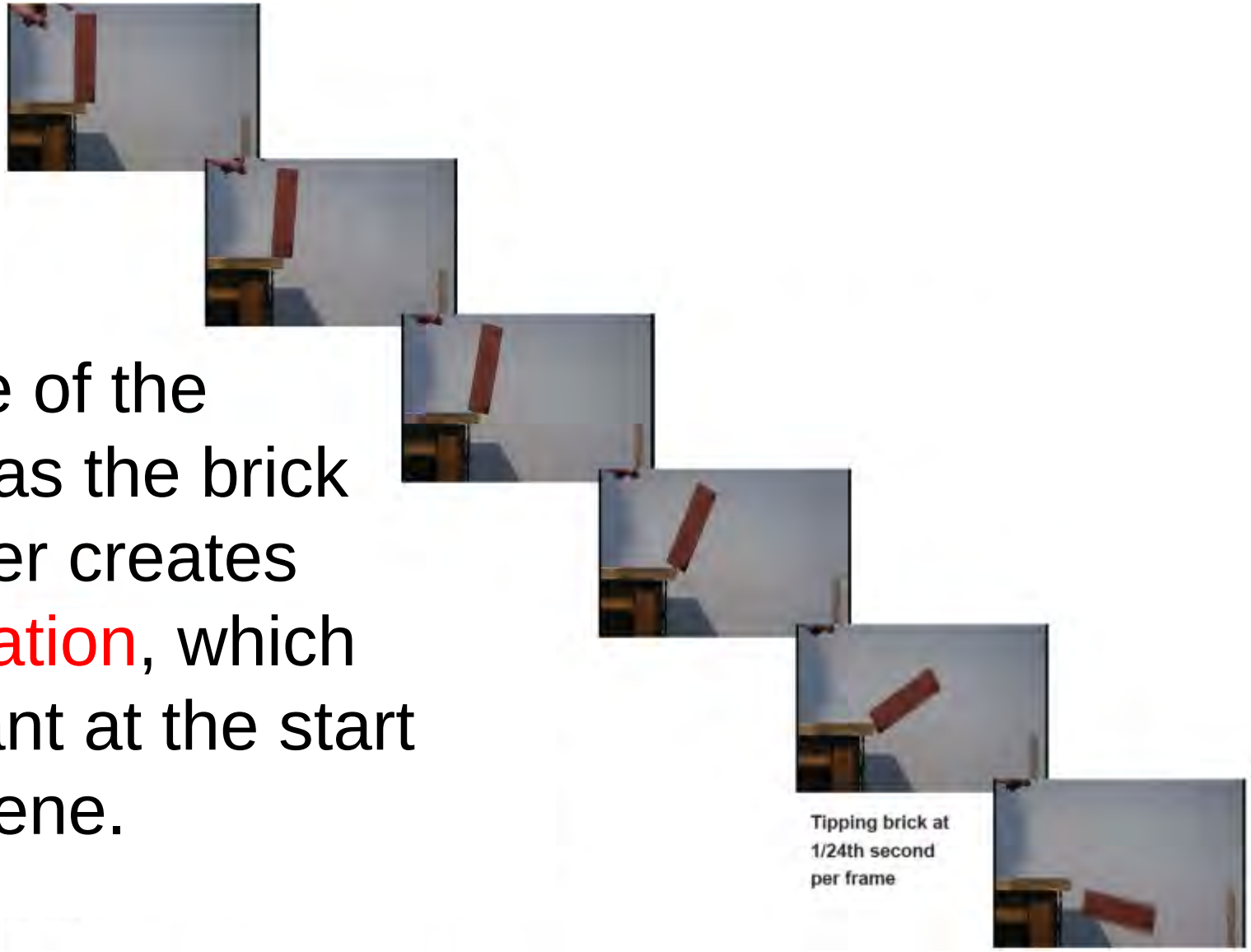
Center of the circle

Video Reference



http://www.youtube.com/watch?v=otYAYMZ4iGg

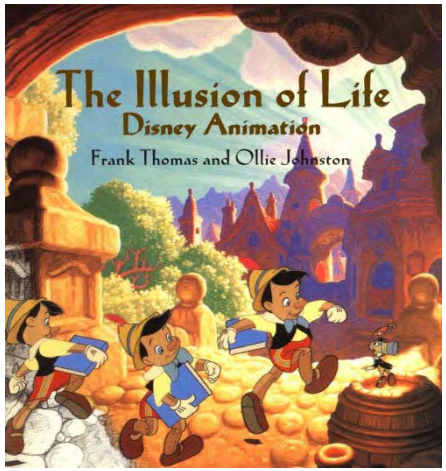
Anticipation & Exponential Spacing



Tipping brick at 1/24th second per frame

Texture of the timing as the brick tips over creates anticipation, which you want at the start of a scene.

Principles of Animation

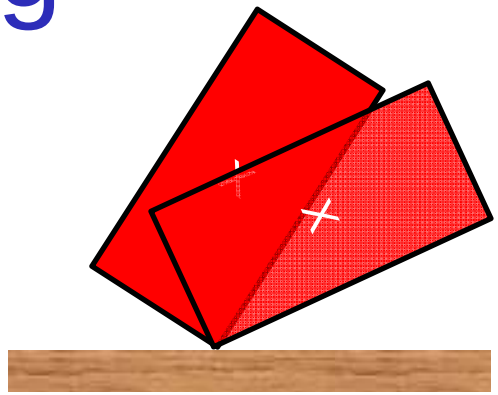


Anticipation prepares the viewer for an action that is about to occur, which improves the visual flow of the action.

1. Squash & Stretch
2. Timing
3. **Anticipation**
4. Staging
5. Follow Through & Overlapping Action
6. Straight Ahead & Pose-to-Pose Action
7. Slow In & Slow Out
8. Arcs
9. Exaggeration
10. Secondary Action
11. Appeal
12. Solid Drawing

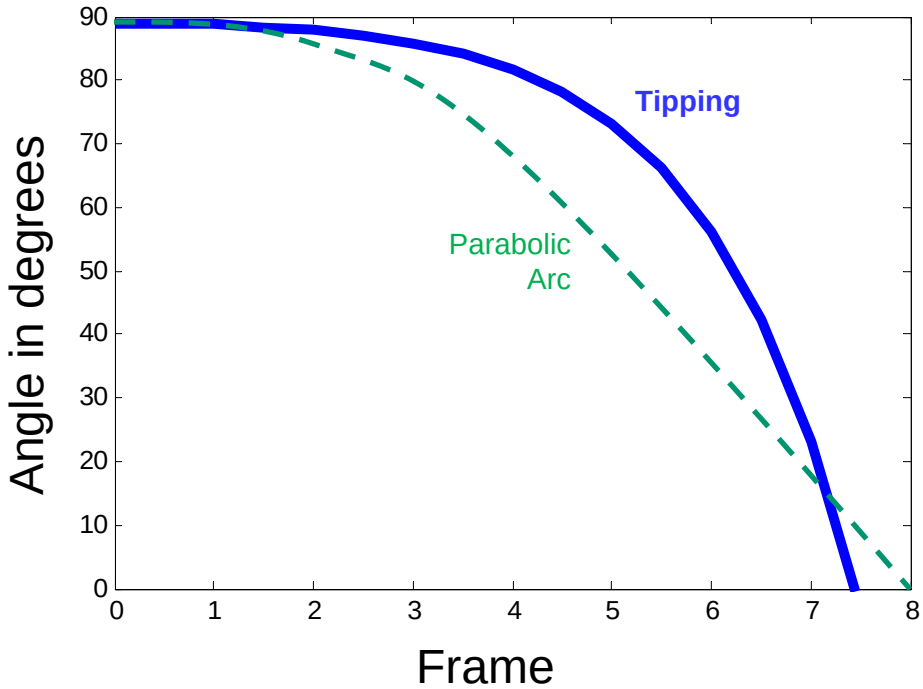
Motion Curve for Tipping

The motion curve for tipping has a more pronounced curvature than a parabolic arc.

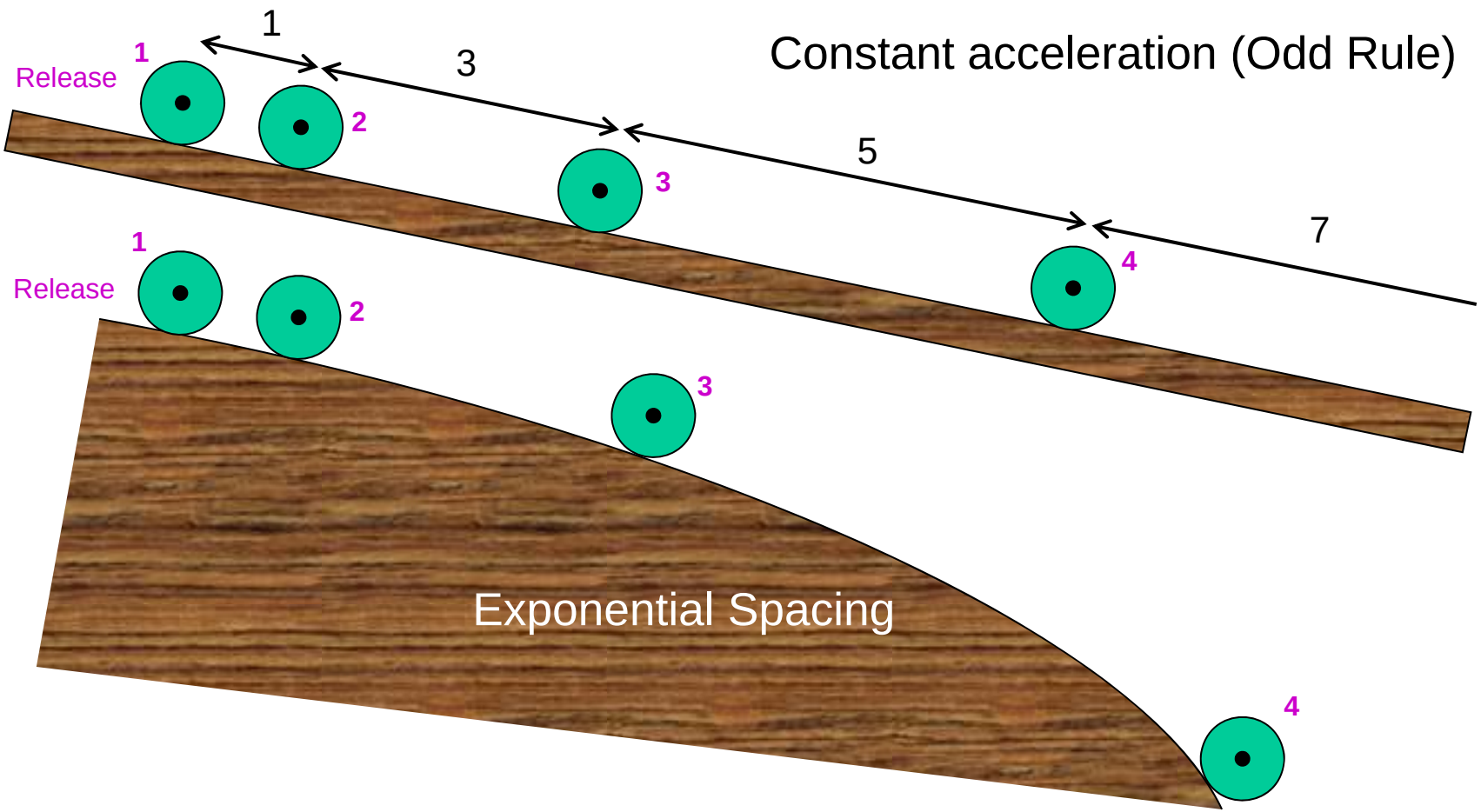


Shown here is the motion curve for a brick tipping over.

The brick is initially at an angle of 89°



Exponential Spacing



As the slope of the incline increases, the acceleration itself accelerates.

Timing for Tipping Motion

The taller the character or object, the more time it takes to tip.

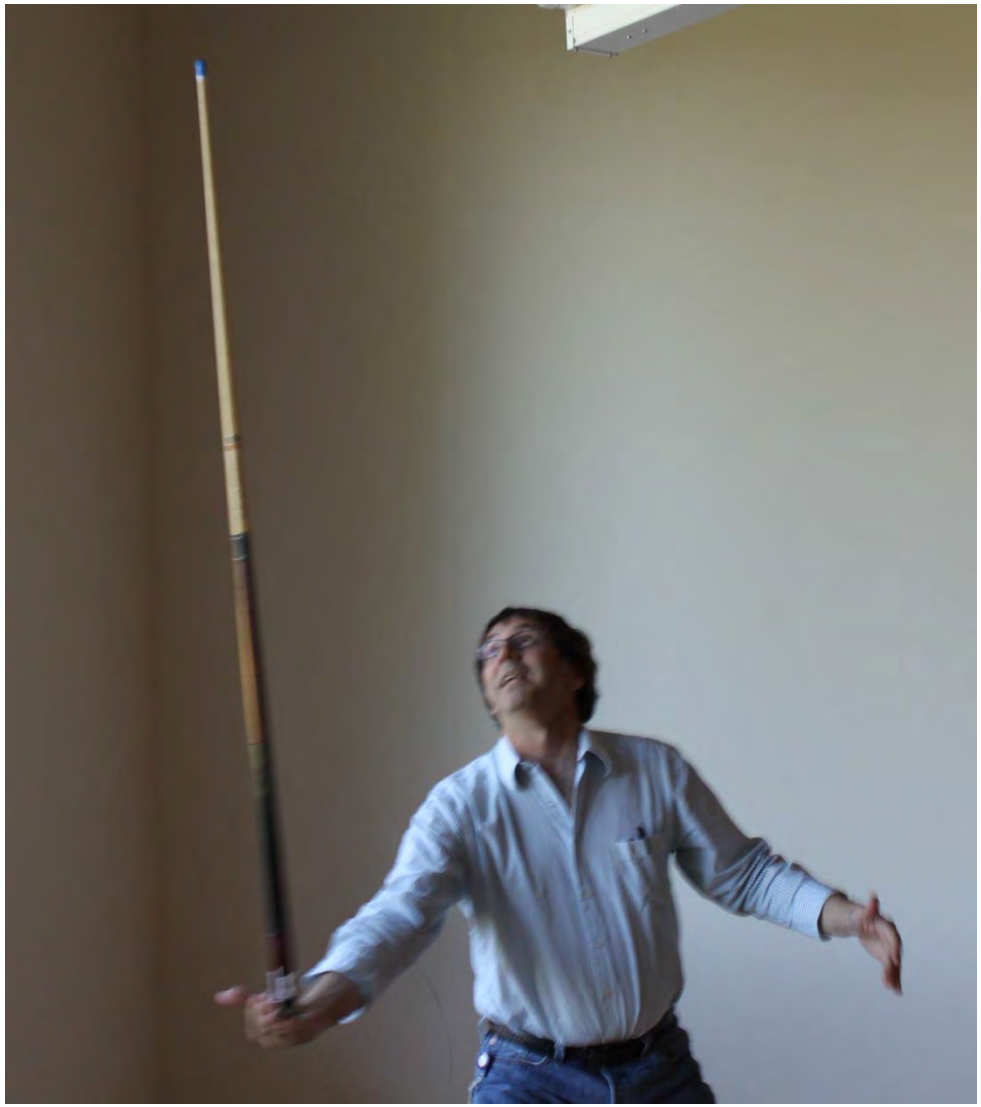
If the man is x4 taller than the baby then he takes x2 more time to fall than the baby.

Balancing a Pool Cue

Try to balance a cue stick in the palm of your hand.

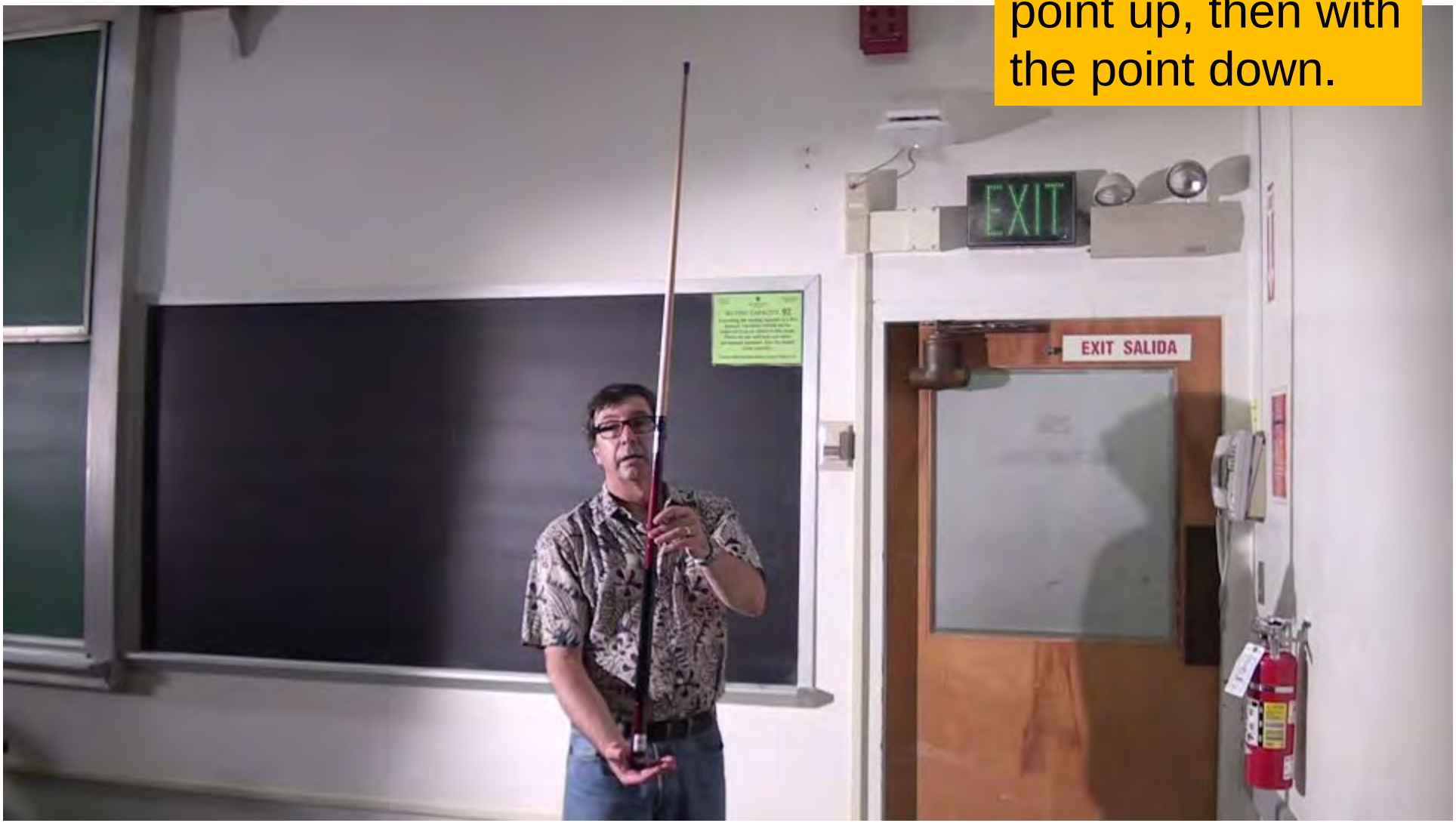
When the stick starts to fall you have to correct the balance quickly.

How can you <u>slow the rotation</u> of the stick to make this easier to do?

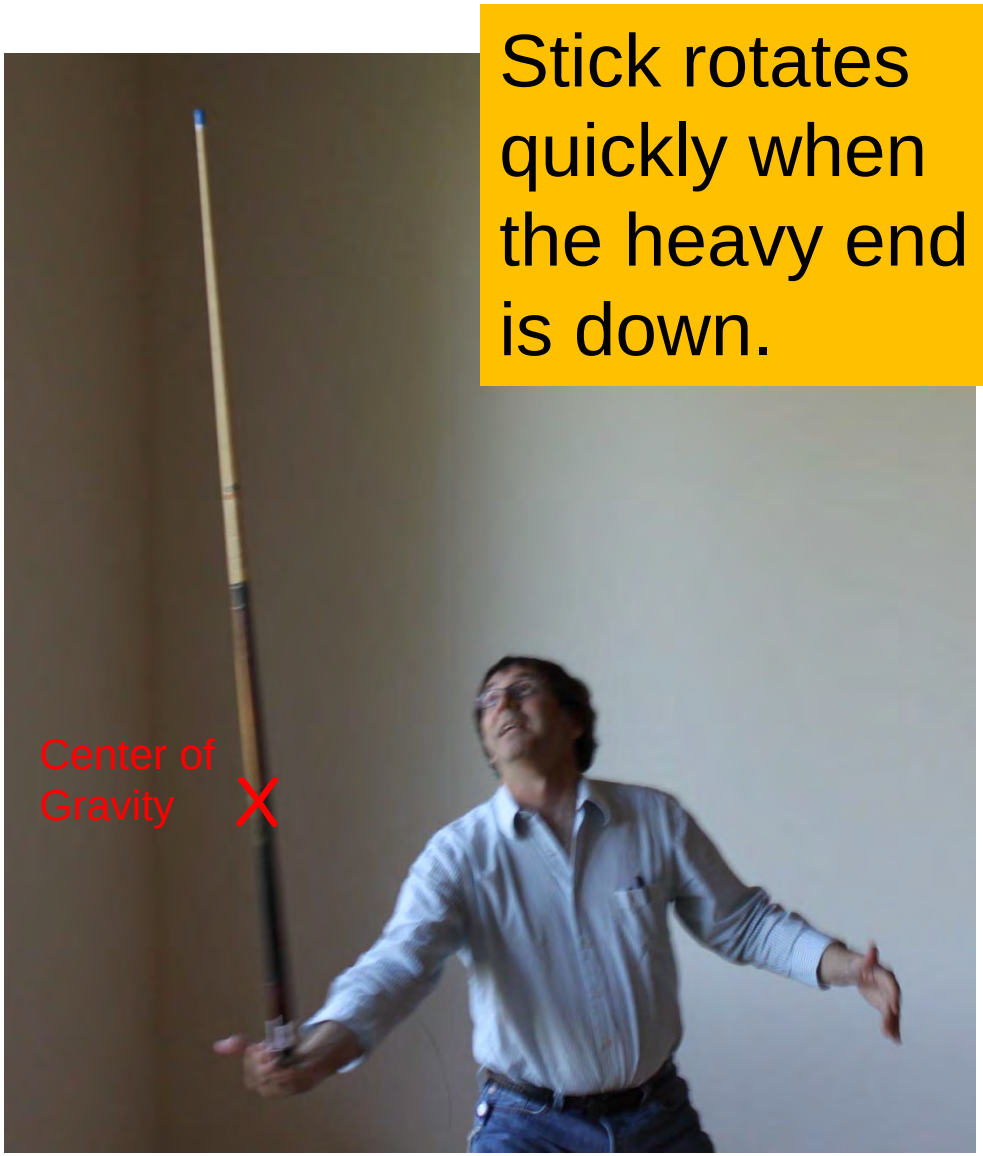


Balancing a Pool Cue

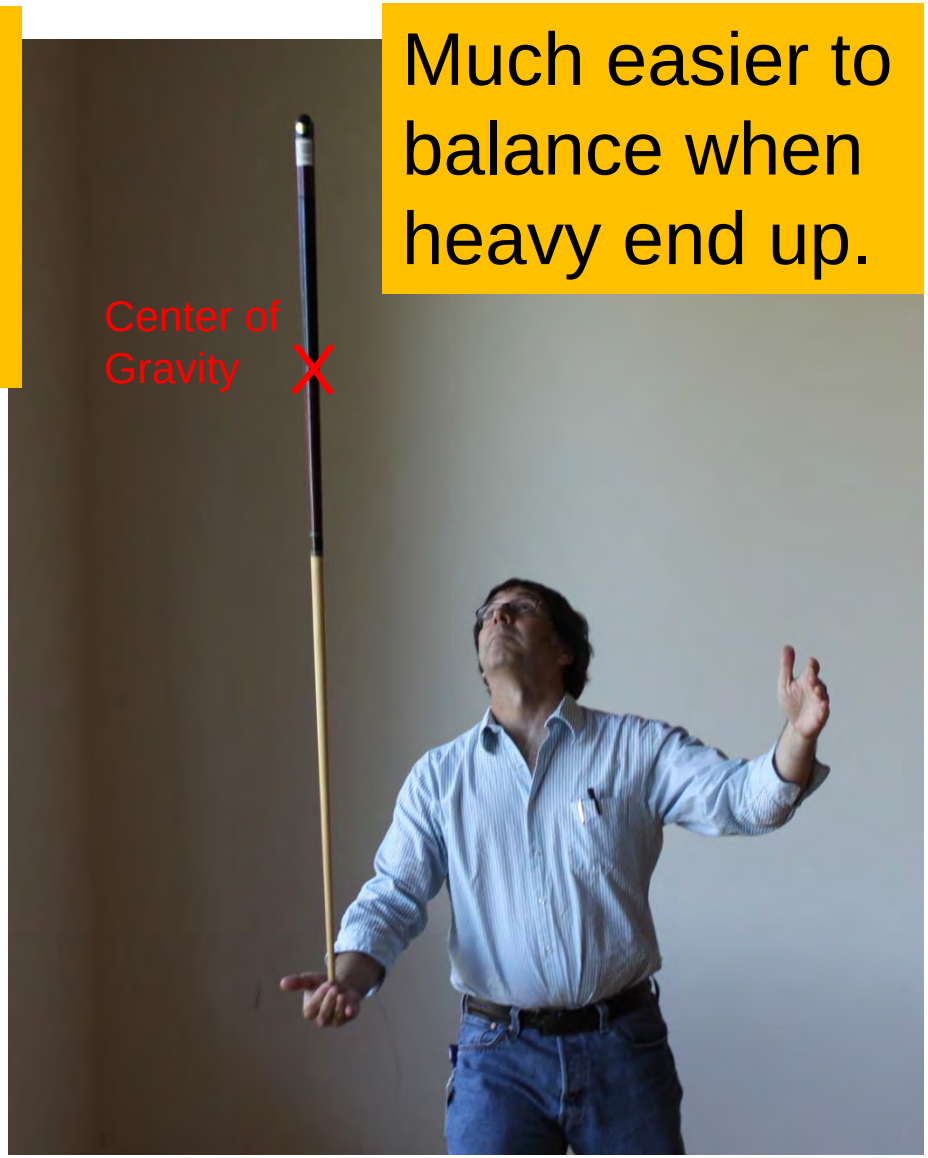
First try with the point up, then with the point down.



Balancing a Pool Cue



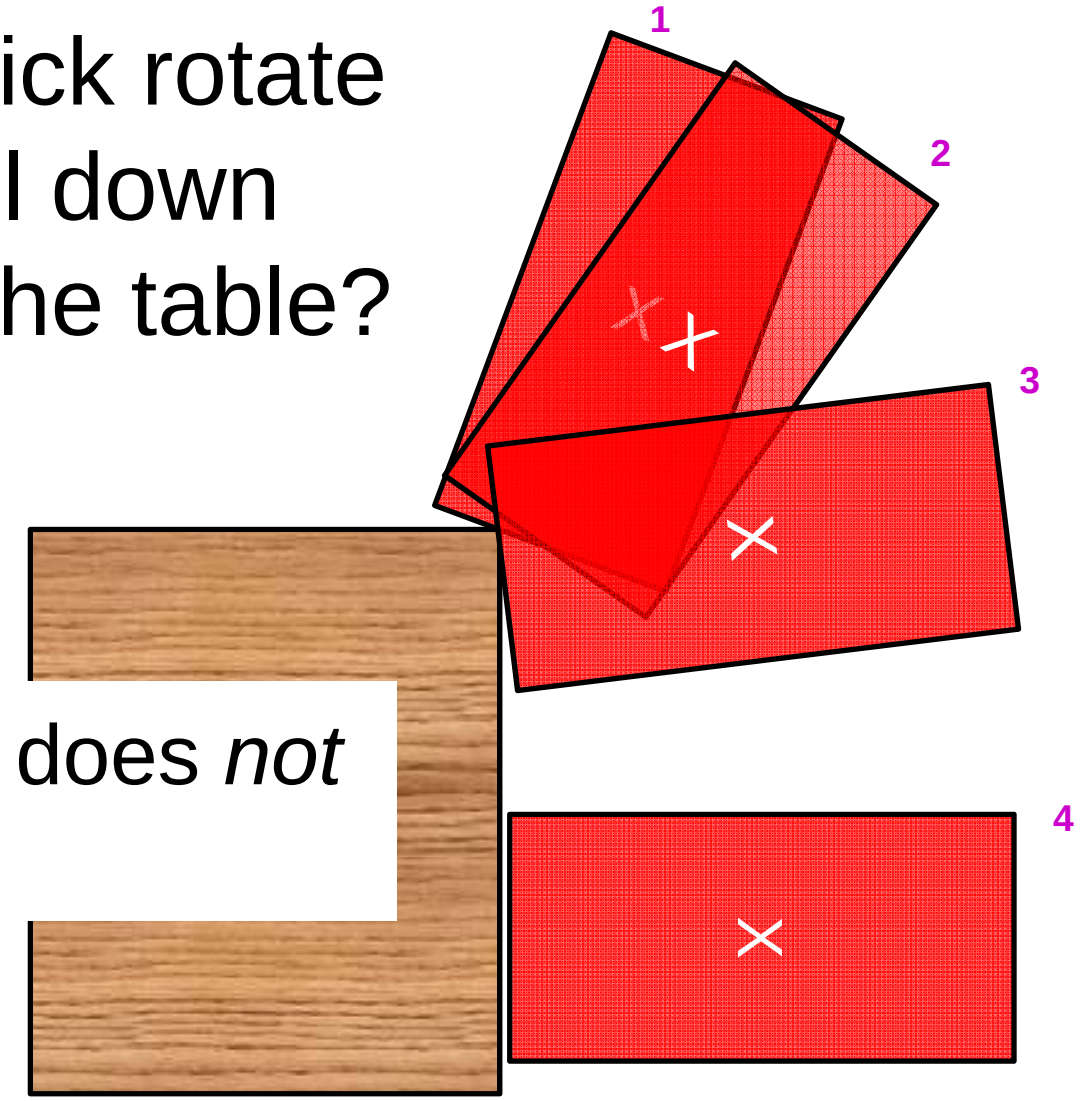
Stick rotates quickly when the heavy end is down.



Much easier to balance when heavy end up.

Falling Off a Table

Does the brick rotate and then fall down the side of the table?

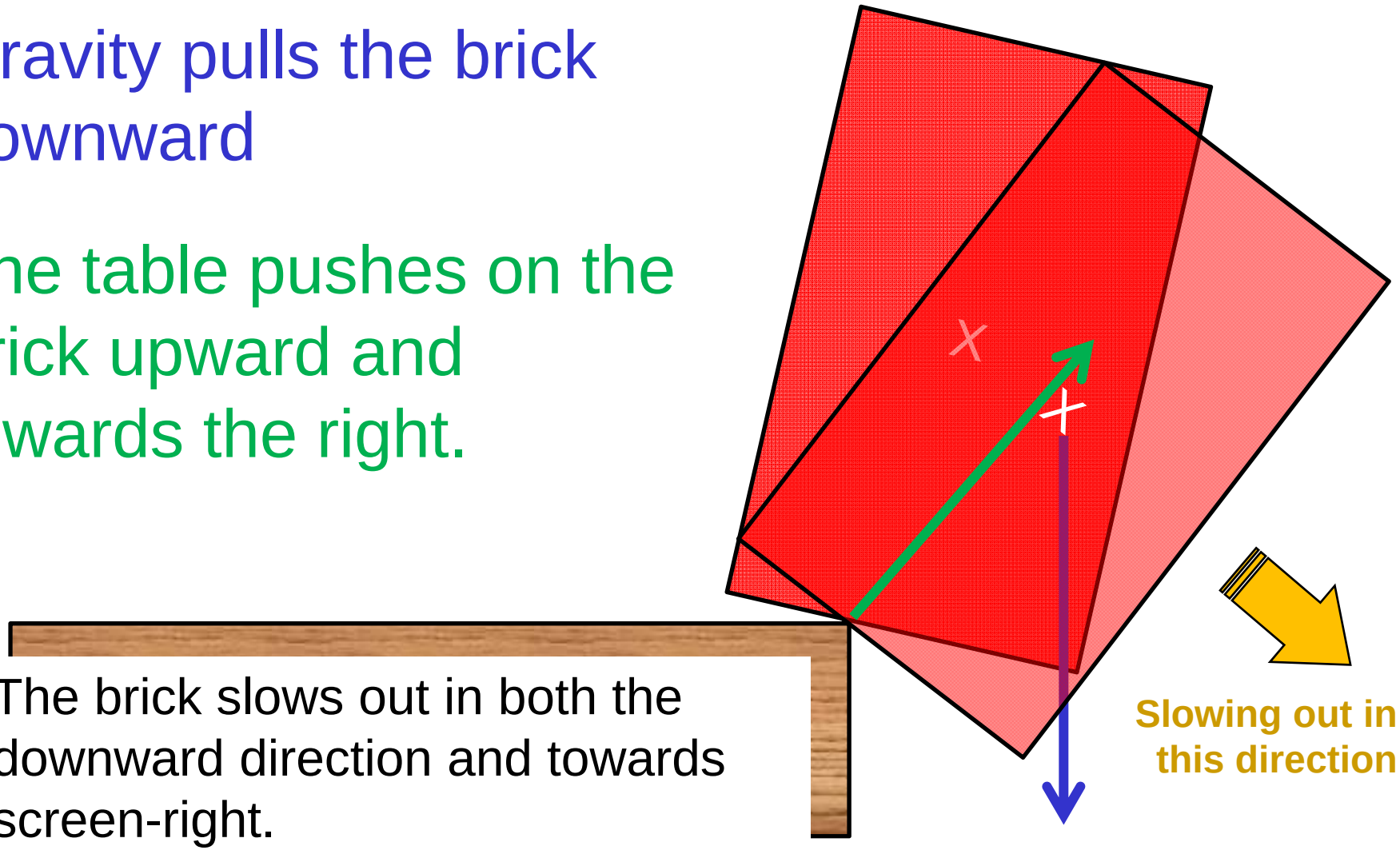


No! The brick does *not* fall this way.

Forces on the Tipping Brick

Gravity pulls the brick downward

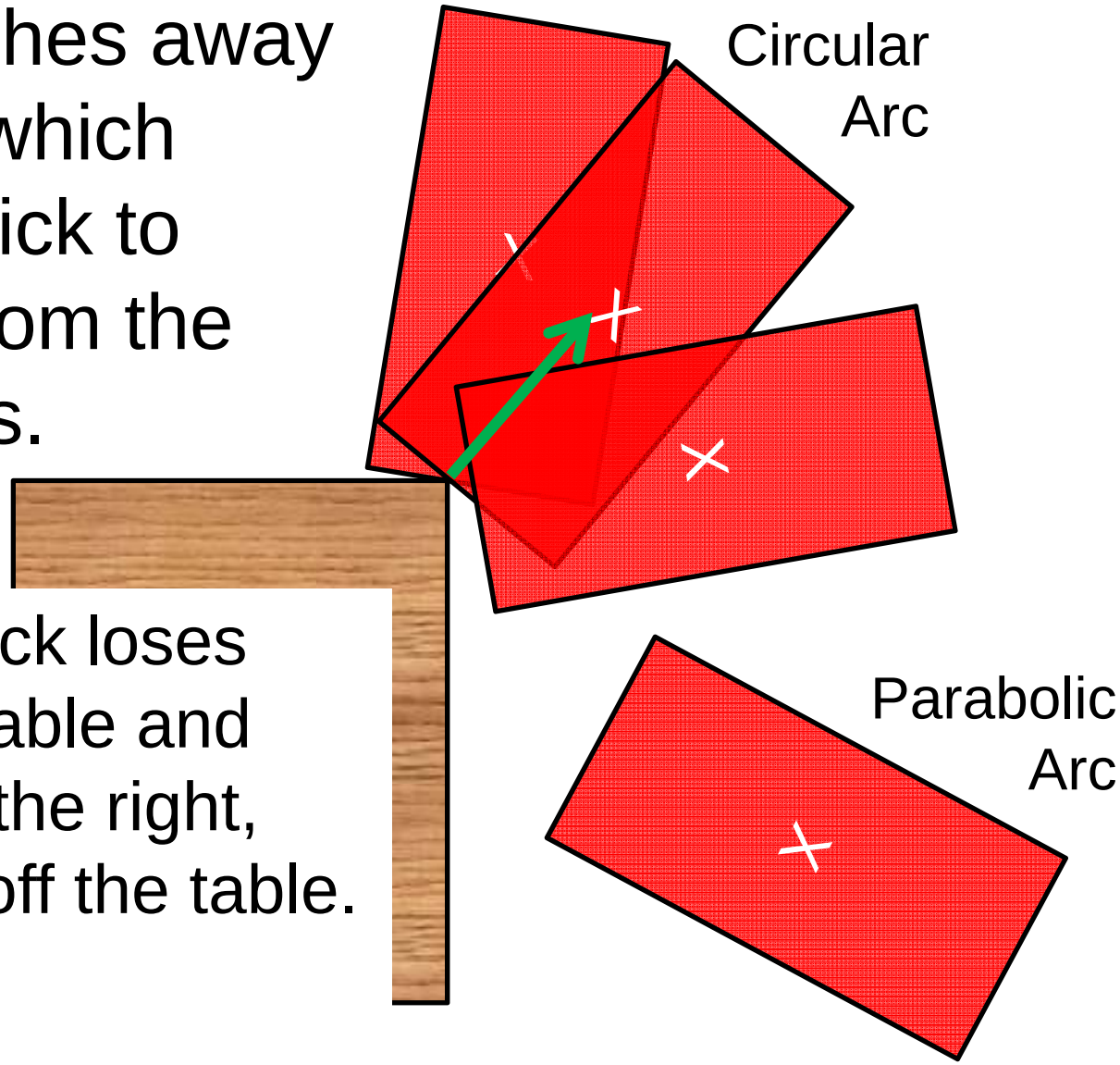
The table pushes on the brick upward and towards the right.



The brick slows out in both the downward direction and towards screen-right.

Leaving the Table

The table pushes away on the brick, which causes the brick to move away from the table as it falls.



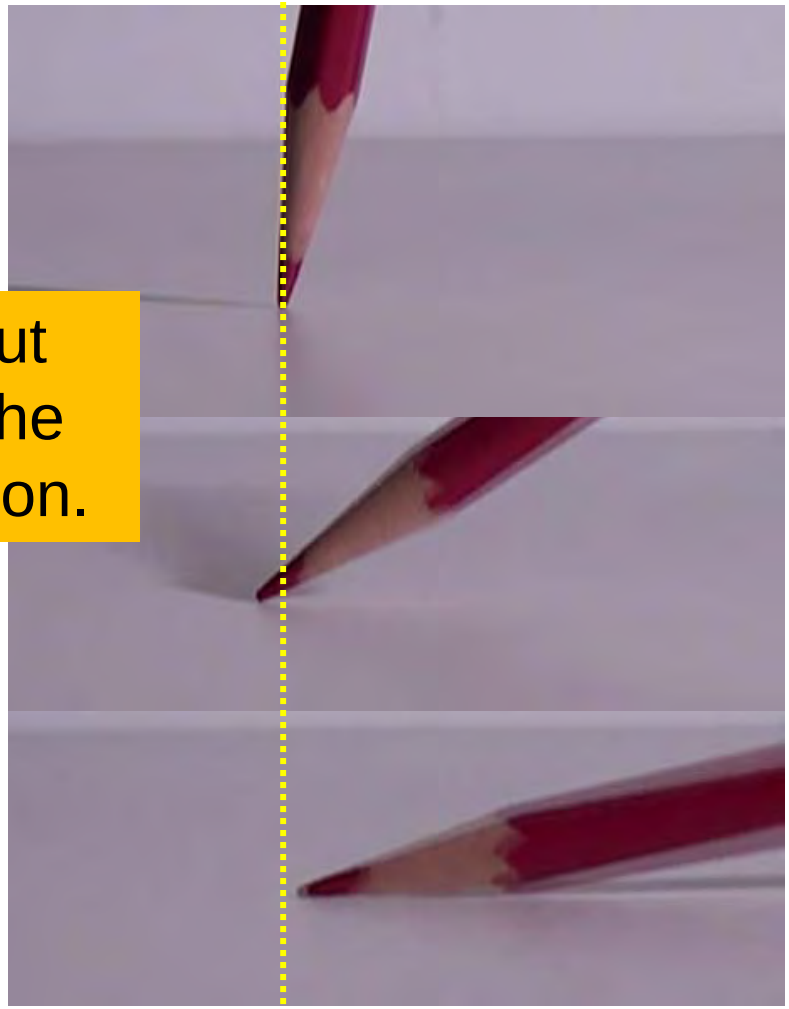
Eventually the brick loses contact with the table and keeps moving to the right, like a ball rolling off the table.

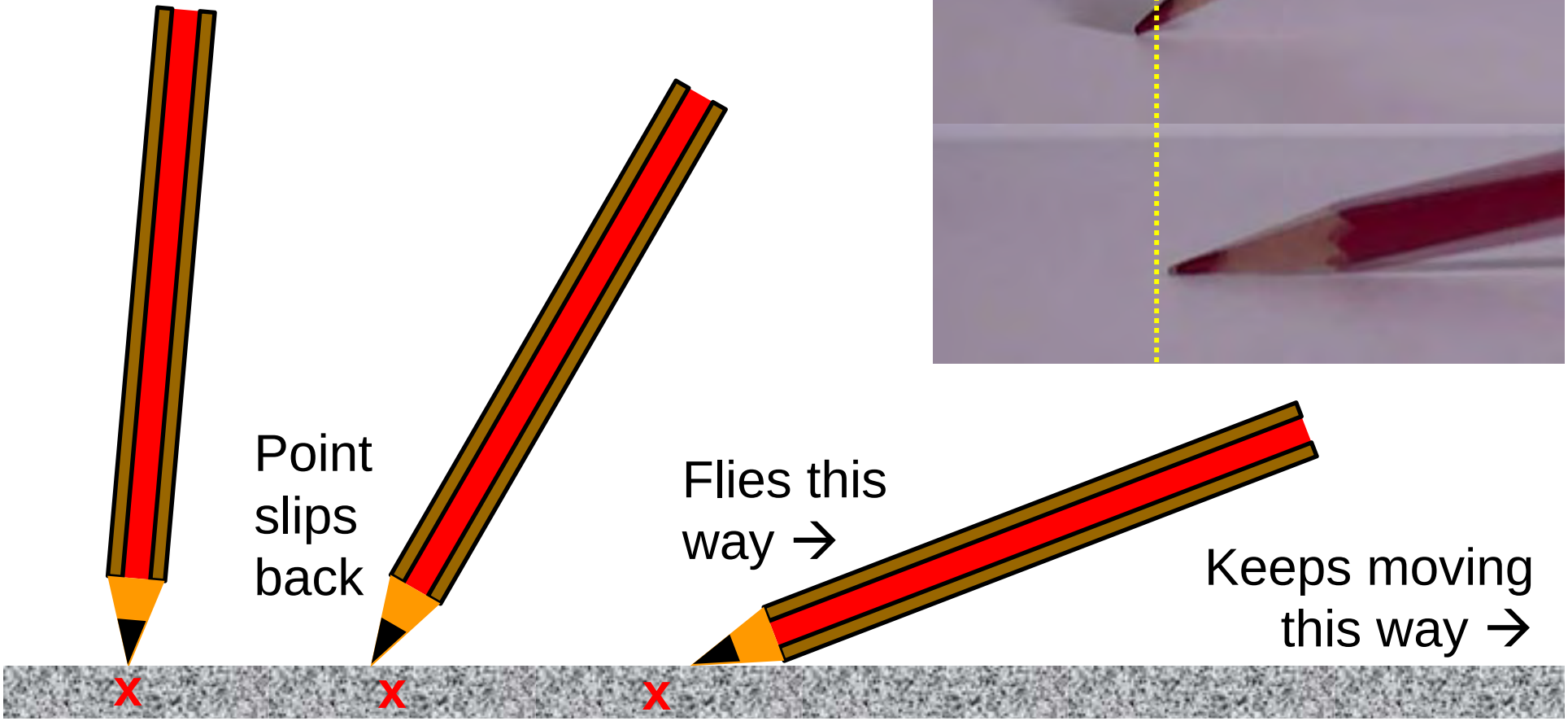
Tipping Pencil

Similar motion occurs when a tall object, like a pencil, tips over on a flat surface.

Tipping Pencil

The point slips backward but the pencil flies forward, in the direction of the tipping motion.





Summary

- Tipping over is a common example of a path of action that’s a circular arc.
- The timing and spacing for tipping motion has more texture than simple falling.
- The texture in this timing and spacing can create anticipation for the tipping motion.
- The taller the character or object, the more time it takes for it to tip over.
- When an object tips off of an edge it moves away from that edge once it loses contact.