

# Circular Arcs: Swinging Motion



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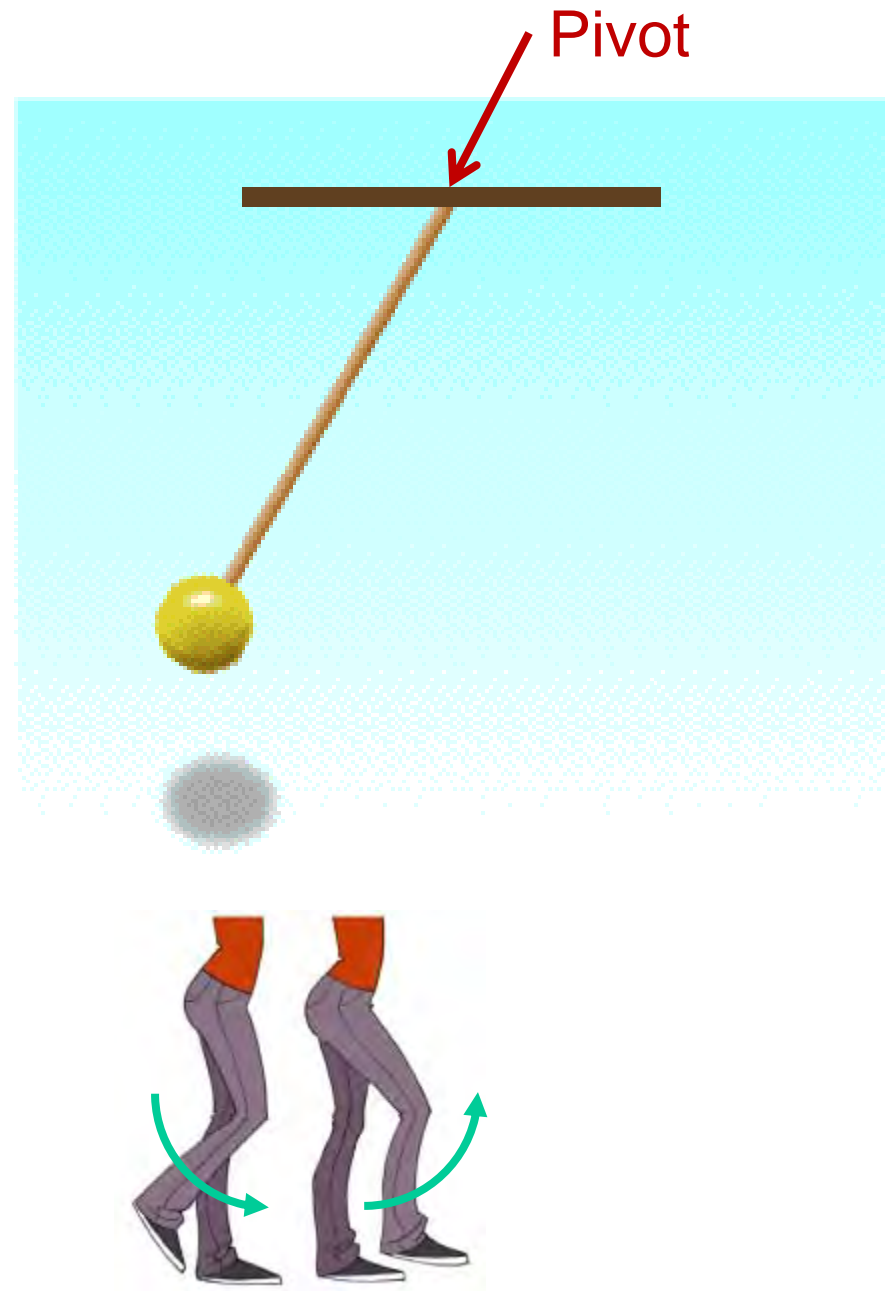
Animation  
Physics



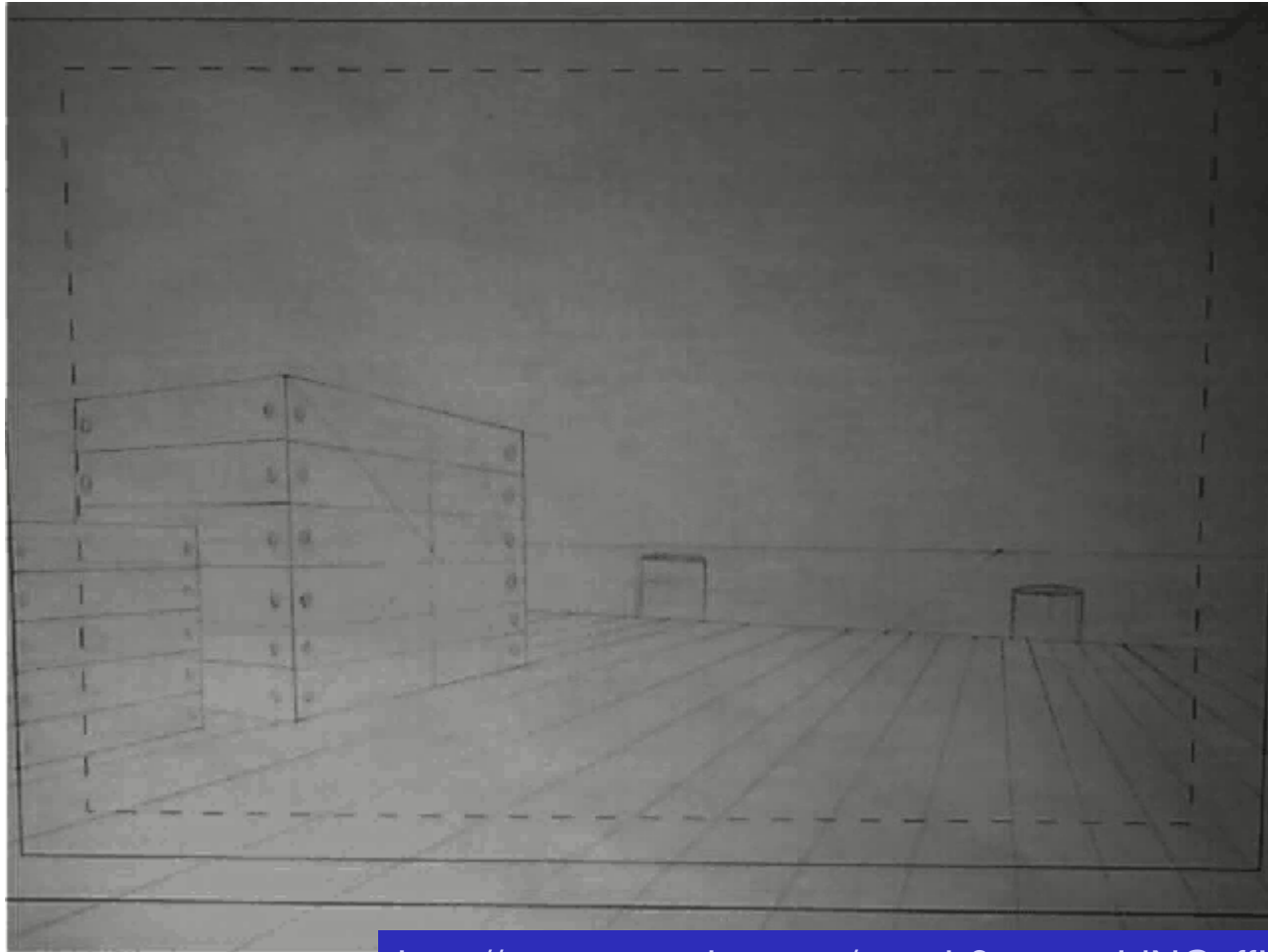
# Pendulum

A pendulum is the classic example for a swinging object.

It can be a weight swinging from a pivot or a limb swinging from a joint.



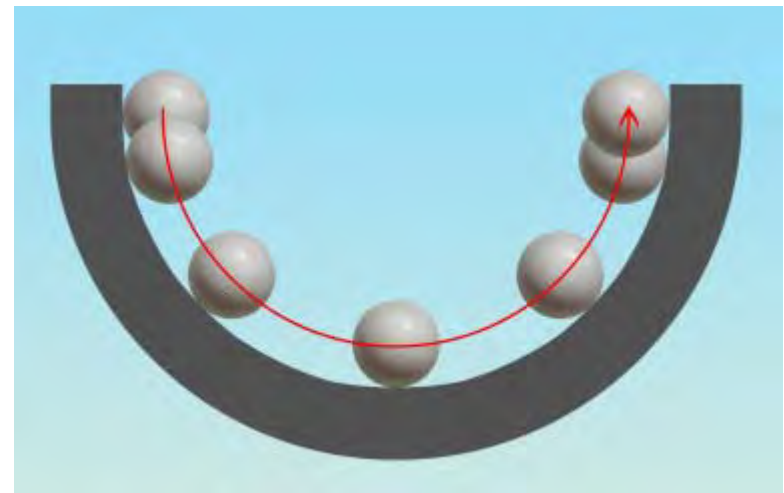
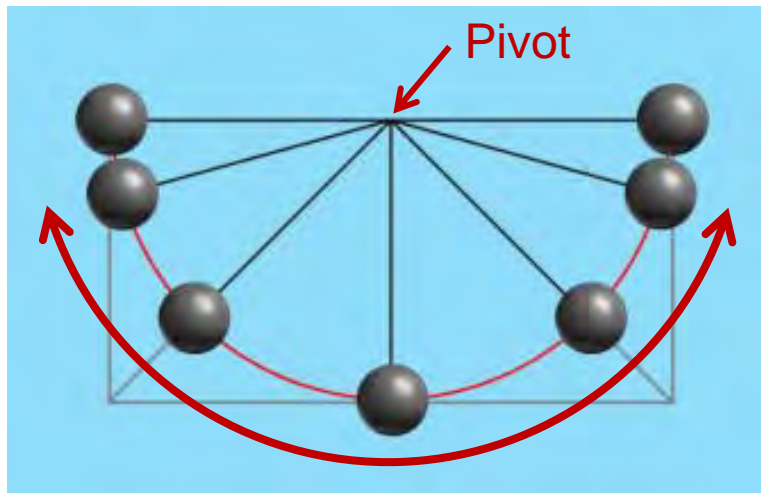
# Pencil Test Example



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

# Spacing & Timing in Swinging

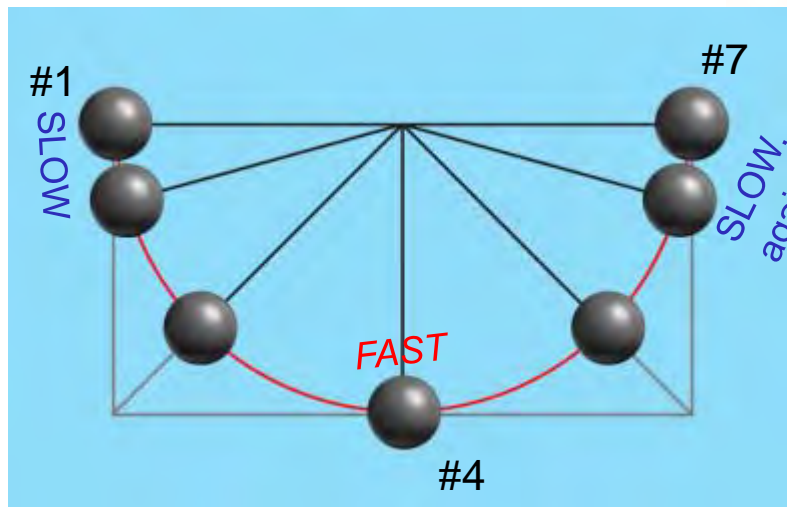
A pendulum slows in and out as it swings back and forth, like a ball in a half-pipe.



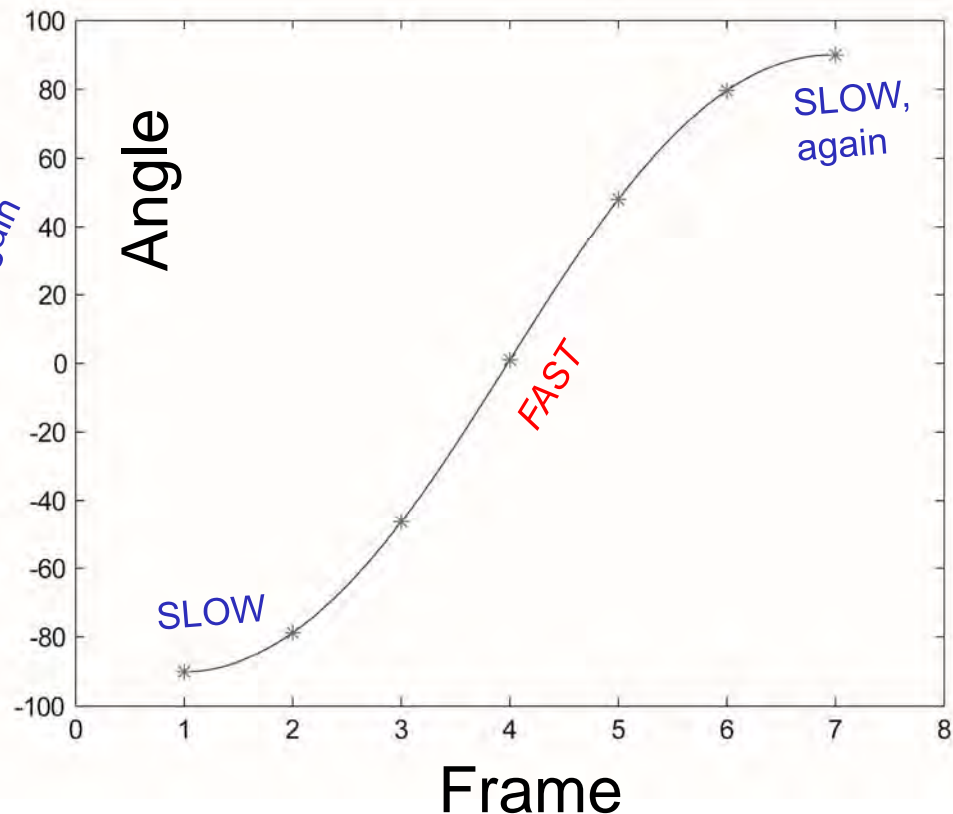
Most of the texture in the timing is at the apexes; spacings are almost constant around the center.

# Motion Graph for Swinging

Motion curve confirms that the timing and spacing has the most texture at the apexes.

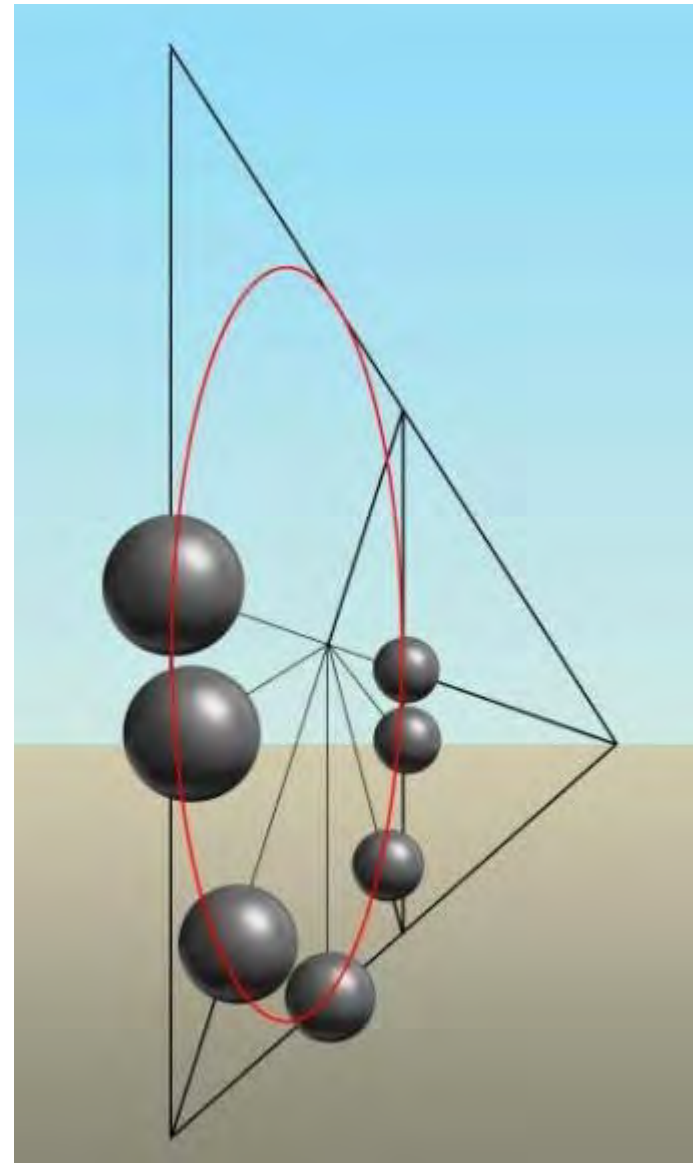
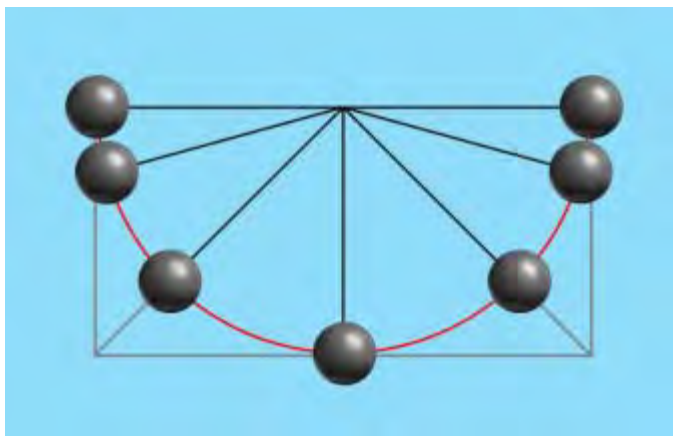


Ball goes fastest around the bottom but the speed is almost constant.



# Swinging in Perspective

Visually the timing and spacing has a different texture when the swing is in perspective.



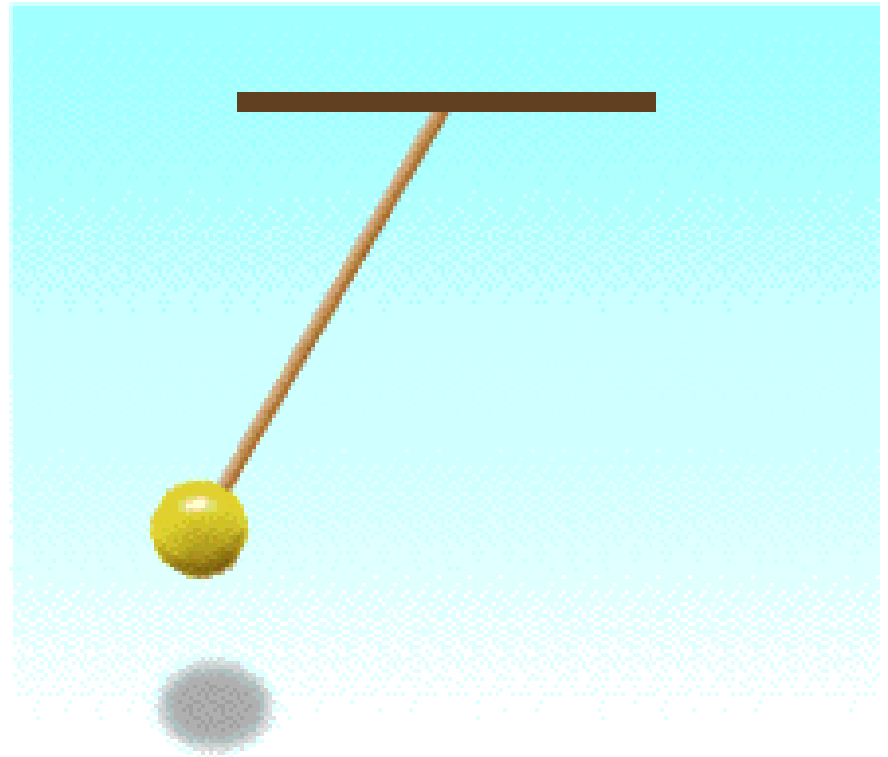
# Bowling Ball Pendulum

<http://www.youtube.com/watch?v=UNsD15GjWWE>



# Period of Swinging

Time required for a full cycle (one round trip) is called the *period* of the cycle.



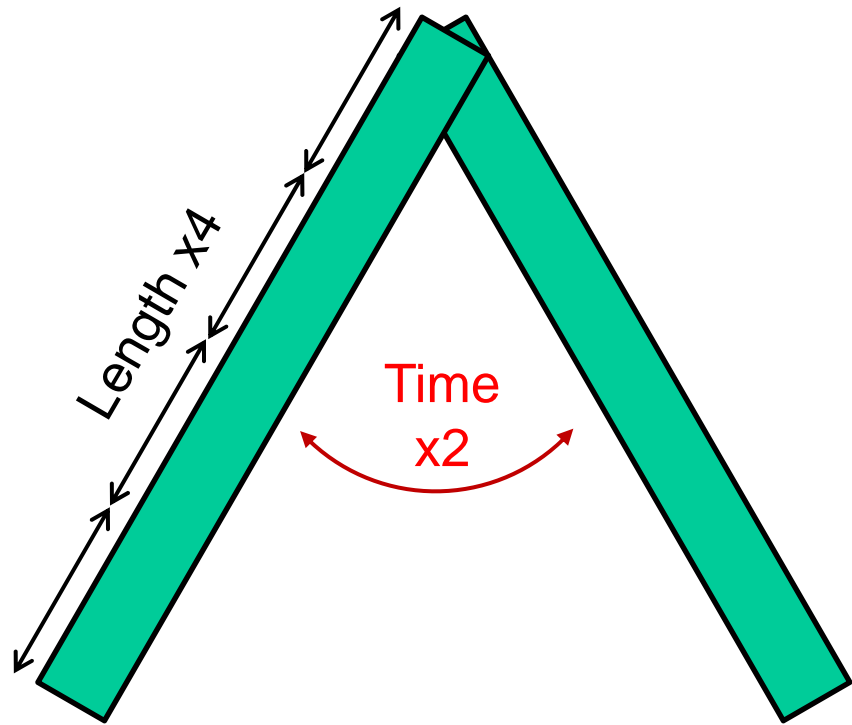
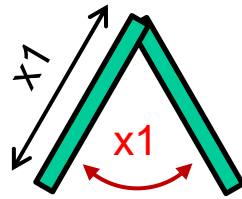


# Period of a Pendulum

Period of a swinging pendulum depends *only* on its length.

Greater the length, the longer the period.

Pendulum x4 longer swings in x2 the time.



# Long vs. Short

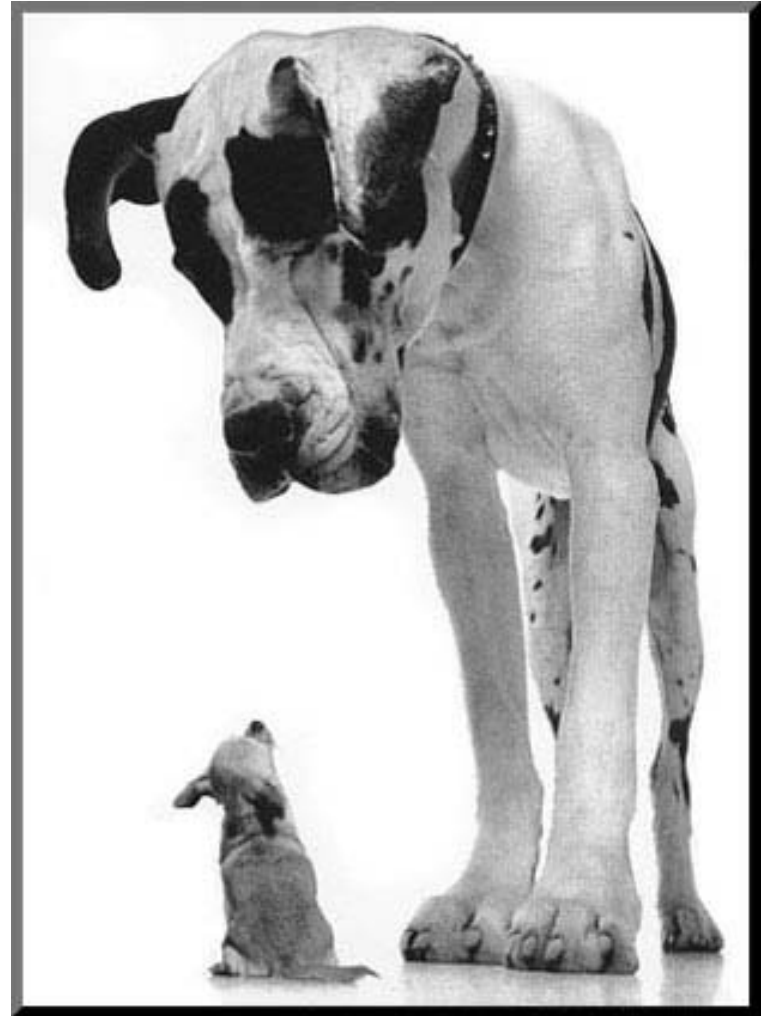
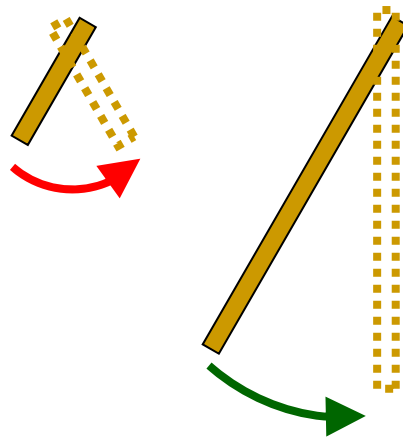
<http://www.youtube.com/watch?v=Xtl0iD5GY54>



# Period of a Walking Gait

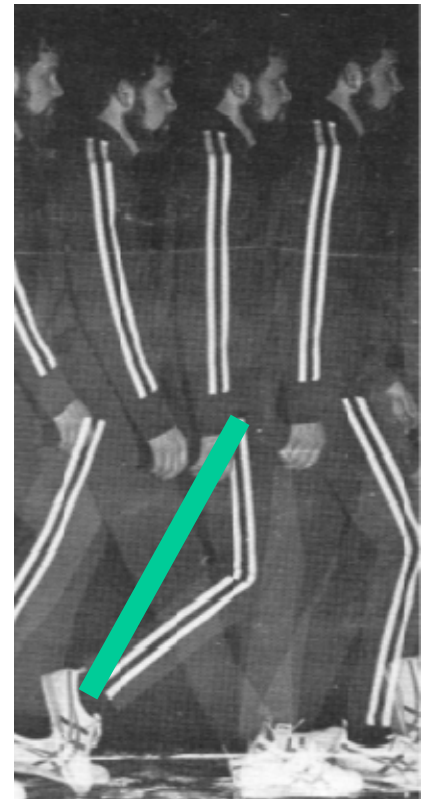
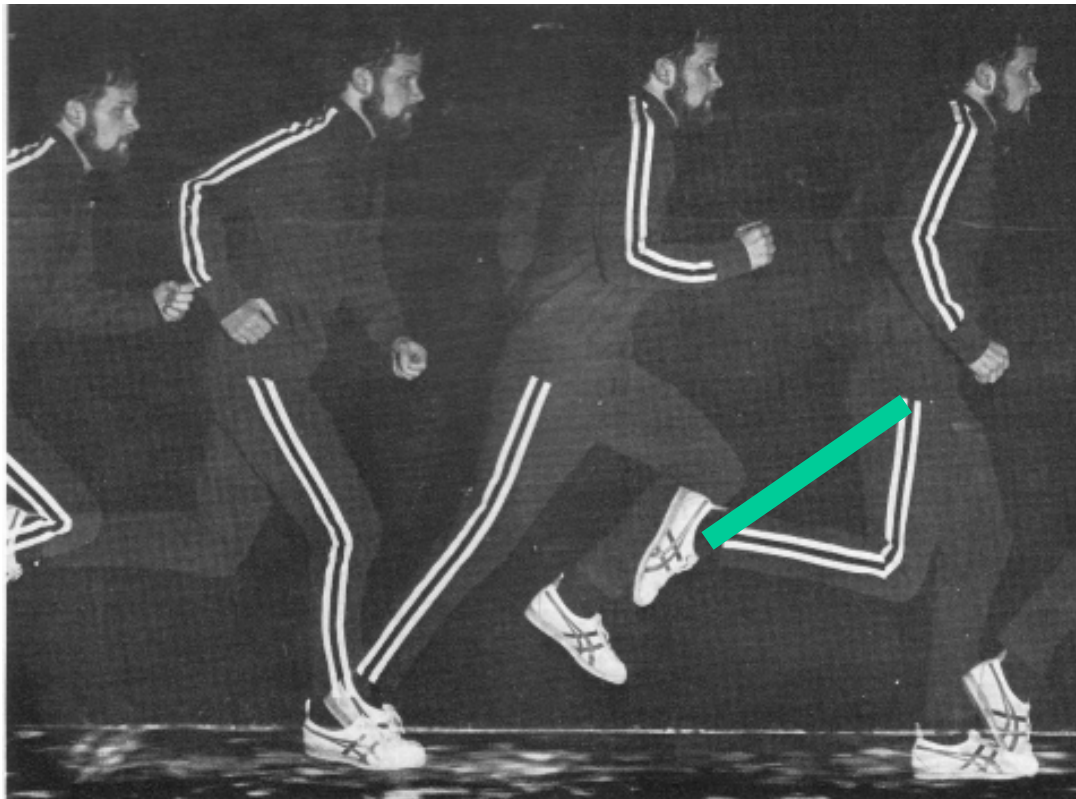
While walking the leg swings at its natural period of oscillation.

Short legged characters have quicker gait than long legged ones.



# Running Gait

In running, you quicken the gait by bending your leg and raising your foot, which effectively shortens the length of your leg.

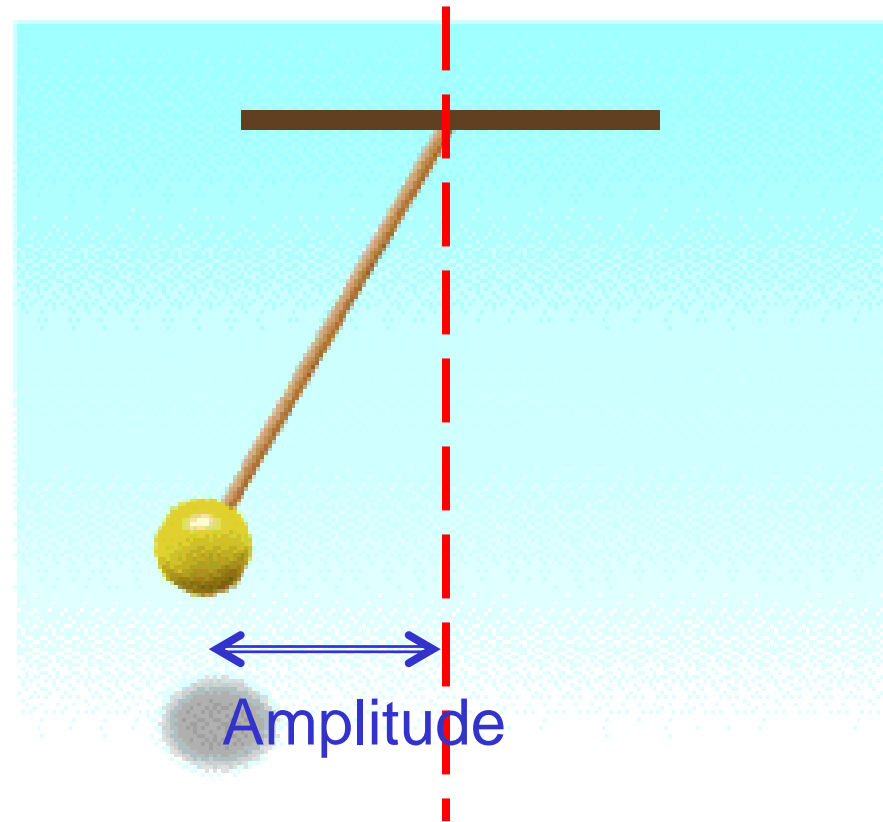


# Amplitude of Swinging

Distance from the apex to the center is the *amplitude* of the swinging motion.

Period of the swinging motion **does not** vary with amplitude.

Speed of the swinging increases with amplitude but so does distance traveled so the period stays the same.



# Small Amplitude Swinging

<http://www.youtube.com/watch?v=9w0EcbWcpCY>





# Large Amplitude Swinging

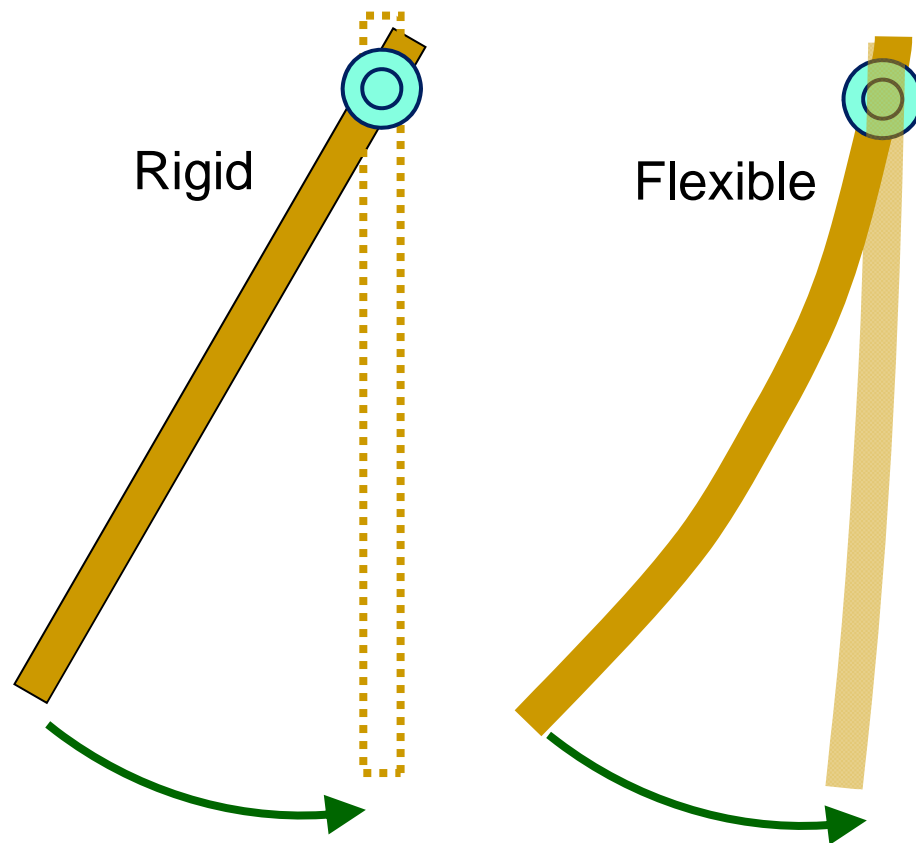
<http://www.youtube.com/watch?v=bscTGhaM8-w>



# Rigid vs. Flexible Pendulum

Swinging of a flexible pendulum (like a heavy rope or long hair) has almost the same timing as a rigid pendulum.

Swing time for a flexible pendulum about 15% slower.





# Summary

- Timing and spacing for swinging motion slows in and out of the apexes, similar to falling.
- Swinging motion is nearly uniform (constant spacings) through the center of the swing.
- Texture of the timing and spacing is enhanced when the swinging motion is in perspective.
- Period of a swinging pendulum varies with the length; longer the pendulum to greater the time it takes to complete each swing.
- When the swinging amplitude is large then the speed is fast but the period time is unchanged.