

Law of Inertia

Part 1



National Science Foundation
WHERE DISCOVERIES BEGIN

Animation
Physics



Why Things Move

You might think it's enough to know how things move (slowing in/out, path of action, arcs, etc.).

But it's also important in animation (and in physics) to know why things move.

The short answer is **forces**.

To understand why things move as they do, you need to know how forces are related to motion.

Newton's Laws of Forces

Newton established three basic laws to explain how motion is caused by forces:

- Law of Inertia
- Law of Acceleration
- Action-Reaction Principle

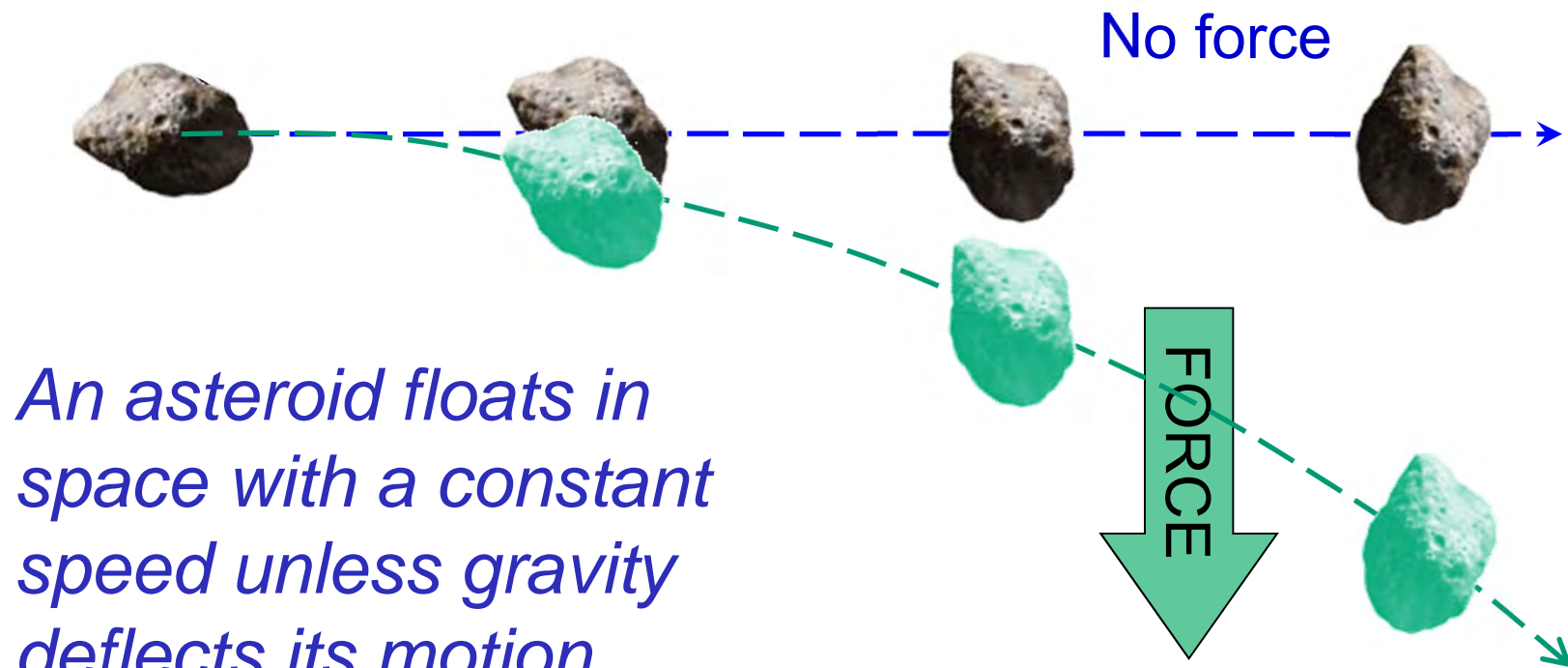


Sir Isaac Newton

Disney and other early animators rediscovered these laws of forces in their studies of motion.

Motion, with & without Forces

When there are no forces, an object moves with constant, uniform motion.

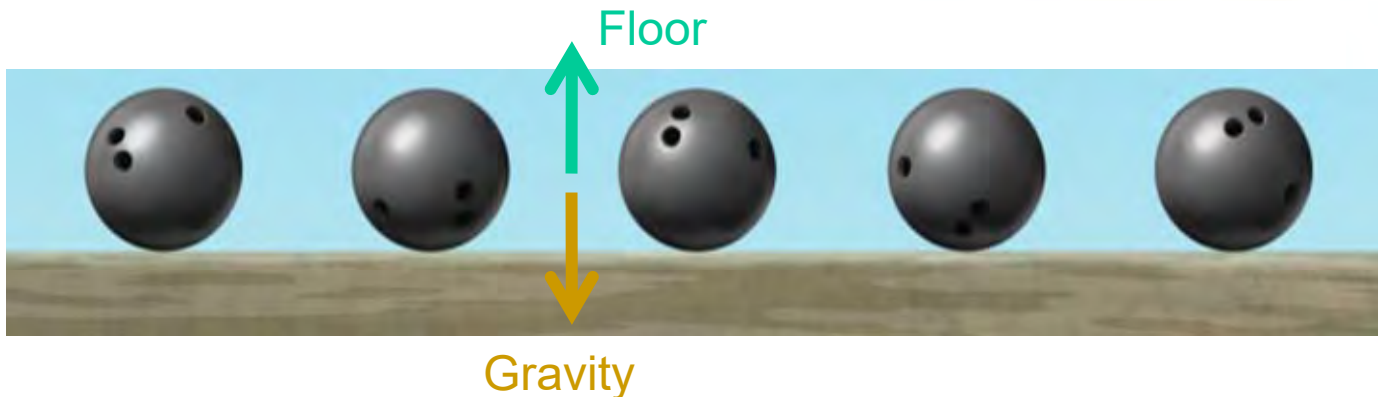
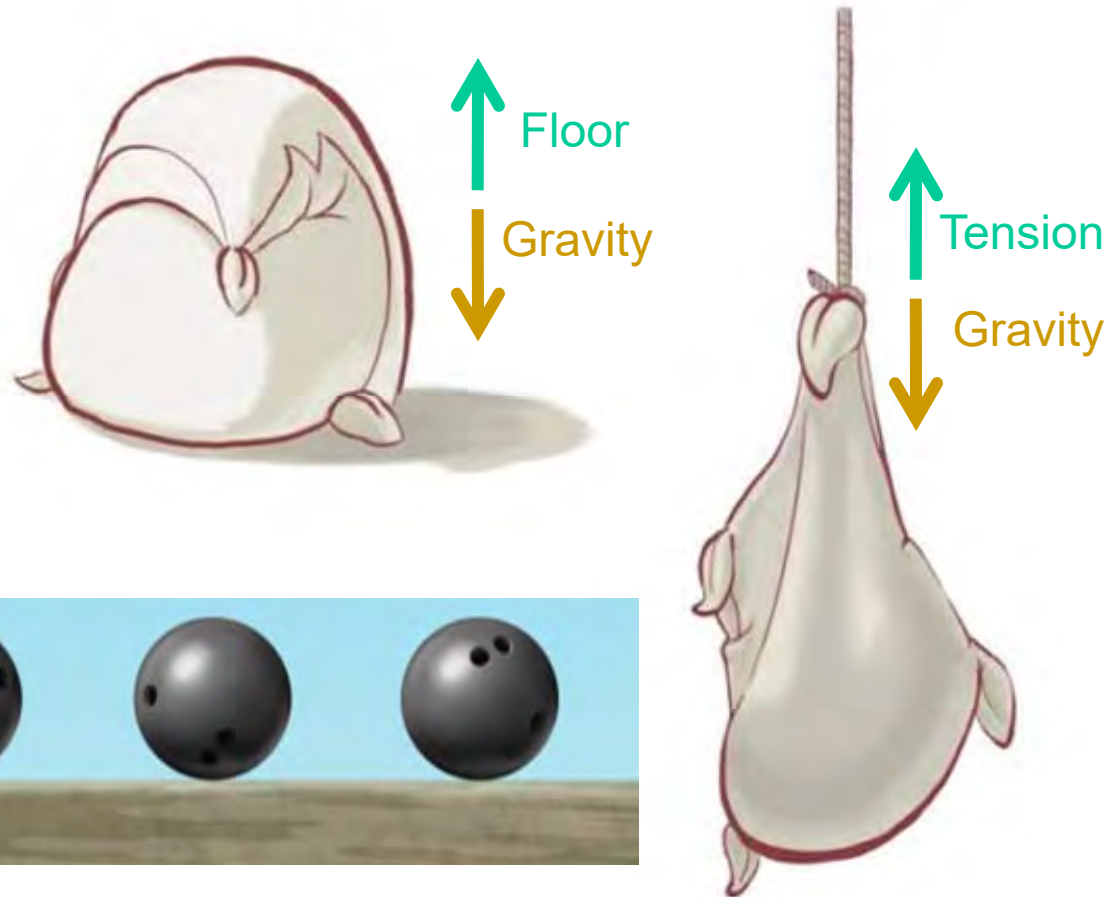


Balance of Forces

Rarely are there no forces but often forces are *balanced* so they “cancel” each other out.

Important:

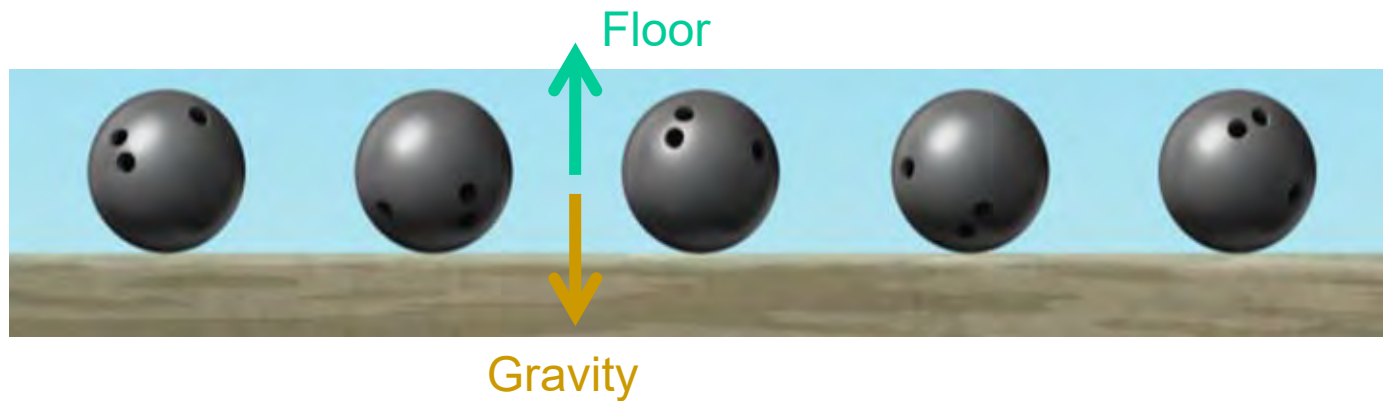
Balanced forces does not mean that there's no motion!



Law of Inertia

Newton's Law of Inertia says:

*An object moves with constant, uniform motion until acted on by an **unbalanced** force.*

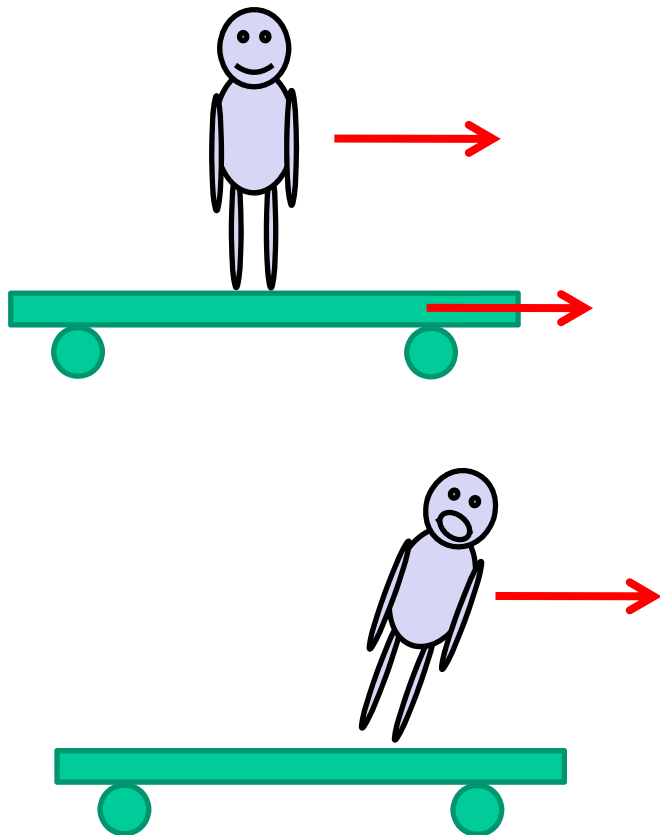


The bowling ball moves with constant speed*

*In reality, there is a small unbalanced force, friction, that does slow the ball's speed.

Riding the Bus

When a moving bus halts, you continue moving forward.



Shoot 'Em Up (2007)



If the crash occurs at 35 miles per hour then the hero flies off at a speed of about 2 feet per frame.

Shoot 'Em Up (2007)



Frame 438

Stuntman flies out the window at about 10 m.p.h.



Frame 439



Frame 440



Frame 441

This is a bit slow but at a realistic speed the audience wouldn't see the action.

Shoot 'Em Up (2007)



Frame 459

Stuntman flies into the van
at about 5 m.p.h.

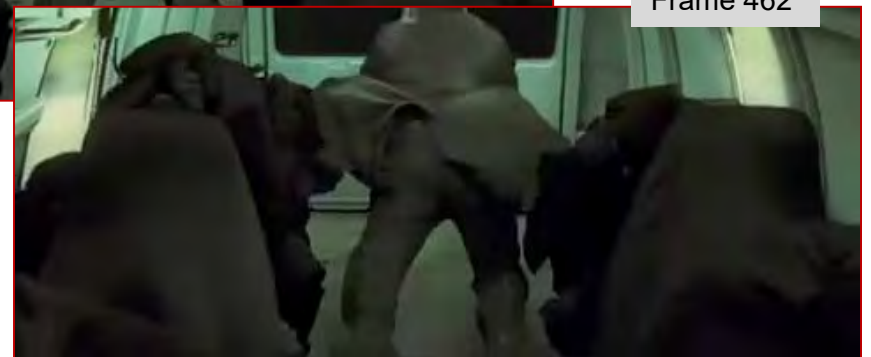


Frame 460



Frame 461

Noticeably much too
slow but the sequence
is outrageous anyway,
so it works.



Frame 462

Follow Through & Overlapping Action

When a character entering a scene reached the spot for his next action, he often came to a sudden and complete stop. This was stiff and did not look natural...Walt was concerned.

“Things don’t come to a stop all at once, guys; first there’s one part and then another.”

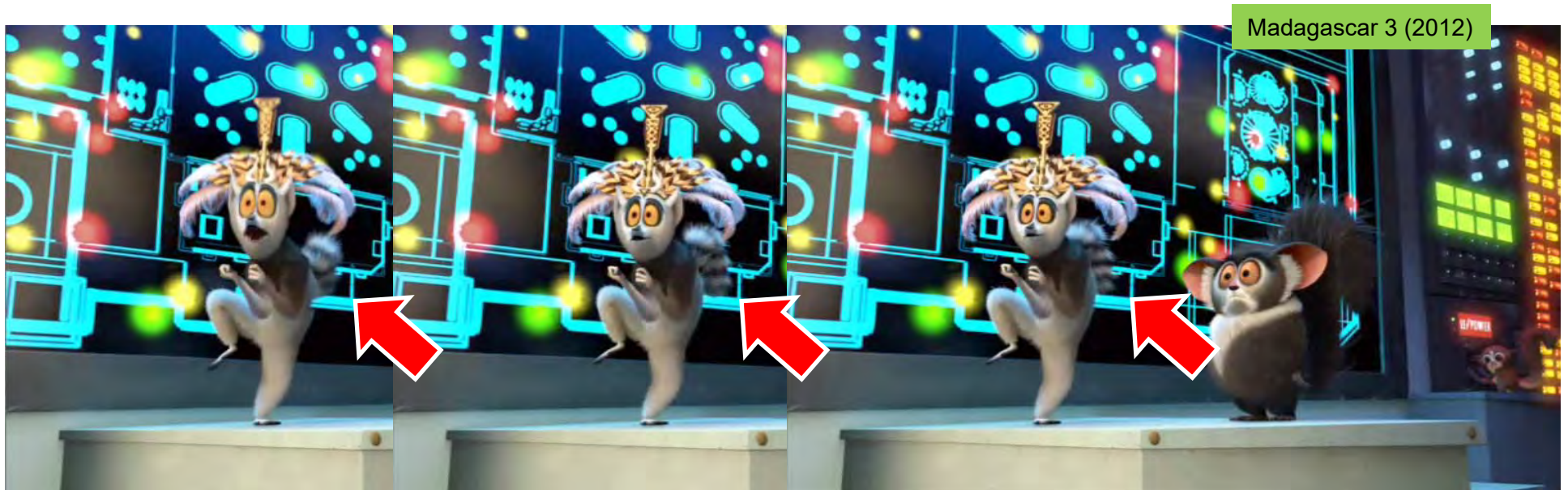
From The Illusion of Life – Disney Animation

Disney animators came up with the concepts of “Follow through” and “Overlapping Action.”



Follow Through & Overlapping Action

Follow through and overlapping action are the result of the Law of Inertia; things continue moving until forces act to bring them to a stop.



King Julien comes to a sudden stop yet his tail continues moving for a few frames.

Summary

- The Law of Inertia says, “An object moves with constant, uniform motion until acted on by an unbalanced force.”
- A force is balanced by an equal force acting in opposition, such as the floor pushing you up versus gravity pulling you downward.
- The Law of Inertia explains follow through and overlapping action, such as the secondary motions that occur when a character comes to a sudden stop.