Animation

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Keyframe Animation

These icons refer to explanatory videos on the class web site

anim2.mp4
Forward Kinematics:
Change Parameters – Connected Things Move
(All Tinker Toy users understand this)
Forward Kinematics: Transformation Hierarchies

Determine Object Locations?

Ground
Inverse Kinematics (IK):
Things Need to Move to a Particular Location –
What Parameters Will Make Them Do That?

Of course, there will always be target locations that can *never* be reached. Think about that spot in the middle of your back that you can never scratch! 😊
Inverse Kinematics (IK)

**Forward Kinematics** solves the problem “if I know the link transformation parameters, where are the links?”.

**Inverse Kinematics** (IK) solves the problem “If I know where I want the end of the chain to be \((X^*, Y^*)\), what transformation parameters will put it there?”
Particle Systems: A Cross Between Modeling and Animation?
Particle Systems:
A Cross Between Modeling and Animation?

The basic process is:

Emit → Display → Update

Random Number Generator
Particle Systems Examples
Particle Systems Examples

particles.mp4
Particle Systems Examples
Particle Systems Examples

The Lion King (2019) -- Disney
A Particle System to Simulate Colliding Galaxies in *Cosmic Voyage*
Particles Don’t Actually Have to Be “Particles”
Newton’s first law:

\[
\text{force} = \text{mass} \times \text{acceleration}
\]

or

\[
\text{acceleration} = \frac{\text{force}}{\text{mass}}
\]

In order to make this work, you need to supply physical properties such as mass, center of mass, moment of inertia, coefficients of friction, coefficients of restitution, etc.
Animating using Fluid Physics

fluid.avi
**Animating using Physics**

\[ F = k(D - D_0) \]

- \( D_0 \) = unloaded spring length
- \( k \) = *spring stiffness* in Newtons/meter or pounds/inch

Or, if you know the displacement, the force exerted by the spring is:

\[ F = k(D - D_0) \]

This is known as Hooke’s law.
Animating using the Physics of a Mesh of Springs

“Lumped Masses”
Simulating a Bouncy String
Simulating a Bouncy String

string.mp4
Placing a Physical Barrier in the Scene
Animating Cloth
Cloth Examples
Cloth Example

cloth.mp4
Cloth Example

Pixar
Functional Animation: 
Make the Object *Want* to Move Towards a Goal Position

\[ m\ddot{x} + c\dot{x} + kx = 0 \]
Functional Animation:
While Making it Want to Move Away from all other Objects

\[ m \ddot{x} = \sum F_{\text{repulsive}} \]

**Repulsion Coefficient**

**Distance between the boundaries of the 2 bodies**

**Repulsion Exponent**
Total Goal – Make the Free Body Move Towards its Final Position While Being Repelled by the Other Bodies

\[ m\ddot{x} + c\dot{x} + kx = \sum F \]
Increasing the Stiffness

Stiffness = 3

Stiffness = 6

Stiffness = 9
Increasing the Repulsion Coefficient

Repulse = 10

Repulse = 30
Functional Animation
Motion Capture as an Input for Animation
Motion Capture is for Faces Too
Tron I –
Probably should have used physics, but didn’t
Card Trick
Pixar Animated Shorts