Keyframe Animation

These icons refer to explanatory videos on the class web site

anim2.mp4

Forward Kinematics: Transformation Hierarchies
Determine Object Locations?

Ground

Change Parameters – Connected Things Move
(All Tinker Toy users understand this)
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) 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?

The basic process is:
- Emit
- Random Number Generator
- Display
- Update
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.
**Computer Graphics**

### Animating using Physics

![Diagram of a spring system showing the variables D, D₀, D-D₀, and F.](image1)

- **D₀** = unloaded spring length
- \((D - D₀) = \frac{F}{k}\)

Where:
- \(k\) = spring stiffness in Newtons/meter or pounds/inch

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

\[ F = k(D - D₀) \]

This is known as Hooke’s law.

### Animating using the Physics of a Mesh of Springs

![Diagram of a mesh of springs with labeled “Lumped Masses.”](image2)

**“Lumped Masses”**

### Simulating a Bouncy String

![Simulation images of a bouncy string.](image3)

- String.mp4

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5
Cloth Example

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

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

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

avoid.mp4
Motion Capture is for Faces Too

Tron I –
Probably should have used physics, but didn’t

Card Trick

Pixar Animated Shorts