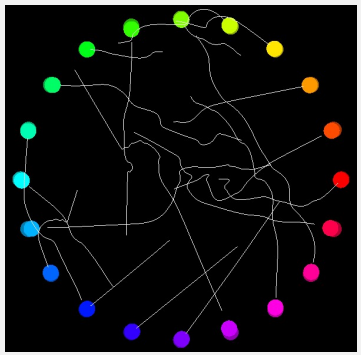
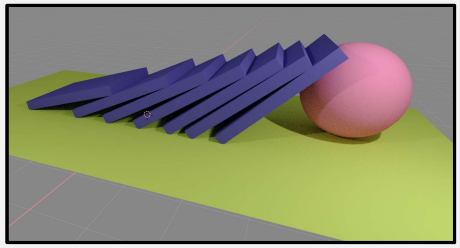
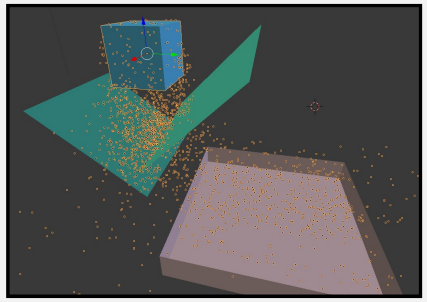


Animation





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Mike Bailey
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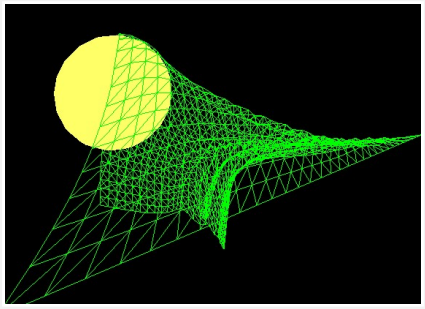

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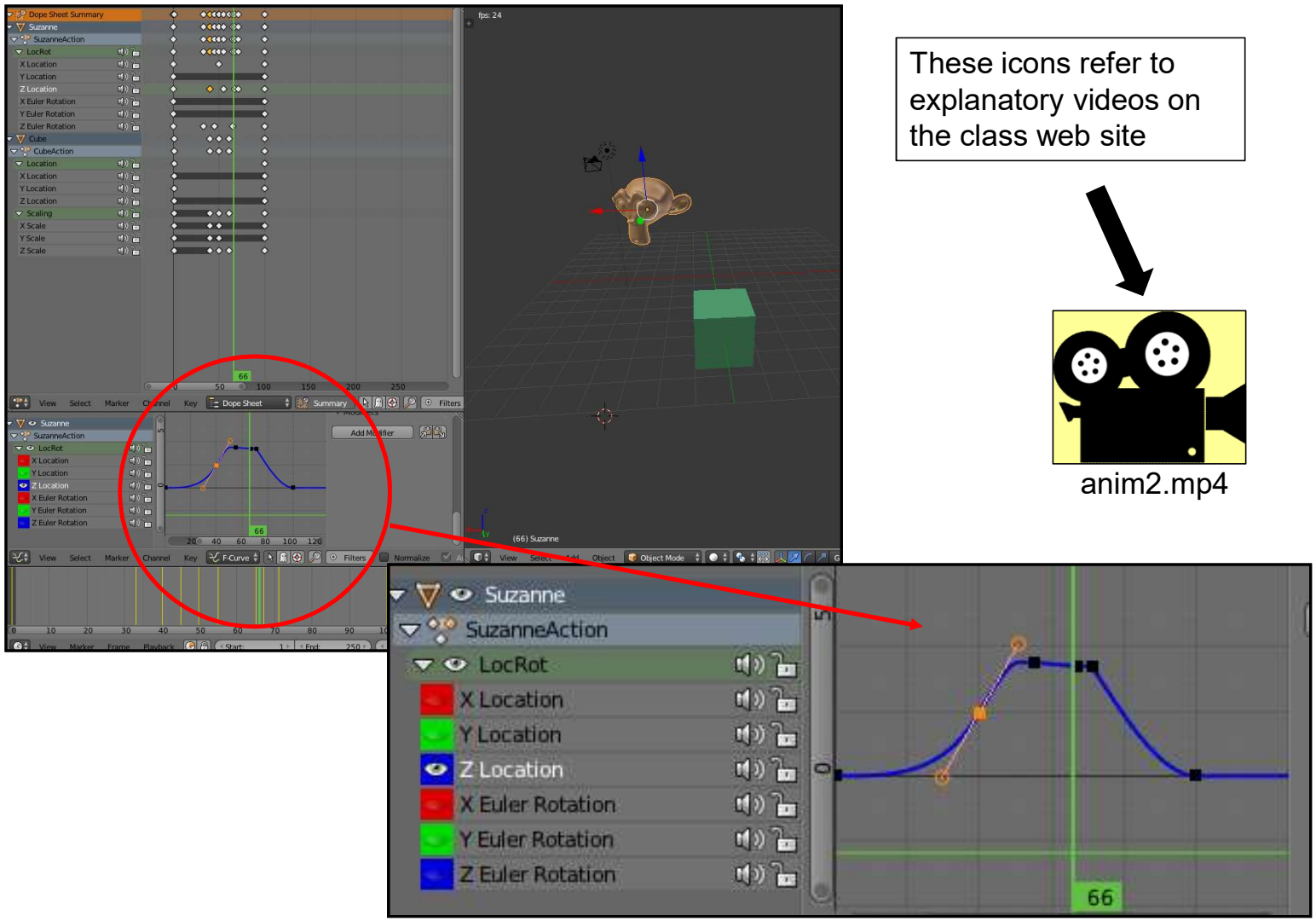
Animation

Rendering is the process of giving motion to your geometric modes. Before animating, there are questions you need to ask first:

- Why am I doing this?
- Do I want the animation to obey the real laws of physics?
- Am I willing to "fake" the physics to get the objects to *want* to move in a way that I tell it?
- Do I have specific key positions I want the objects to pass through no matter what?
- Do I want to simply record the motion of a real person, animal, etc., and then play it back?

Keyframe Animation

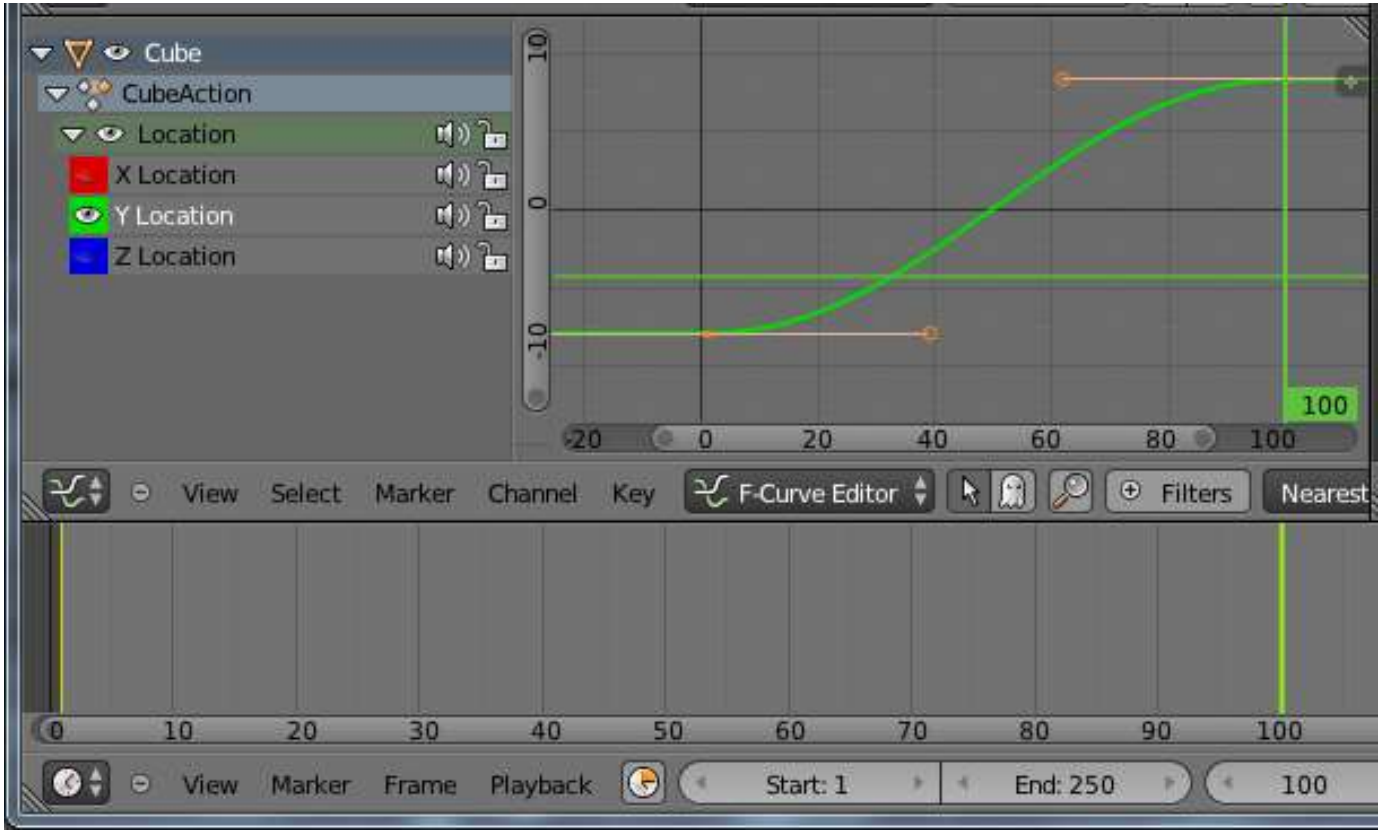


These icons refer to explanatory videos on the class web site

anim2.mp4

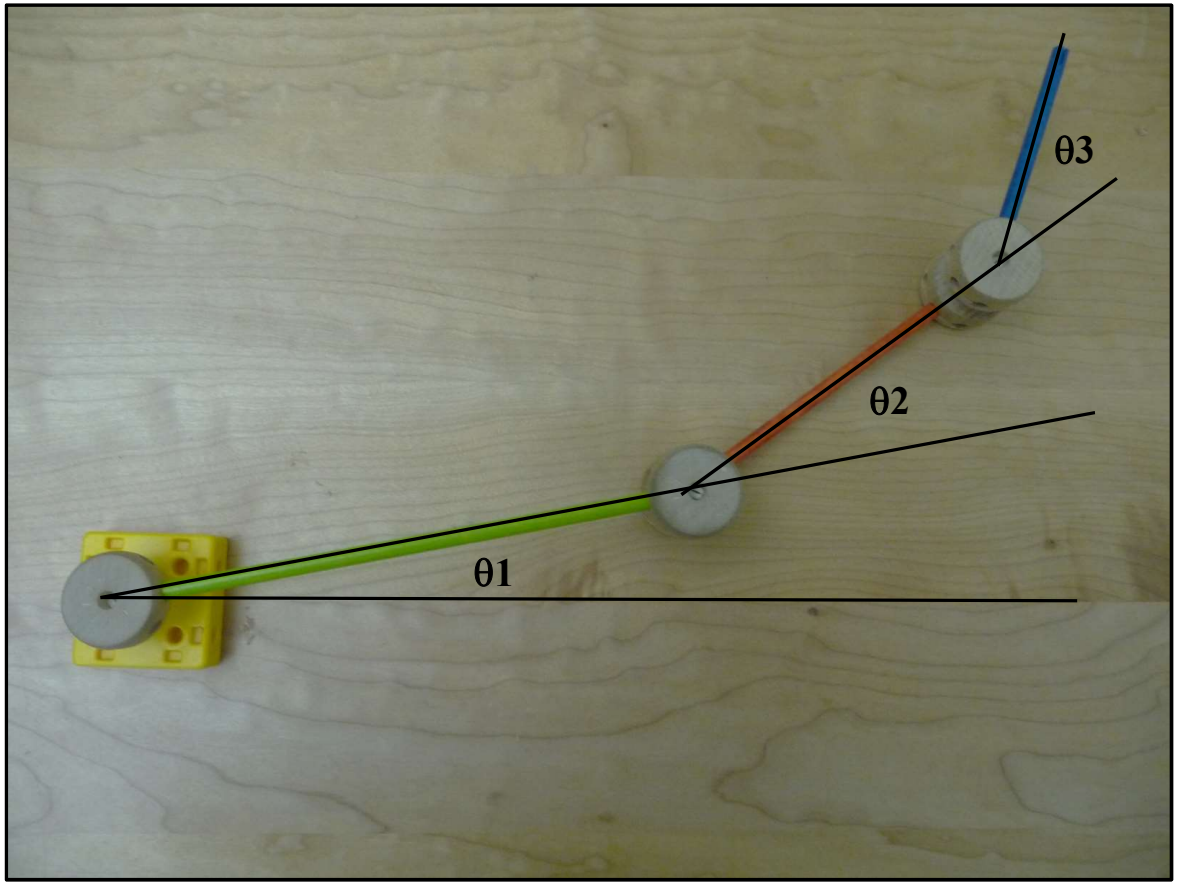
Keyframe Animation

Blender:

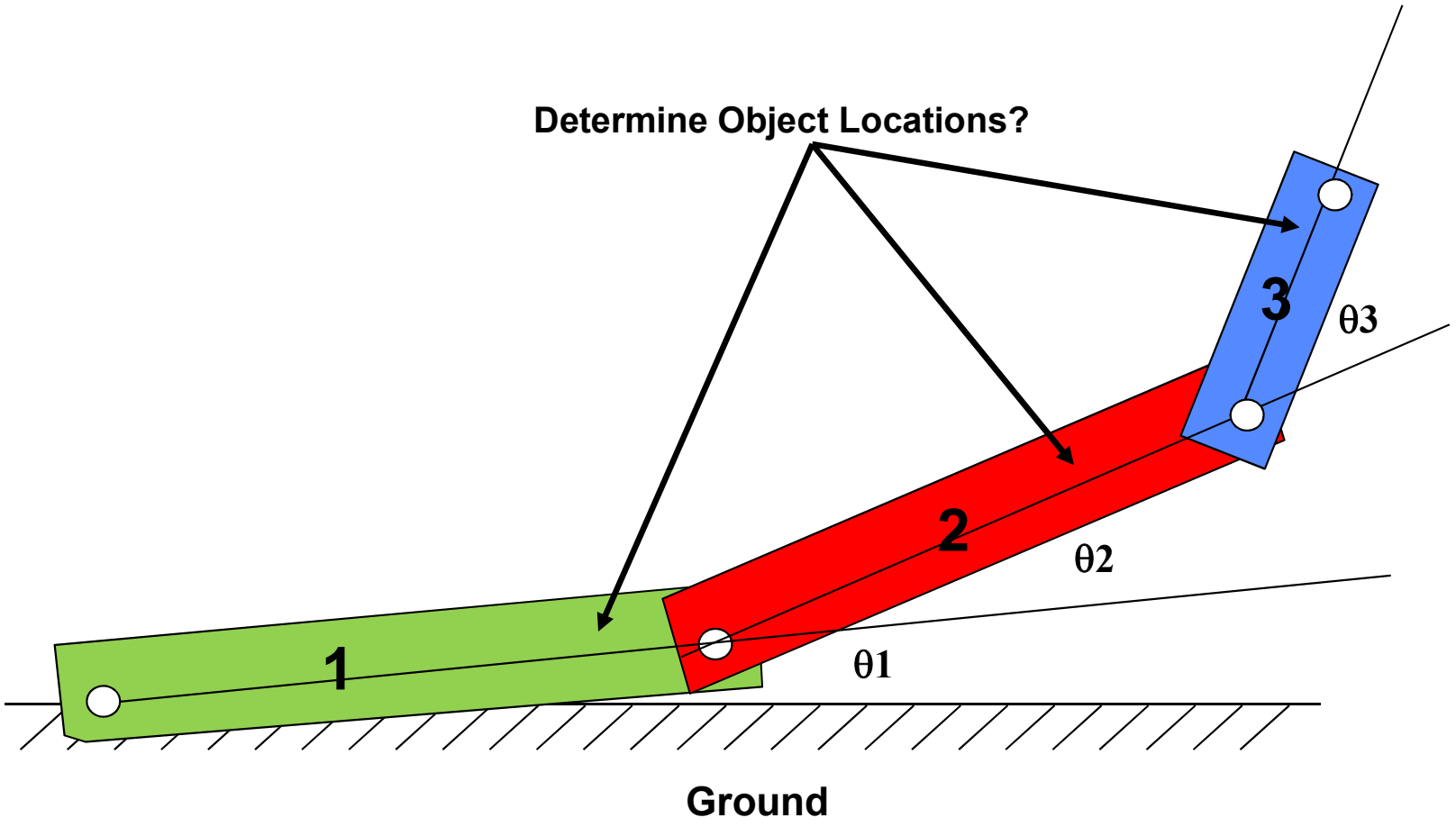


Oregon State
University
Computer Graphics

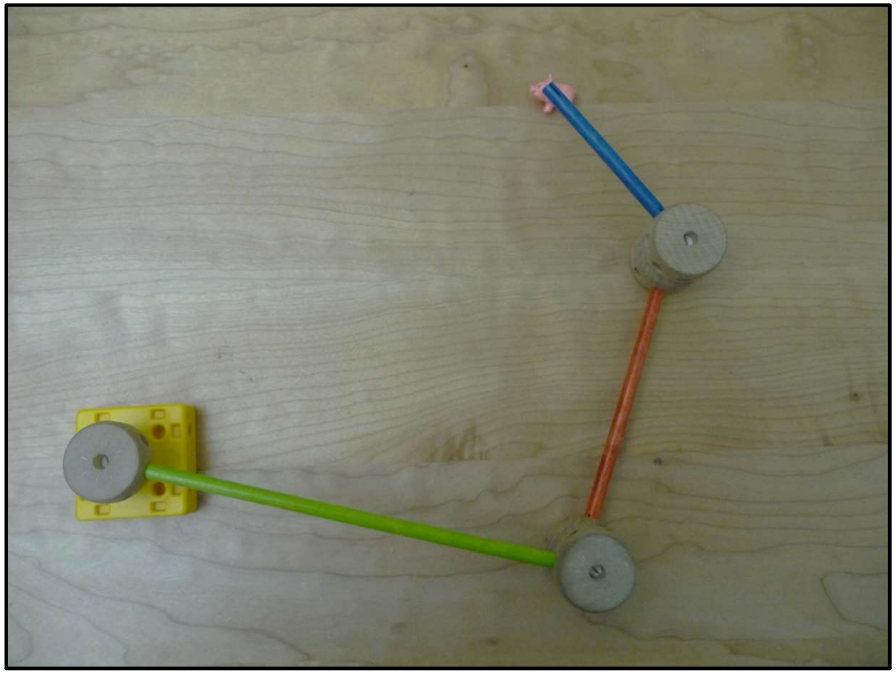
Forward Kinematics:
Change Parameters – Connected Things Move
(All Tinker Toy users understand this)

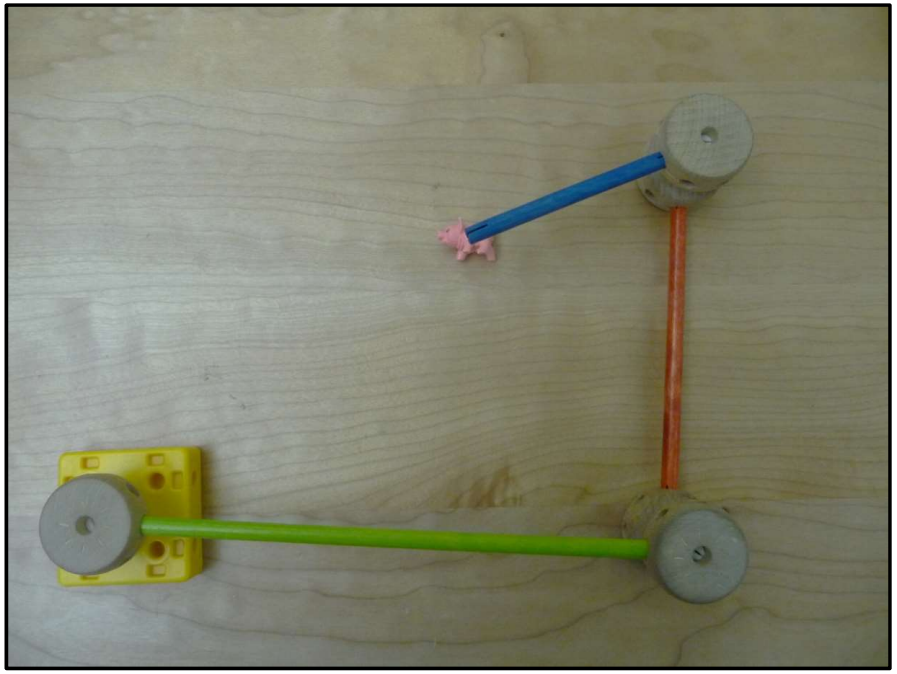


Forward Kinematics: Transformation Hierarchies



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



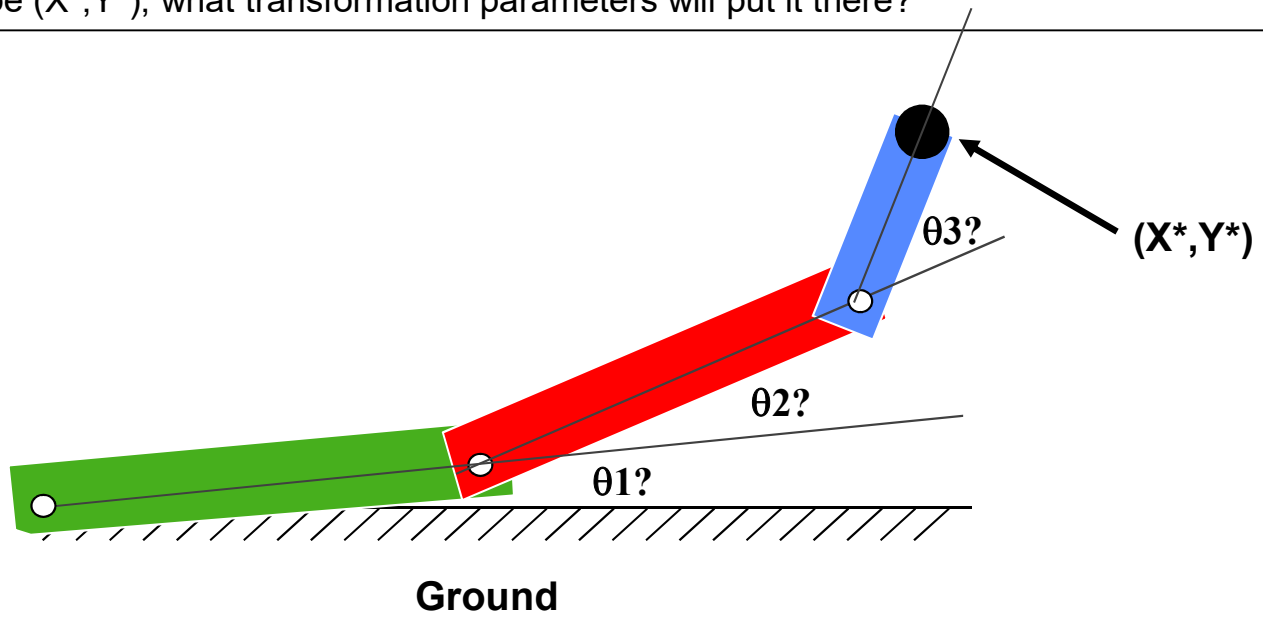


Of course, there will always be target locations that can *never* be reached.
Think about that spot in the middle of your back that you can never scratch! ☺

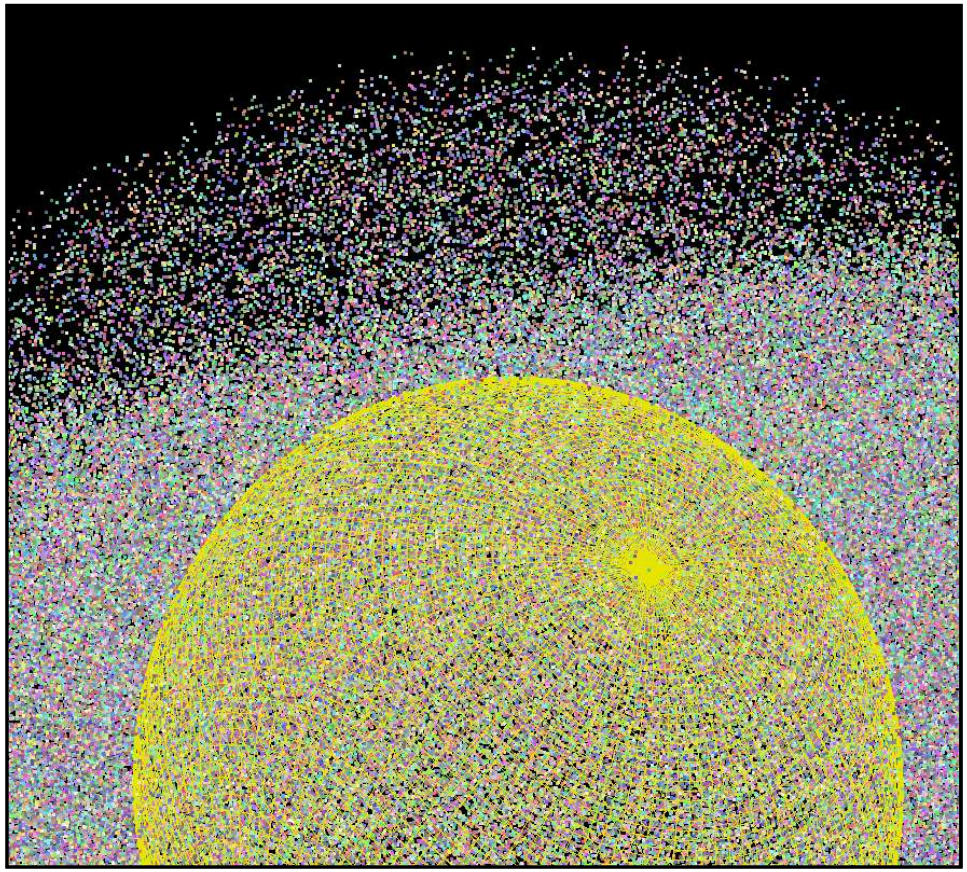
Inverse Kinematics (IK)

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?"

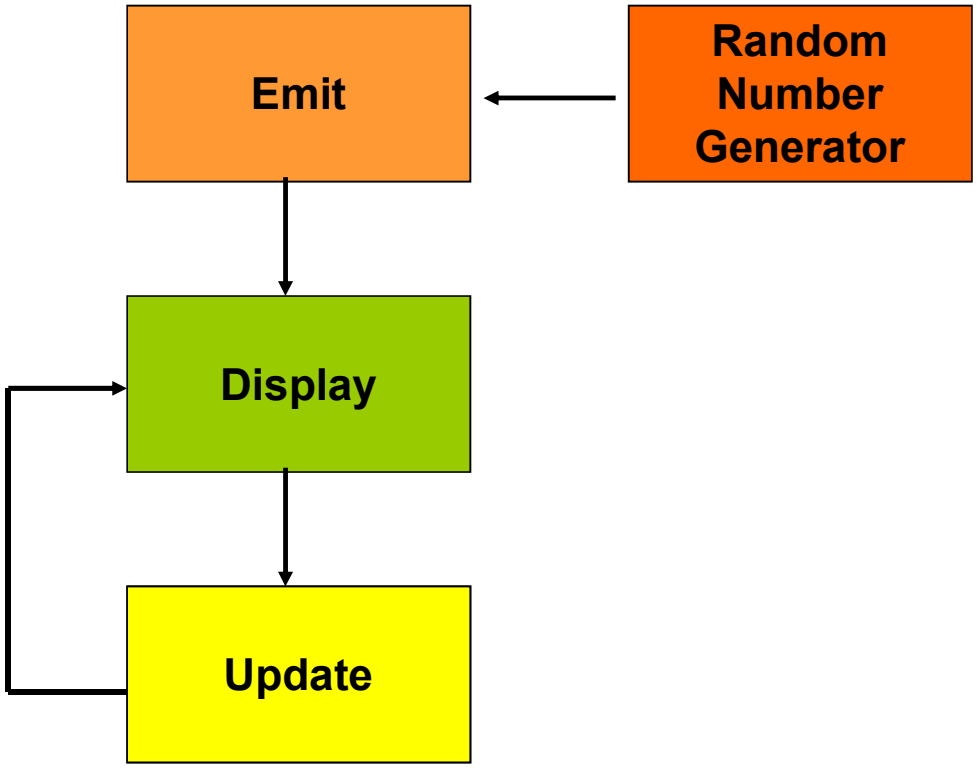


Particle Systems:
A Cross Between Modeling and Animation?

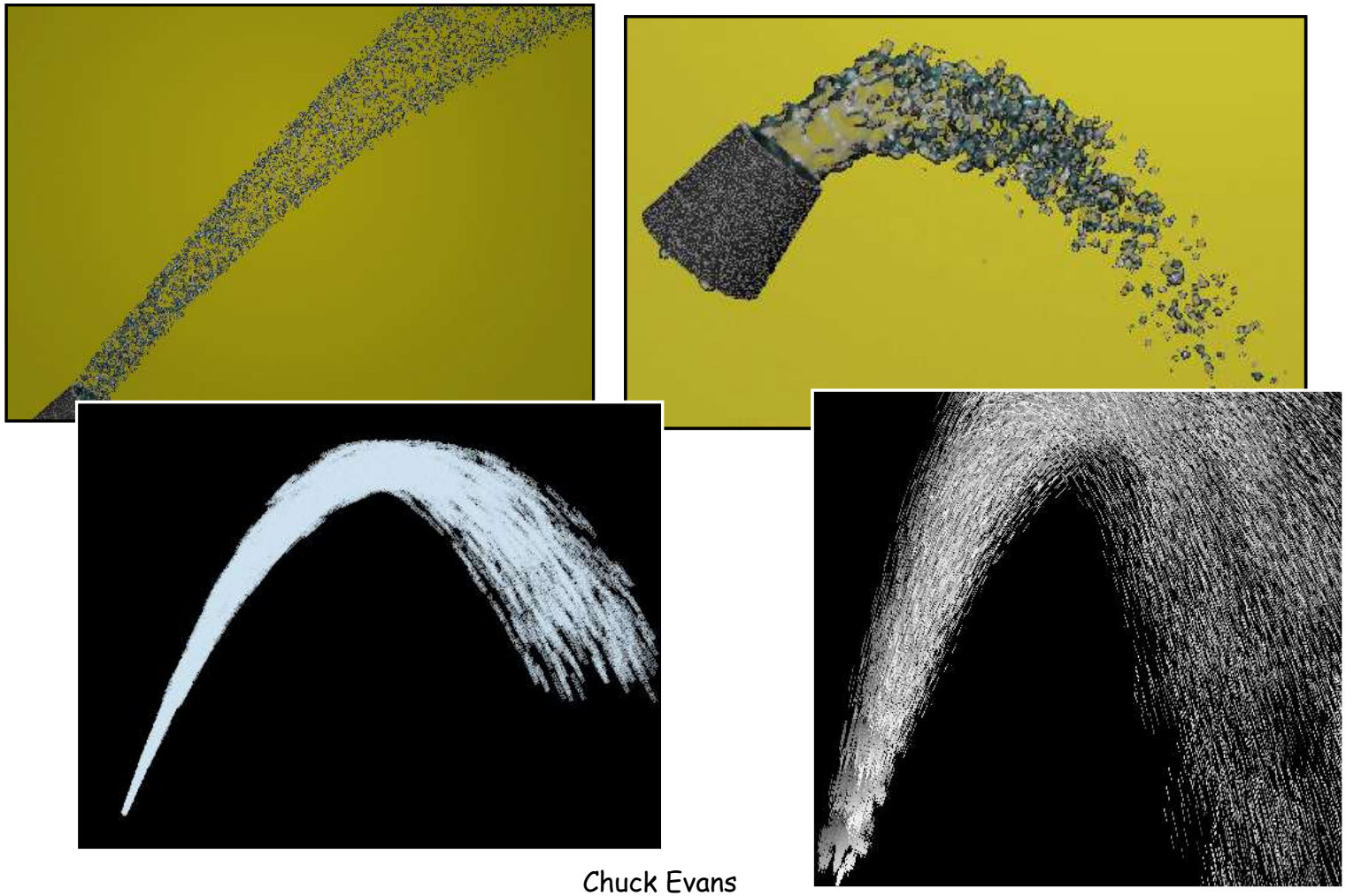


Particle Systems:
A Cross Between Modeling and Animation?

The basic process is:

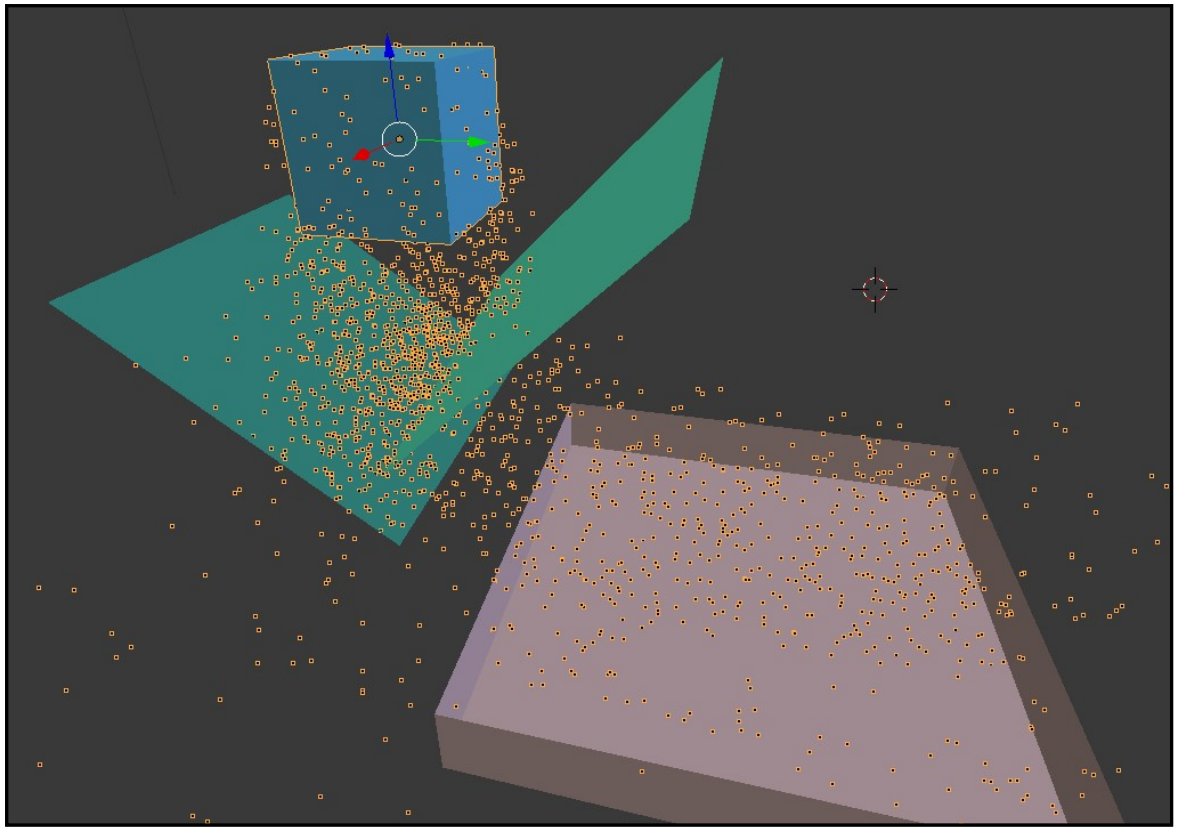


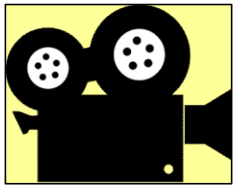
Particle Systems Examples



Chuck Evans

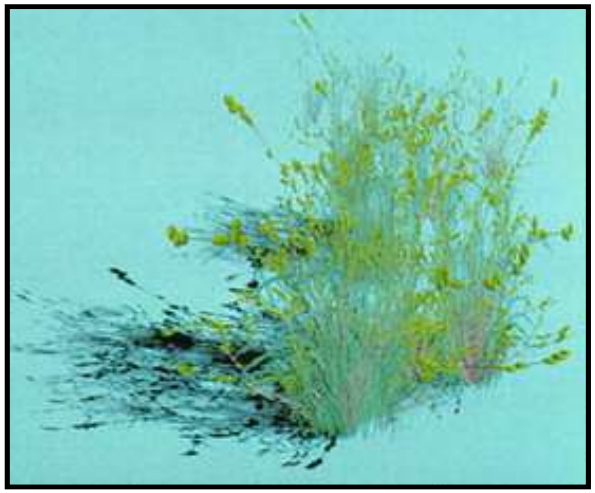
Particle Systems Examples





particles.mp4

Particle Systems Examples



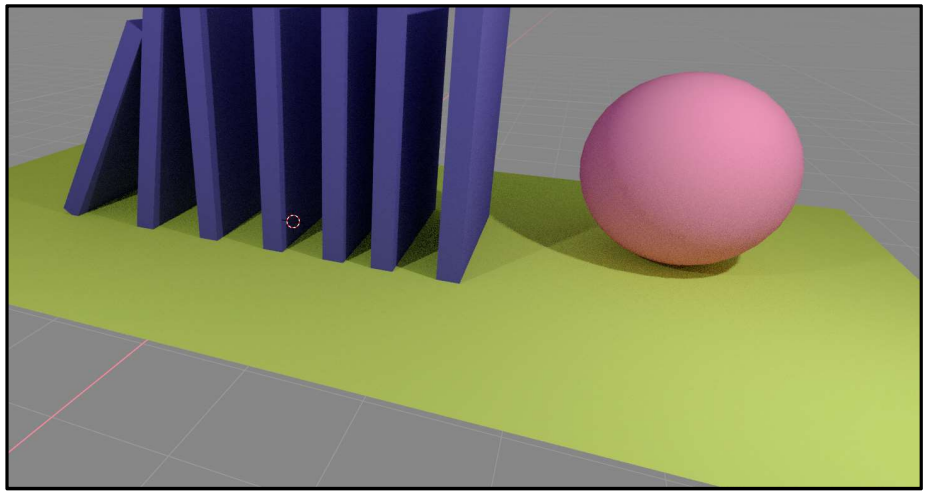
Particle Systems Examples

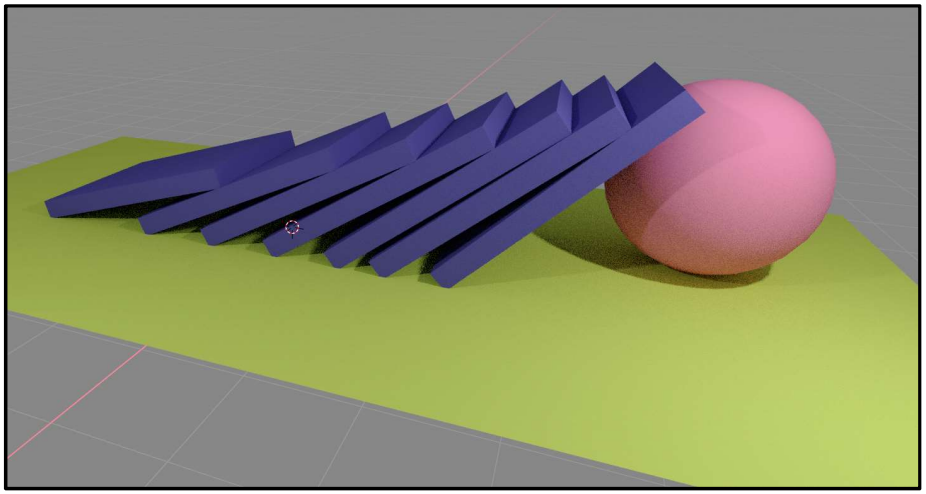
The Lion King (2019) -- Disney

A Particle System to Simulate Colliding Galaxies in *Cosmic Voyage*

Particles Don't Actually Have to Be "Particles"

Animating using Rigid-body Physics



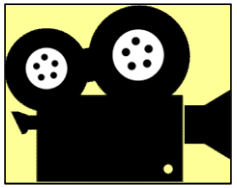


Newton's second law:

force = mass * acceleration

or

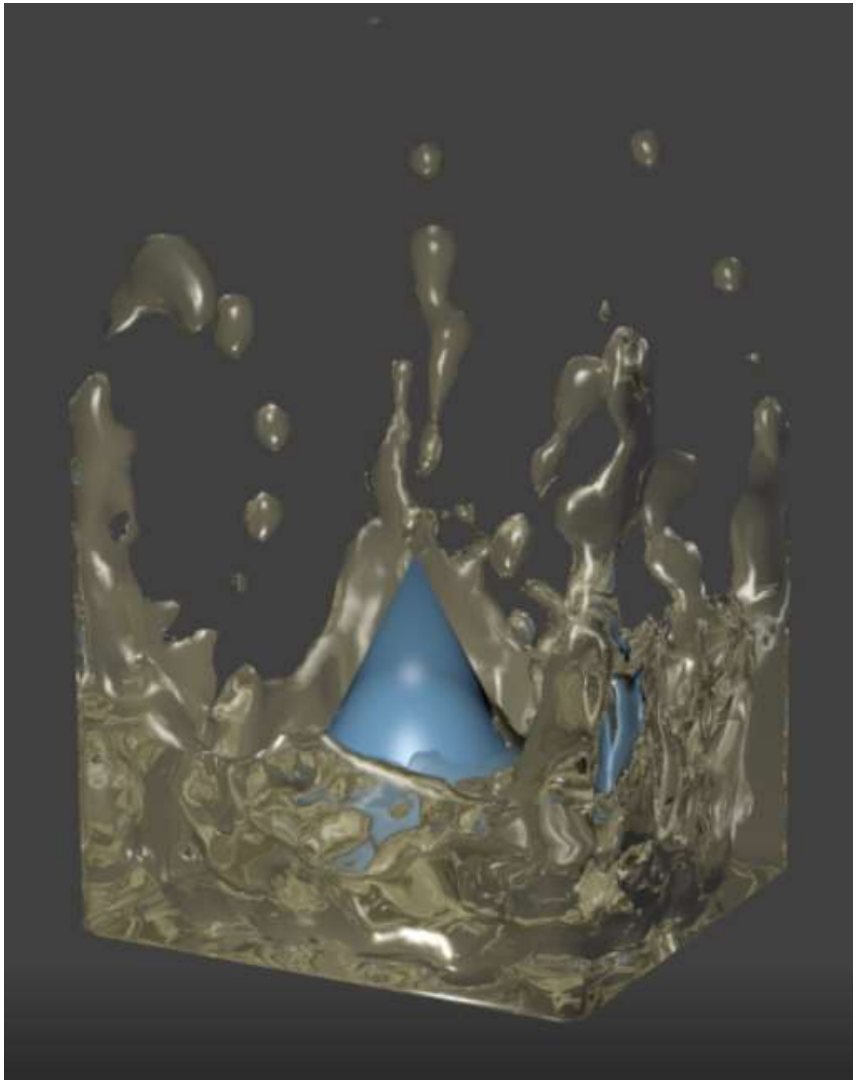
acceleration = force / mass

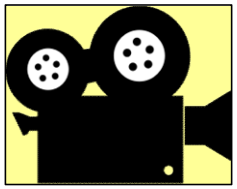


dominos.mp4

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.

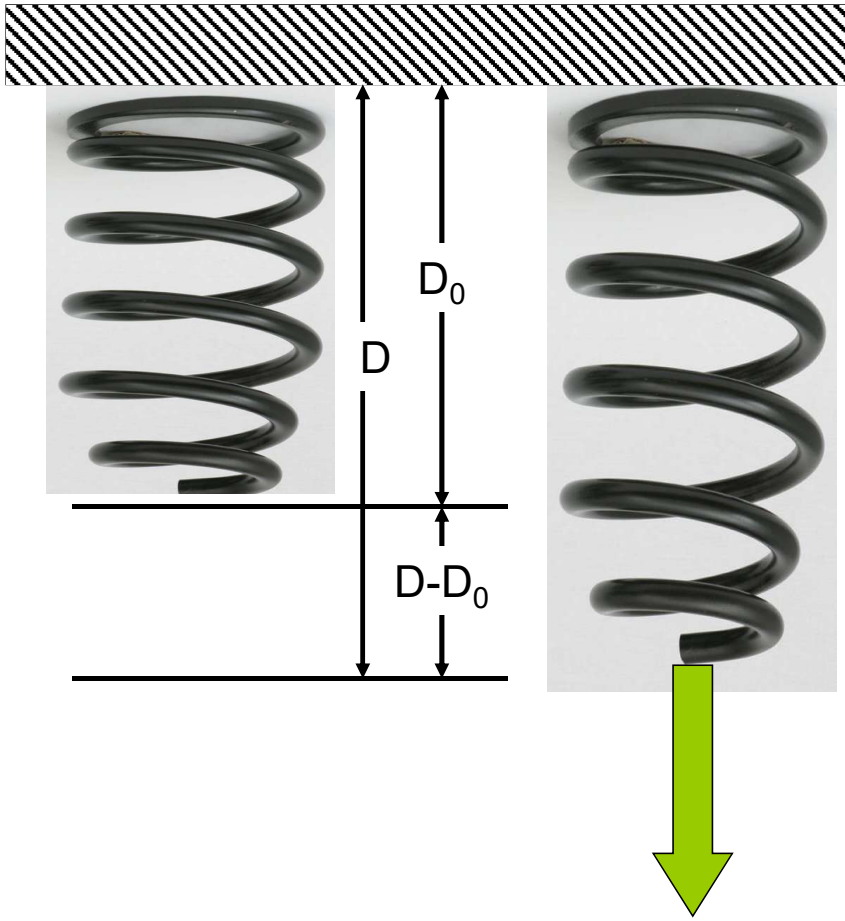
Animating using Fluid Physics





fluid.avi

Animating using Physics



D_0 = unloaded spring length

$$(D - D_0) = \frac{F}{k}$$

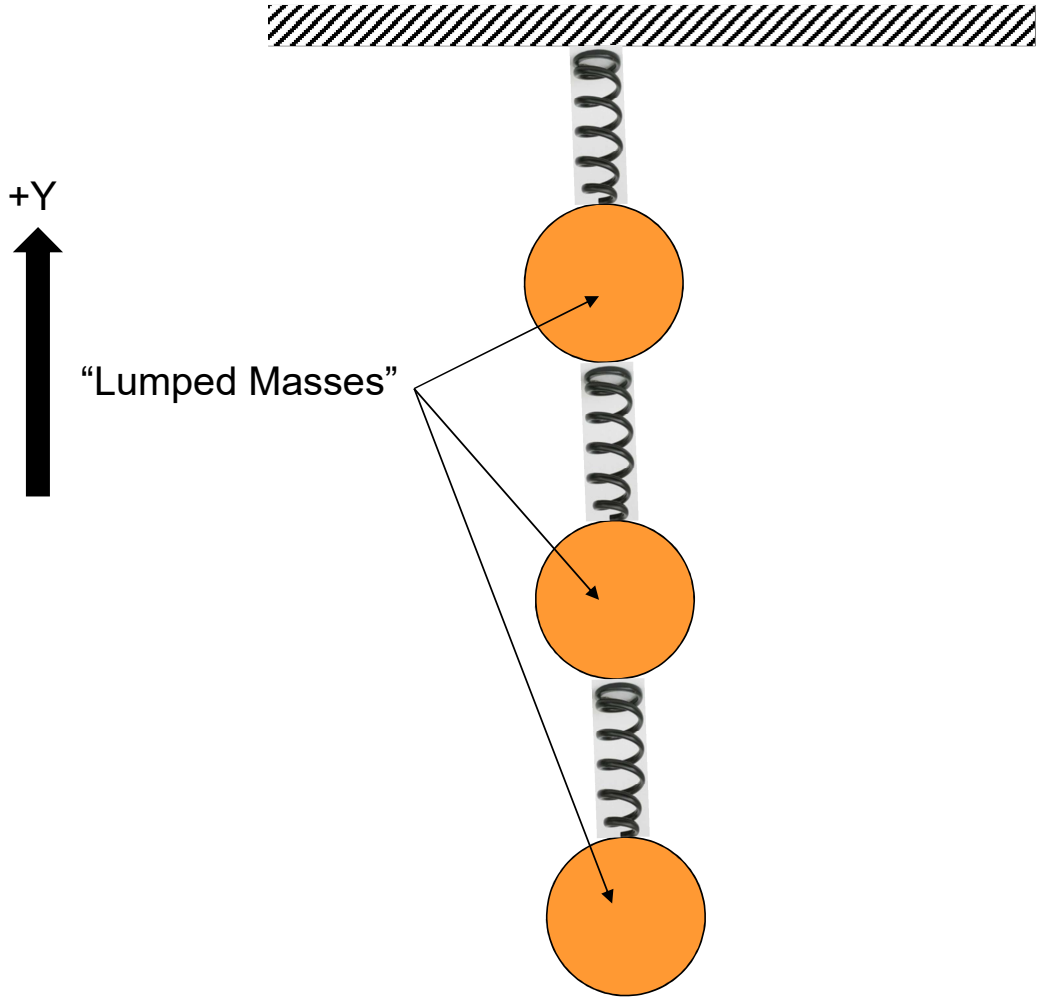
k = ***spring stiffness*** in Newtons/meter or pounds/inch

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

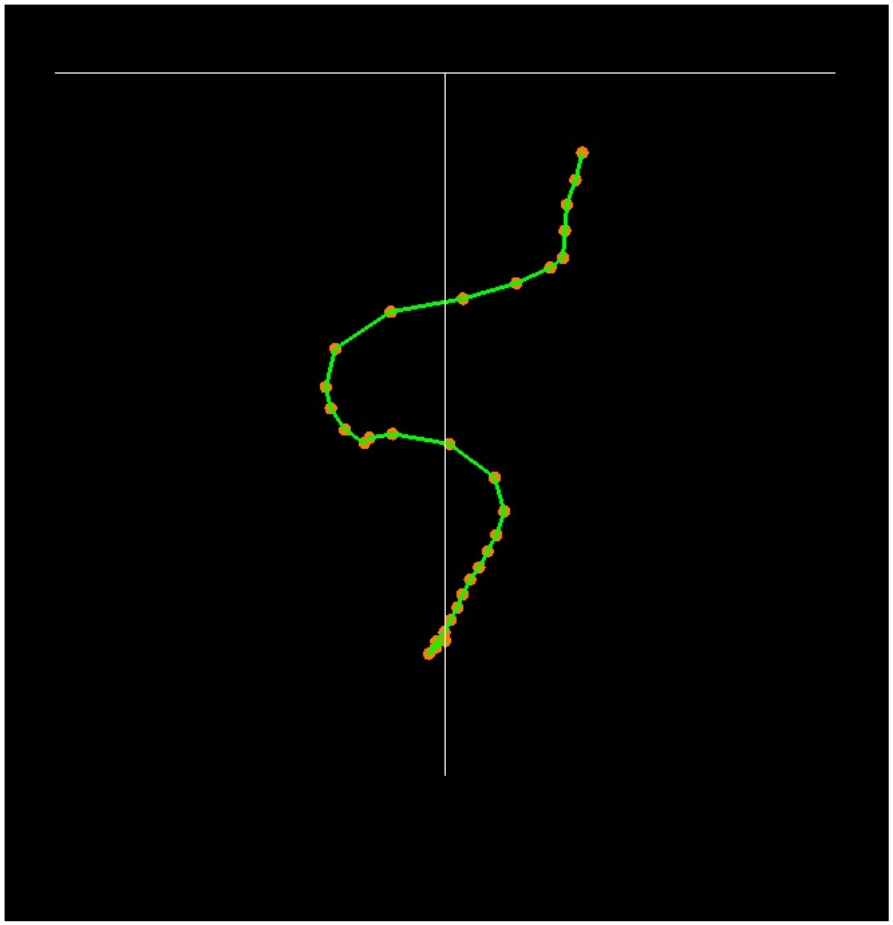
$$F = k\left(D - D_0\right)$$

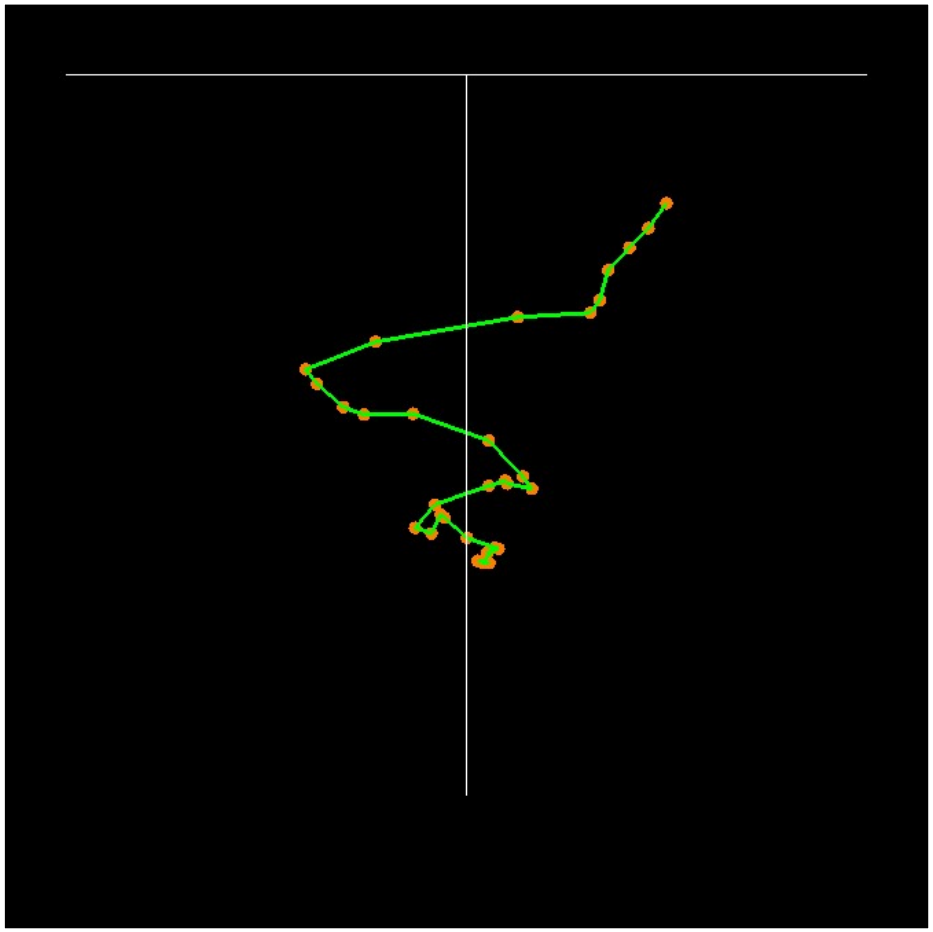
This is known as **Hooke's Law**

Animating using the Physics of a Mesh of Springs

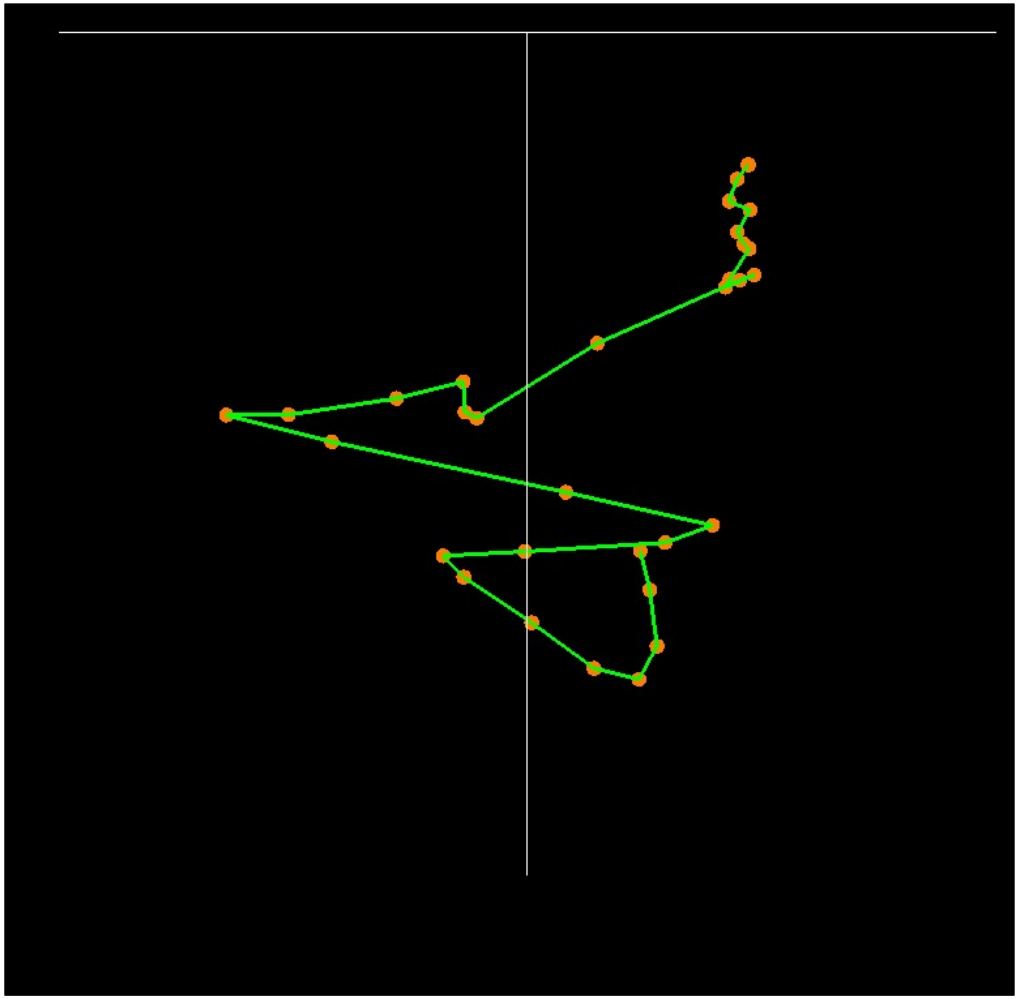


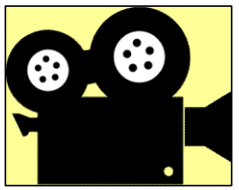
Simulating a Bouncy String





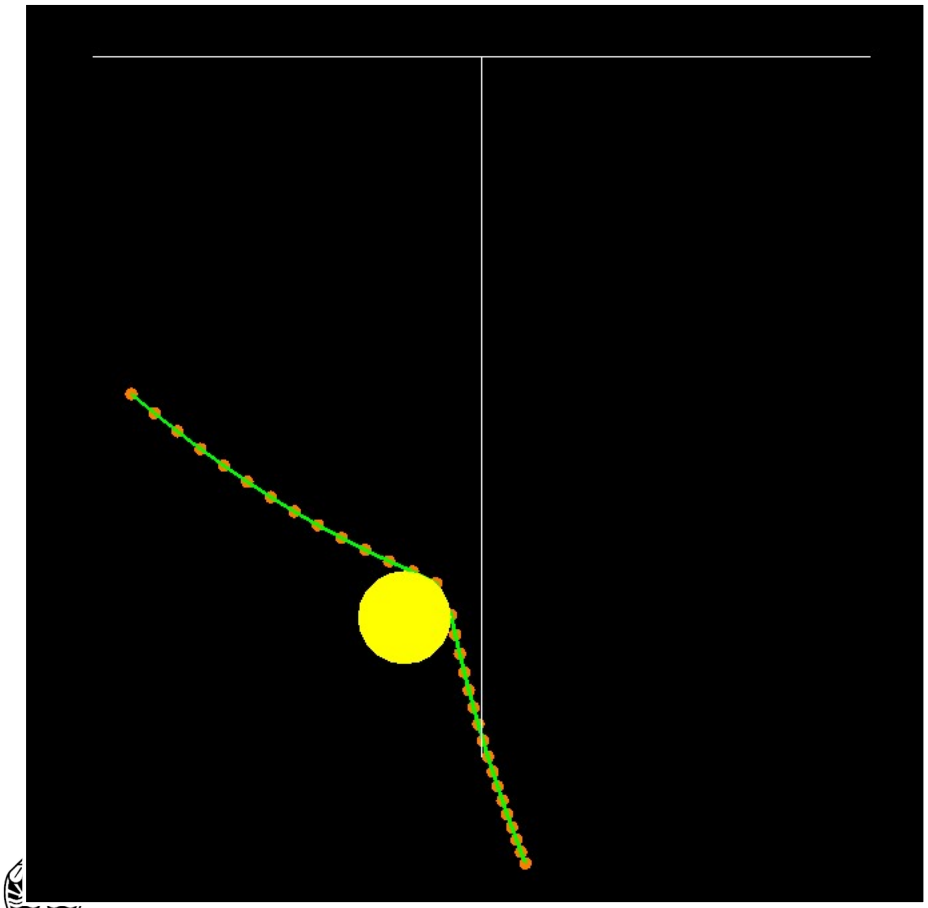
Simulating a Bouncy String

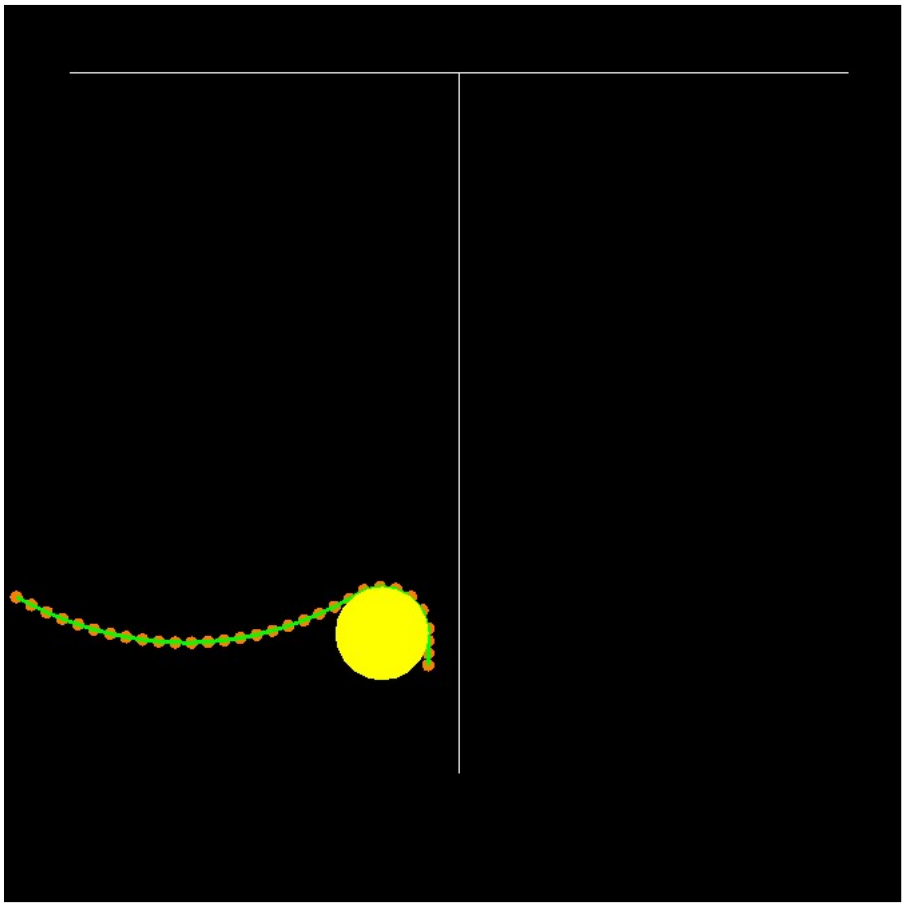




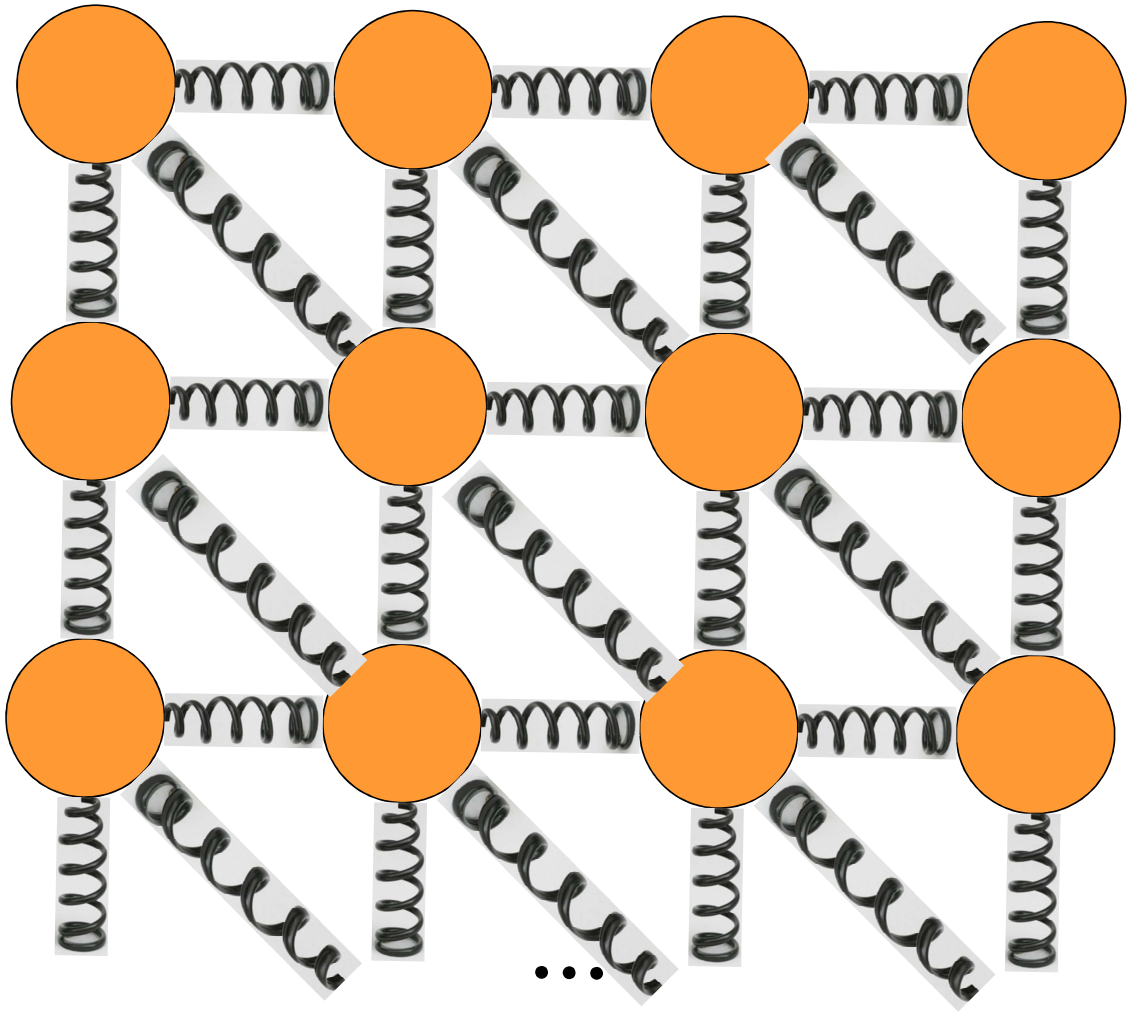
string.mp4

Placing a Physical Barrier in the Scene

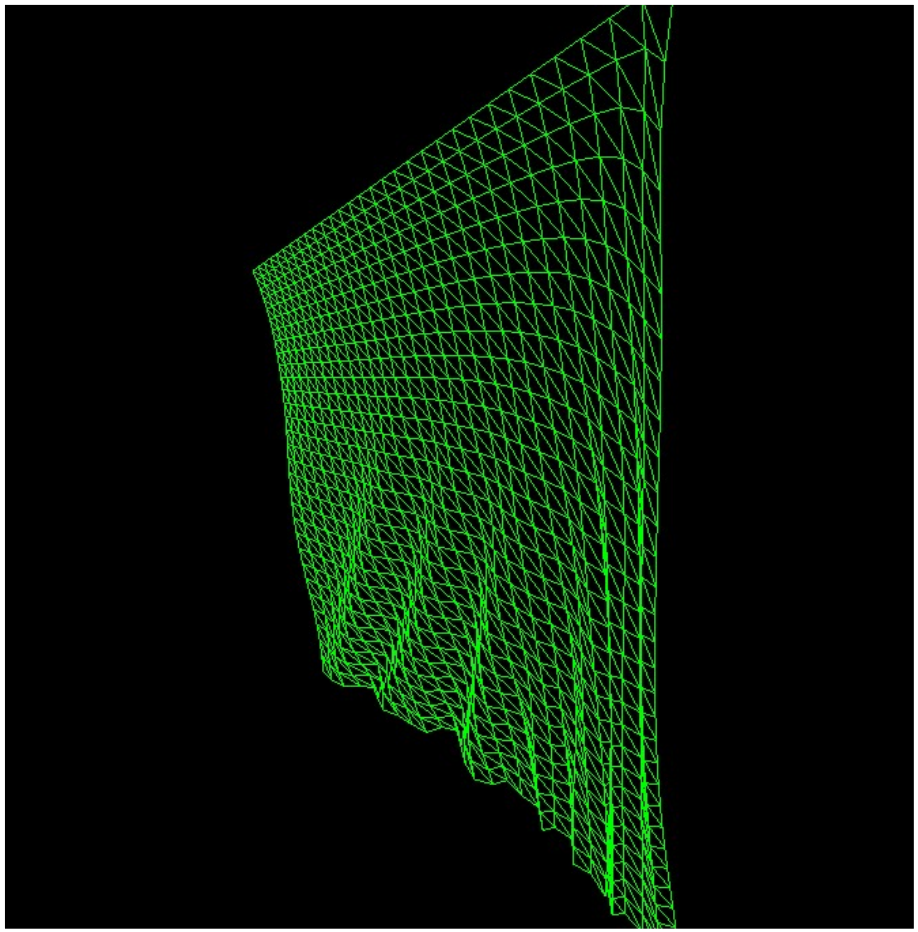


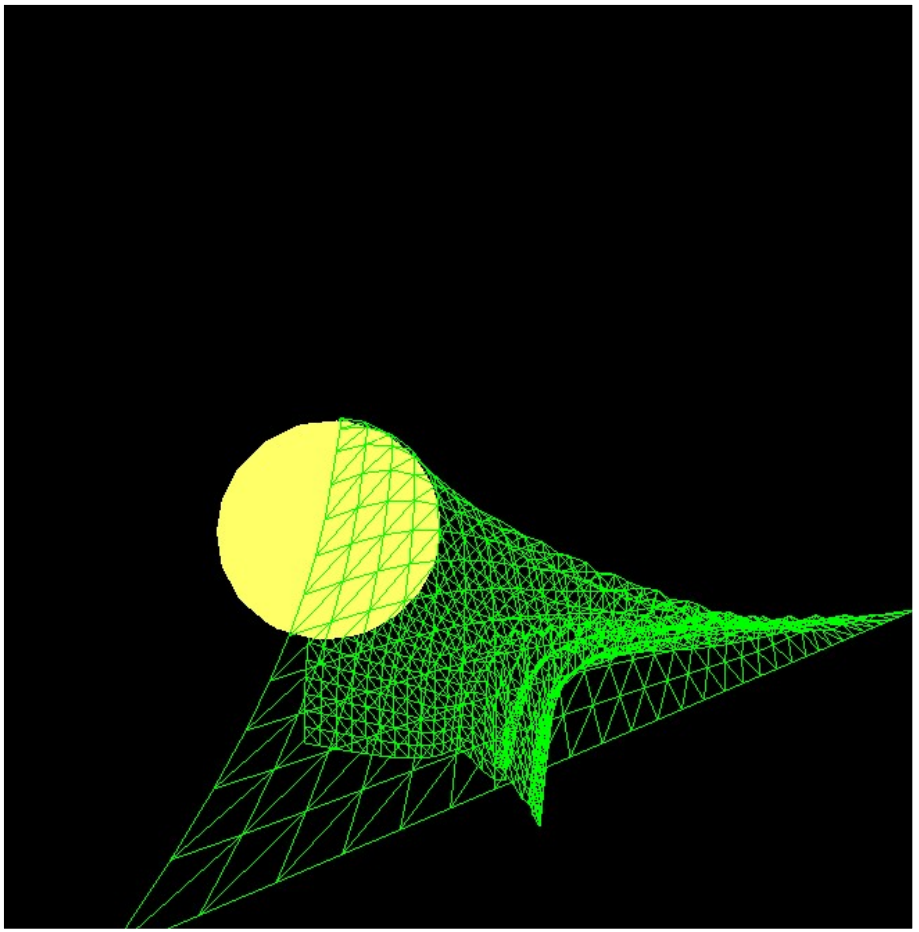


Animating Cloth

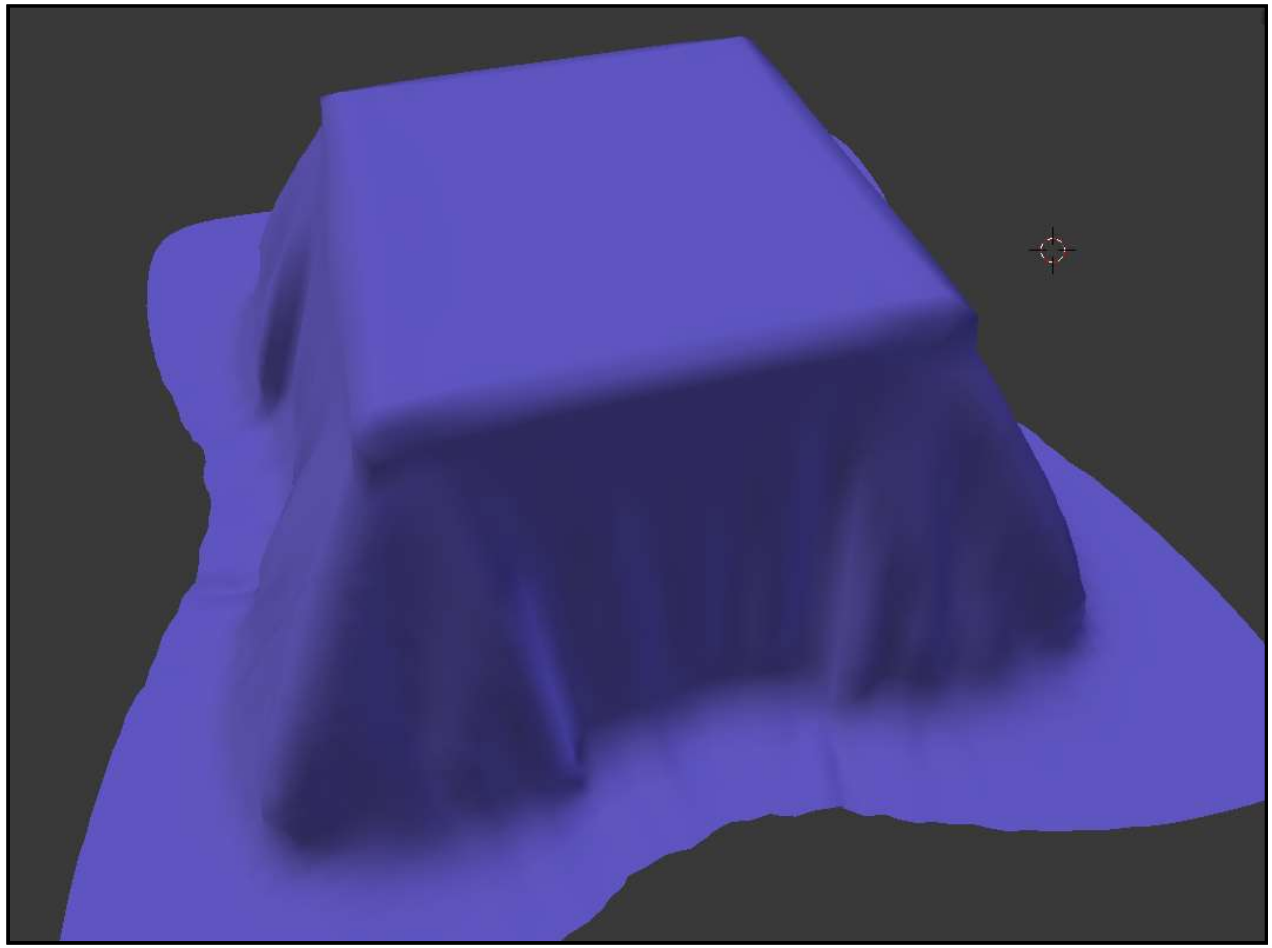


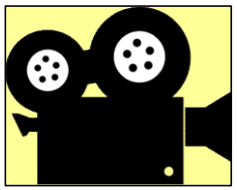
Cloth Examples





Cloth Example



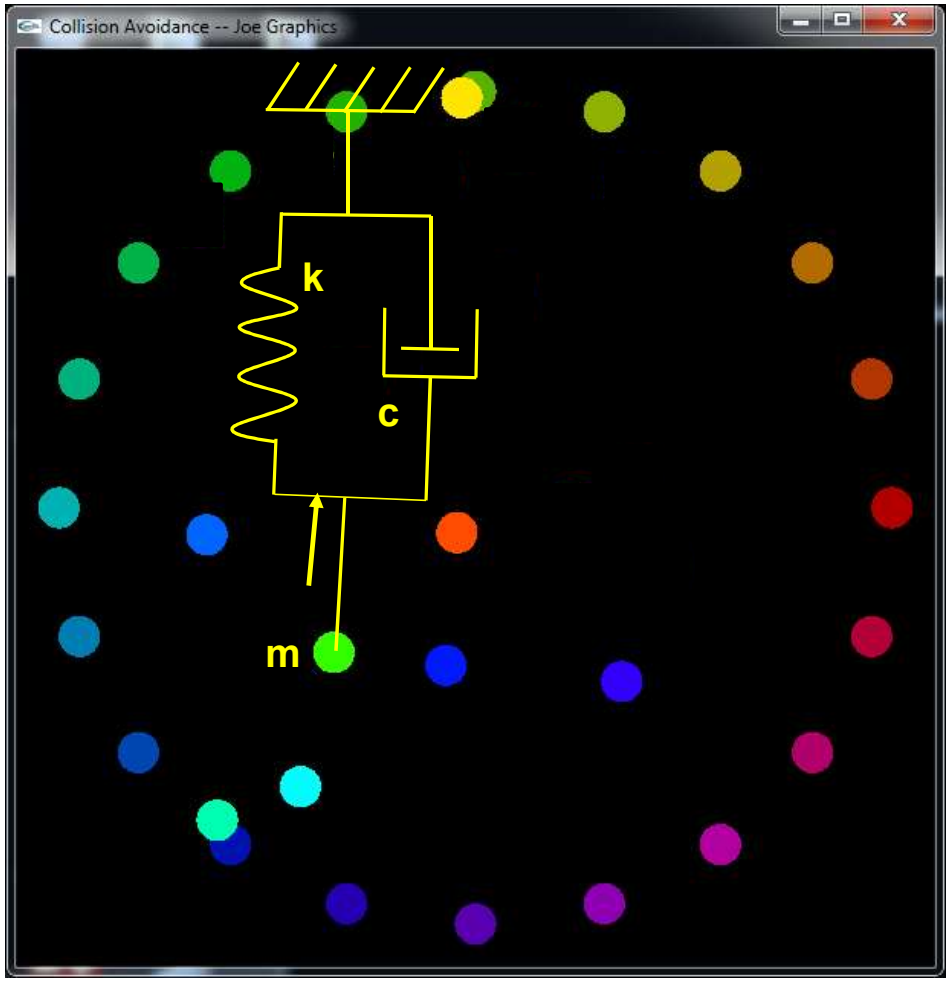


cloth.mp4

Cloth Example

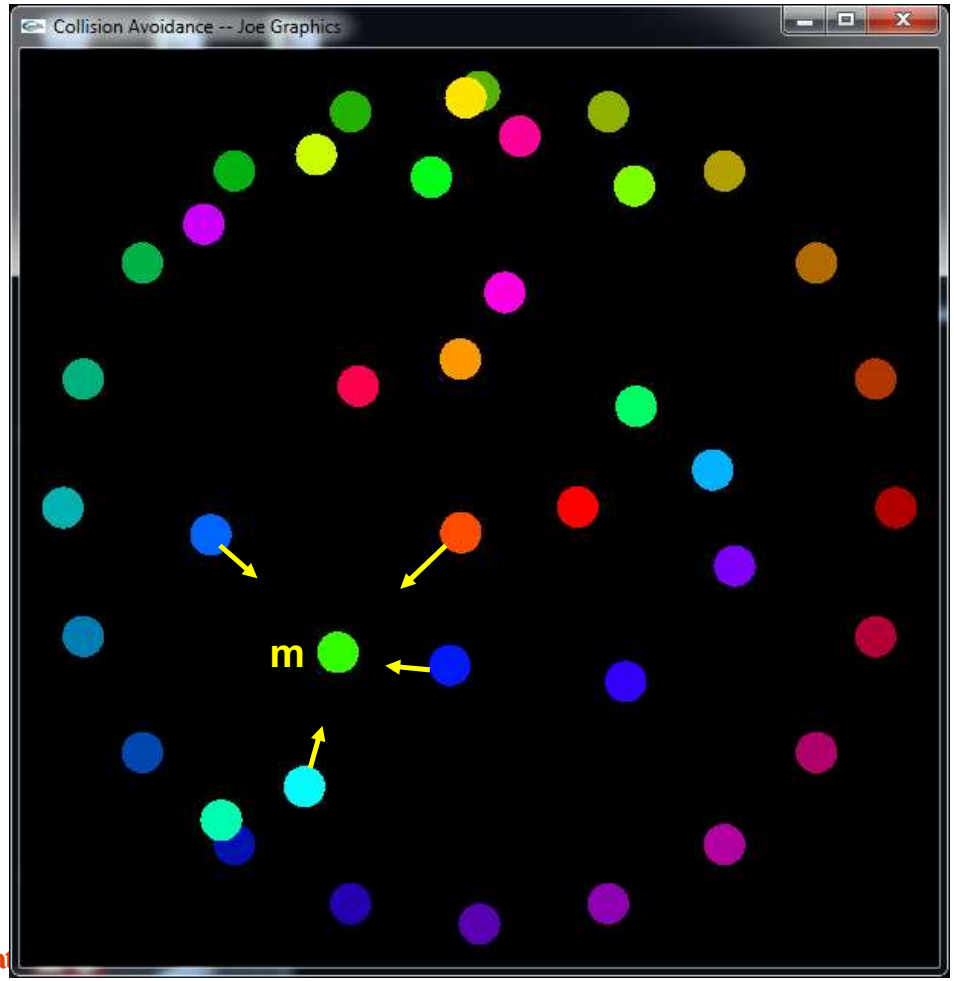
Pixar

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



$$m\ddot{x} = \sum F_{repulsive}$$

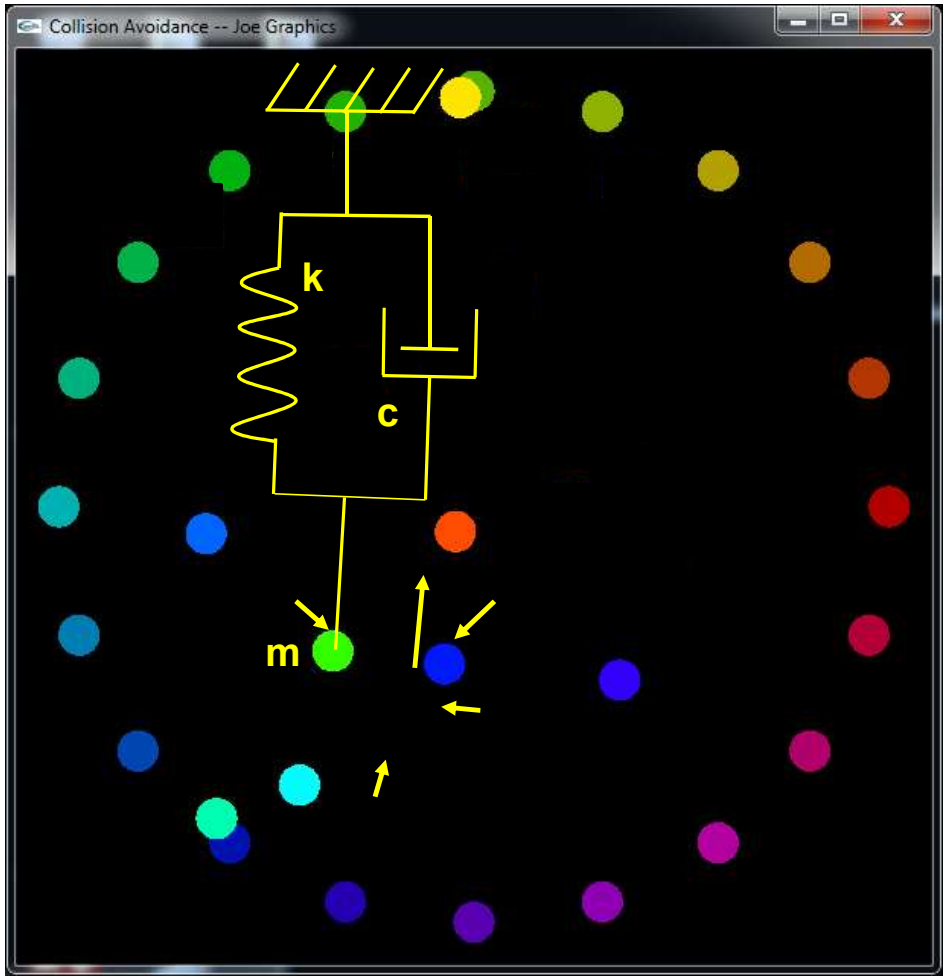
Repulsion Coefficient

$$F_{repulsive} = \frac{C_{repulse}}{d^{Power}}$$

Distance between the boundaries of the 2 bodies

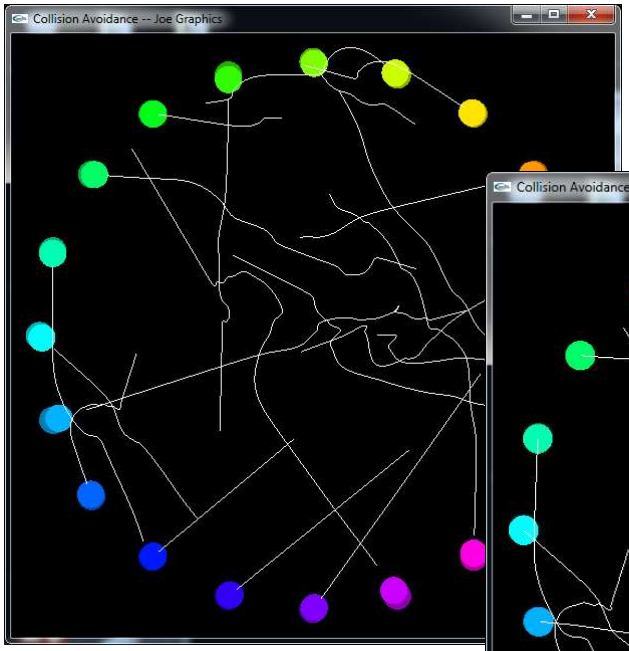
Repulsion Exponent

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

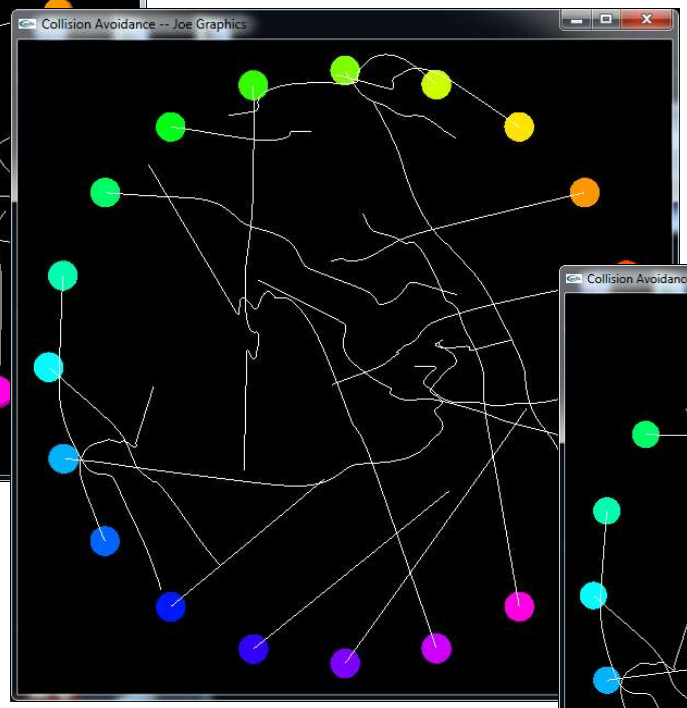


$$m\ddot{x} + c\dot{x} + kx = \sum F$$

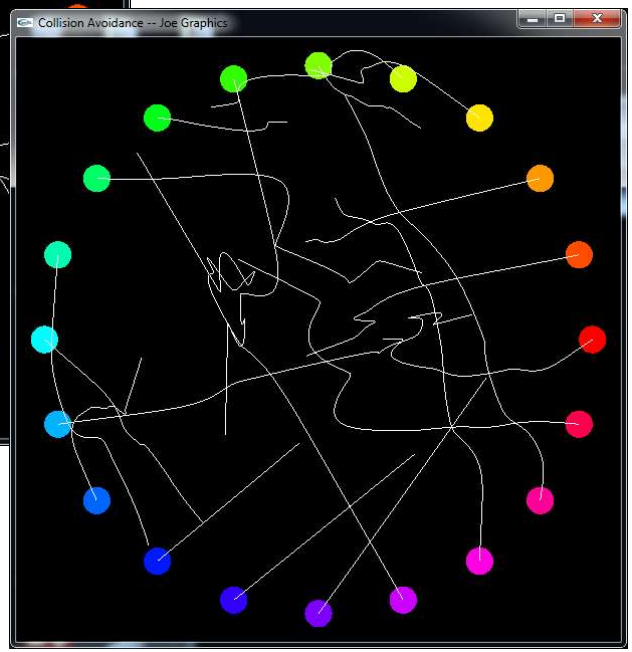
Increasing the Stiffness



Stiffness = 3

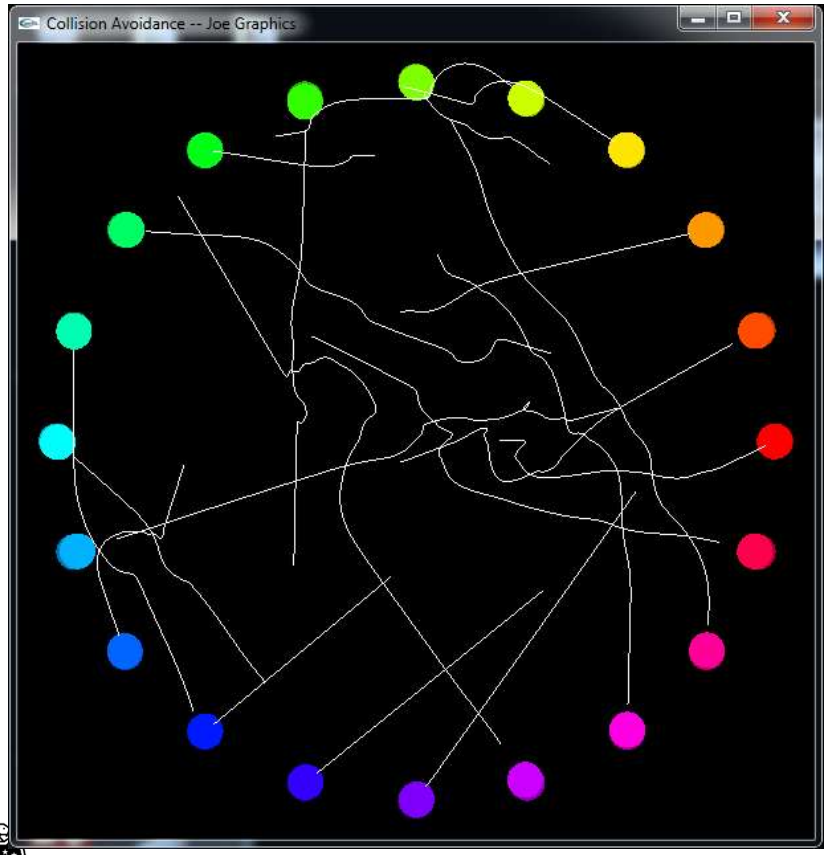


Stiffness = 6

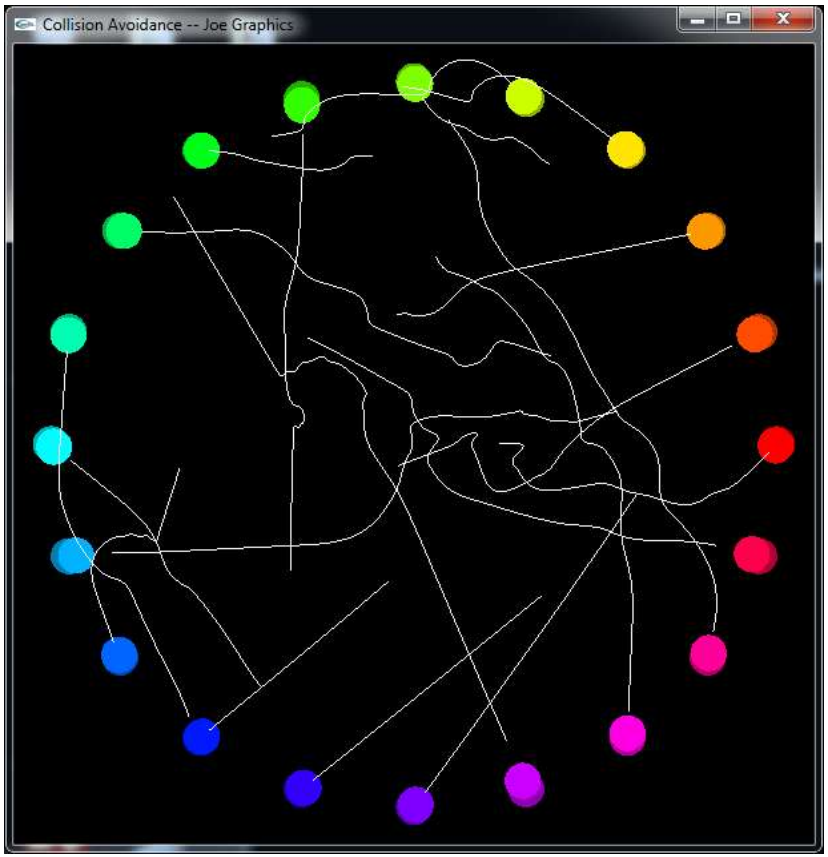


Stiffness = 9

Increasing the Repulsion Coefficient

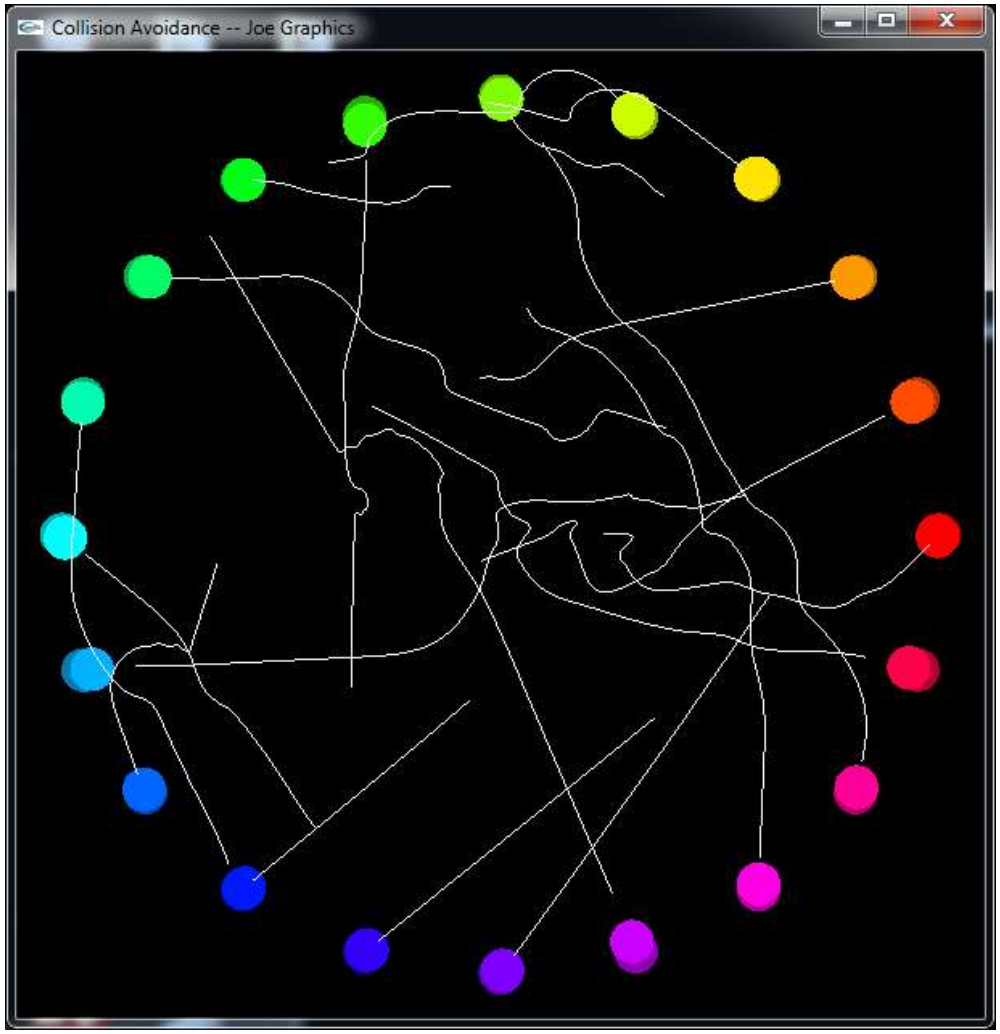


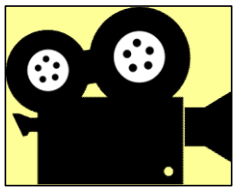
Repulse = 10



Repulse = 30

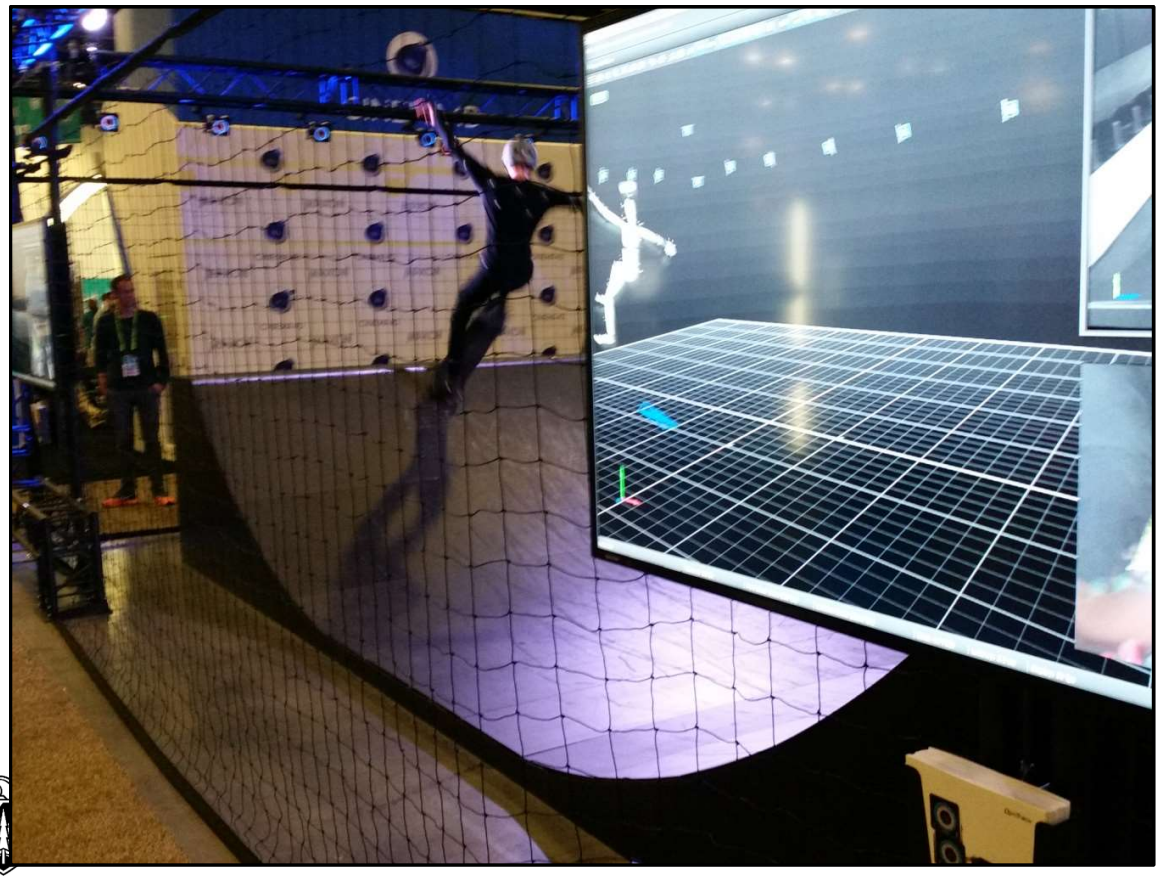
Functional Animation





avoid.mp4

Motion Capture as an Input for Animation



Natural Point

Motion Capture is for Faces Too

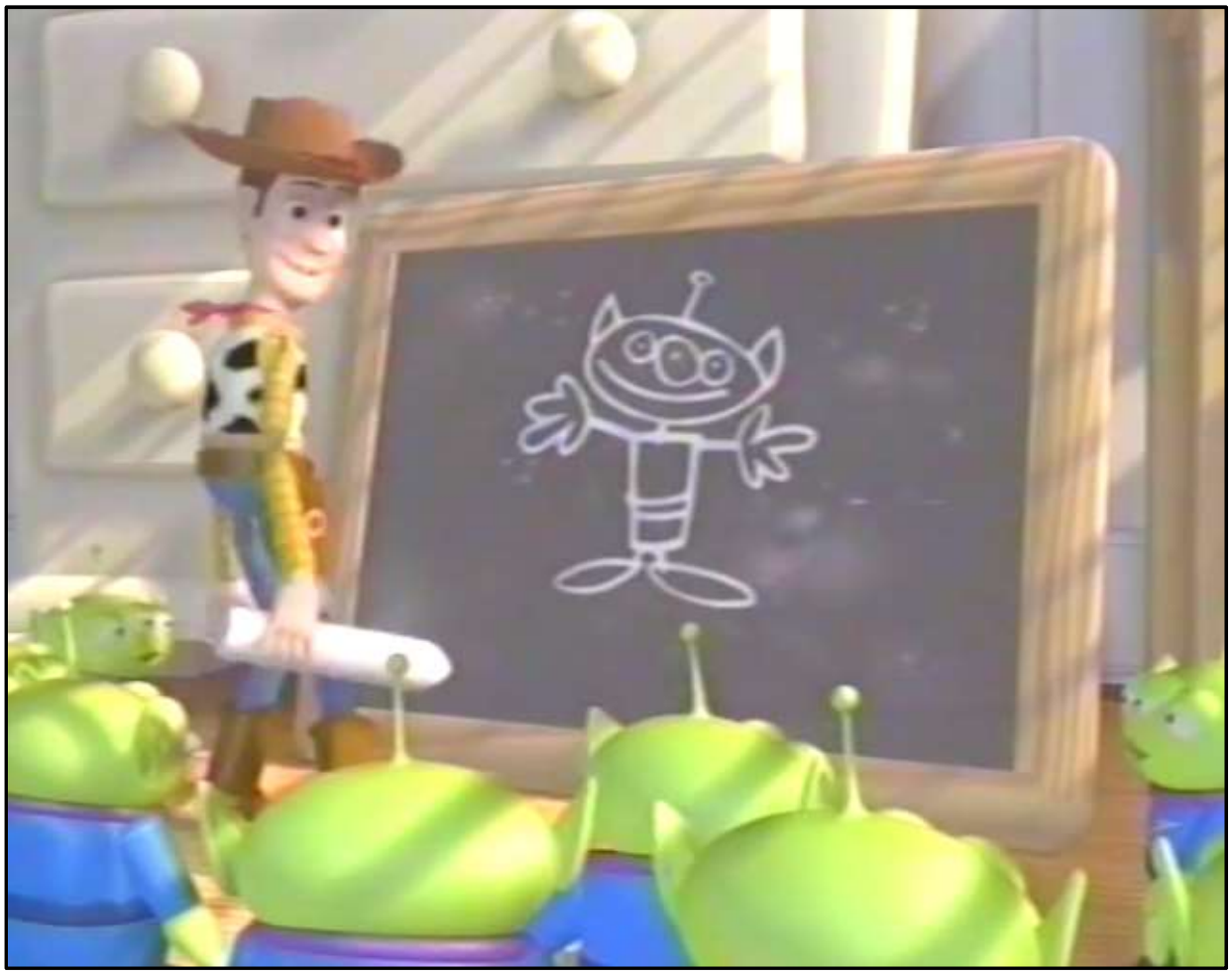
Tron I –
They probably should have used physics, but didn't

MAGI

Card Trick

Rob Russ

Pixar Animated Shorts



Pixar

Sidebar: DIY KeyTime Animation

A C++ class can do it all for you

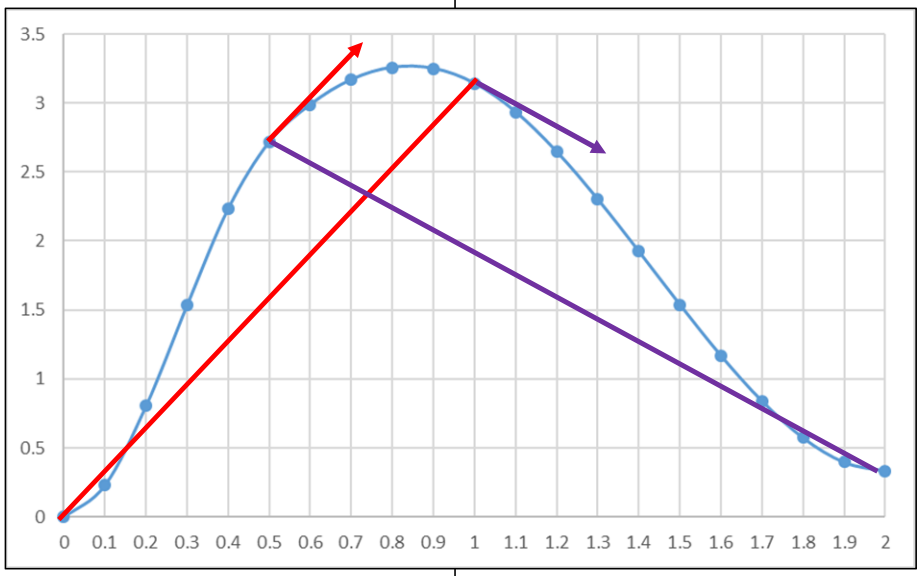
```
class Keytimes:

        void    AddTimeValue( float time, float value );
        float   GetFirstTime( );
        float   GetLastTime( );
        int     GetNumKeytimes( );
        float   GetValue( float time );
        void    PrintTimeValues( );
```

DIY KeyTime Animation

```
Keytimes Xpos;

int
main( int argc, char *argv[ ] )
{
	Xpos.AddTimeValue(  0.0,  0.000 );
	Xpos.AddTimeValue(  2.0,  0.333 );
	Xpos.AddTimeValue(  1.0,  3.142 );
	Xpos.AddTimeValue(  0.5,  2.718 );
	fprintf( stderr, "%d time-value pairs:\n", Xpos.GetNumKeytimes( ) );
	Xpos.PrintTimeValues( );

	fprintf( stderr, "Time runs from %8.3f to %8.3f\n", Xpos.GetFirstTime( ), Xpos.GetLastTime( ) );

	for( float t = 0.; t <= 2.01; t += 0.1 )
	{
		float v = Xpos.GetValue( t );
		fprintf( stderr, "%8.3f\t%8.3f\n", t, v );
	}
}
```

DIY KeyTime Animation

```
( 0.00,  0.000)
( 0.00,  0.000)  ( 2.00,  0.333)
( 0.00,  0.000)  ( 1.00,  3.142)  ( 2.00,  0.333)
( 0.00,  0.000)  ( 0.50,  2.718)  ( 1.00,  3.142)  ( 2.00,  0.333)
4 time-value pairs
Time runs from   0.000 to   2.000
  0.000         0.000
  0.100         0.232
  0.200         0.806
  0.300         1.535
  0.400         2.234
  0.500         2.718
  0.600         2.989
  0.700         3.170
  0.800         3.258
  0.900         3.250
  1.000         3.142
  1.100         2.935
  1.200         2.646
  1.300         2.302
  1.400         1.924
  1.500         1.539
  1.600         1.169
  1.700         0.840
  1.800         0.574
  1.900         0.397
  2.000         0.333
```



Using the System Clock for Timing in Display( )

```
#define MSEC       10000                    // i.e., 10 seconds
Keytimes Xpos, Ypos, Zpos;
Keytimes ThetaX, ThetaY, ThetaZ;

. . .

if( AnimationIsOn )
{
        // # msec into the cycle ( 0 - MSEC-1 ):
        int msec = glutGet( GLUT_ELAPSED_TIME )  %  MSEC;

        // turn that into a time in seconds:
        float nowTime = (float)msec  / 1000.;
        glPushMatrix( );
                glTranslatef( Xpos.GetValue( nowTime ), Ypos.GetValue( nowTime ), Zpos.GetValue( nowTime )  );
                glRotatef(  ThetaX.GetValue( nowTime ),  1., 0., 0. );
                glRotatef(  ThetaY.GetValue( nowTime ),  0., 1., 0. );
                glRotatef(  ThetaZ.GetValue( nowTime ),  0., 0., 1. );
                << draw the object >>
        glPopMatrix( );
}
```

Number of msec in the animation cycle