

# Computer Graphics

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**Prof. Feng Liu**

**Fall 2018**

<http://www.cs.pdx.edu/~fliu/courses/cs447/>

**11/29/2018**

# Last time

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Ray tracing

# Today

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Animation

Final Exam

■ December 4 (Tuesday) 17:30-19:00

■ To-know list available

# Animation

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- Animation is about bringing things to life
- Technically:
  - Generate a sequence of images that, when played one after the other, make things move
  - One image is called a *frame*
    - 24 frames per second for film, resolution approx 1600x1200, good anti-aliasing
    - 30 frames per second for NTSC video, resolution less than 640x480
    - 60+ frames per second for “twitch” computer games, 640x480 or higher resolution
  - Interlacing: Display every second row for one frame, every other row for the next. Used in NTSC TV and older monitors

# Perceptual Issues

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- We perceive many still images in rapid succession as continuous motion
  - Even if there is a transition period between the images
  - Can even put distracters in and motion is still perceived
- You can be fooled, however, if the flicker rate is incorrect
- The frame rate for film was perceptually chosen

# Animation Issues

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- When evaluating an animation technique or application, the following things should be considered:
  - How fast can the images be generated?
  - How easy is it to control the appearance of the animation?
  - How much human expertise is required to generate the animation?
  - Can the animation be generated in response to a user's action (interactive animation)?
- Application driven: Different applications have different requirements:
  - Feature film animation is different from interactive gaming animation

# The 11 Principles

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- ❑ Developed at Disney over the 1920s and 1930s
- ❑ Described by John Lasseter (Pixar) 1987
- ❑ Squash-and-Stretch, Timing, Anticipation, Follow Through and Overlapping Action, Straight Ahead Action and Pose-to-Pose Action, Slow In and Out, Arcs, Exaggeration, Secondary Action, Appeal
- ❑ Basically, principles are driven by:
  - Perceptual factors, such as directing the viewer's attention and smoothing the motion for easier perception
  - Conveying emotion through motion

# Basic Animation Techniques

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- Keyframe animation
  - Animator specifies important positions throughout the animation - the *keyframes*
  - Someone or something fills in the intermediate frames - *inbetweening*, or just *'tweening*
- Motion capture
  - System captures motion data from a real enactment of the animation
  - The data then drives a virtual character or object
- Procedural animation
  - A set of equations or rules are evaluated to determine how the animation behaves



# Keyframing

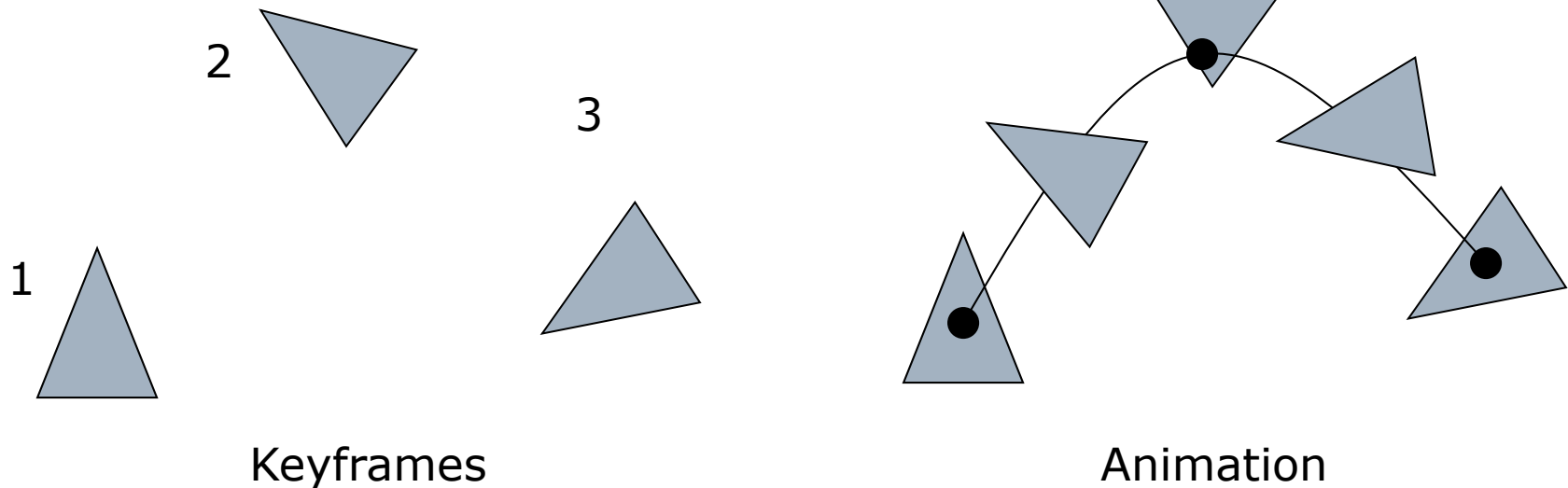
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- The original way to animate, and still the most common form for feature animation
  - Process has shifted to computers, but basic approach is the same
- Underlying technique is *interpolation*
  - The in-between frames are interpolated from the keyframes
  - Originally done by armies of underpaid animators
  - Now done with computers
  - Which of the techniques that we have learned about is used extensively for keyframe animation?

# Interpolation

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- Interpolating splines are smooth curves that interpolate their control points
  - For example, **Cardinal cubics** ( Shirley book ch. 15.5.3)
- Perfect for keyframe animation
- Typically, time is directly associated with the parameter value, controlling speed



# More Interpolation

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- Anything can be keyframed and interpolated
  - Position, Orientation, Scale, Deformation, Patch Control Points (facial animation), Color, Surface normals...
- Special interpolation schemes for things like rotations
  - Use *quaternions* to represent rotation and do spherical interpolation
- Control of parameterization controls speed of animation

# Motion Capture

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- Extract data from real-world people acting out a scene
- Many techniques for getting the data:
  - Optical - take video and extract motion
  - Magnetic/Radio - attach magnets, transponders and use sensors to get location
  - Mechanical methods of extracting motion (for small motions)
- Most methods have some problems, all are limited in the complexity of the scenes they can capture
  - Solution: Break scenes into smaller pieces and re-construct later

# Motion Capture Example

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From [http://www.batou.fr/wp-content/uploads/motion\\_capture\\_1.jpg](http://www.batou.fr/wp-content/uploads/motion_capture_1.jpg)

# Motion Capture in Use

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- Motion capture is one of the primary animation techniques for computer games
  - Gather lots of snippets of motion capture
    - e.g.: Several ways to dunk, dribble, pass
  - Arrange them so that they can be pieced together smoothly
  - At run time, figure out which pieces to play to have the character do the desired thing
- Problems: Once the data is captured, it's hard to modify for a different purpose

# Face animation



<https://www.youtube.com/watch?v=ohmajJTcpNk>

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# Procedural Animation

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- ❑ Animation is generated by writing a program that outputs the position/shape/whatever of the scene over time
- ❑ Generally:
  - Program some rules for how the system will behave
  - Choose some initial conditions for the world
  - Run the program, maybe with user input to guide what happens
- ❑ Advantage: Once you have the program, you can get lots of motion
- ❑ Disadvantage: The animation is generally hard to control, which makes it hard to tell a story with purely procedural means



# Particle Systems

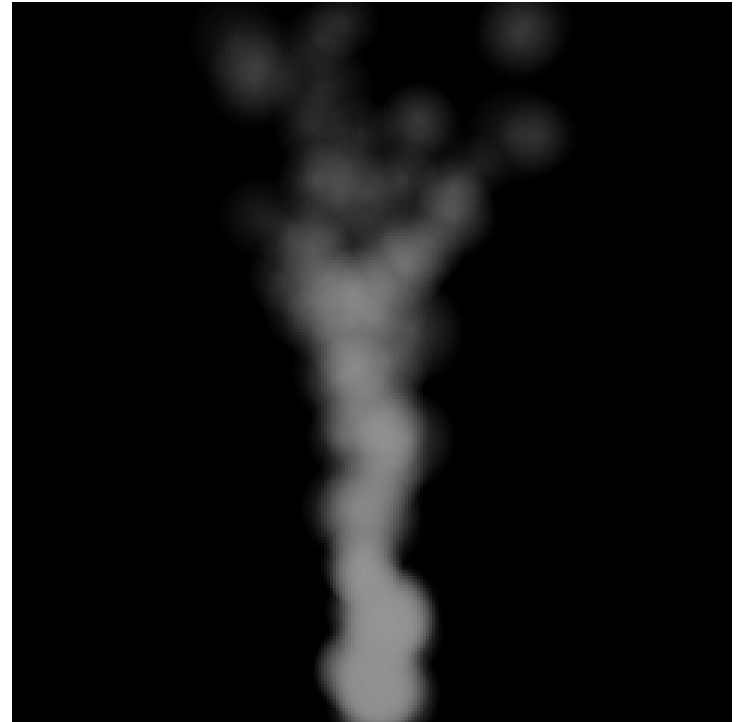
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- A particle has:
  - A position in the world
  - Rules for how it moves over time
  - Rules for how it is drawn
- A particle system:
  - Controls when particles are created and destroyed
  - Makes sure that all the particles are updated

# Smoke Particle System

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- Constantly create particles
- Particles move upwards, with *turbulence* added
  - Ken Perlin: An academy award
- Draw them as partially transparent circles that fade over time



# Movie Particle Systems

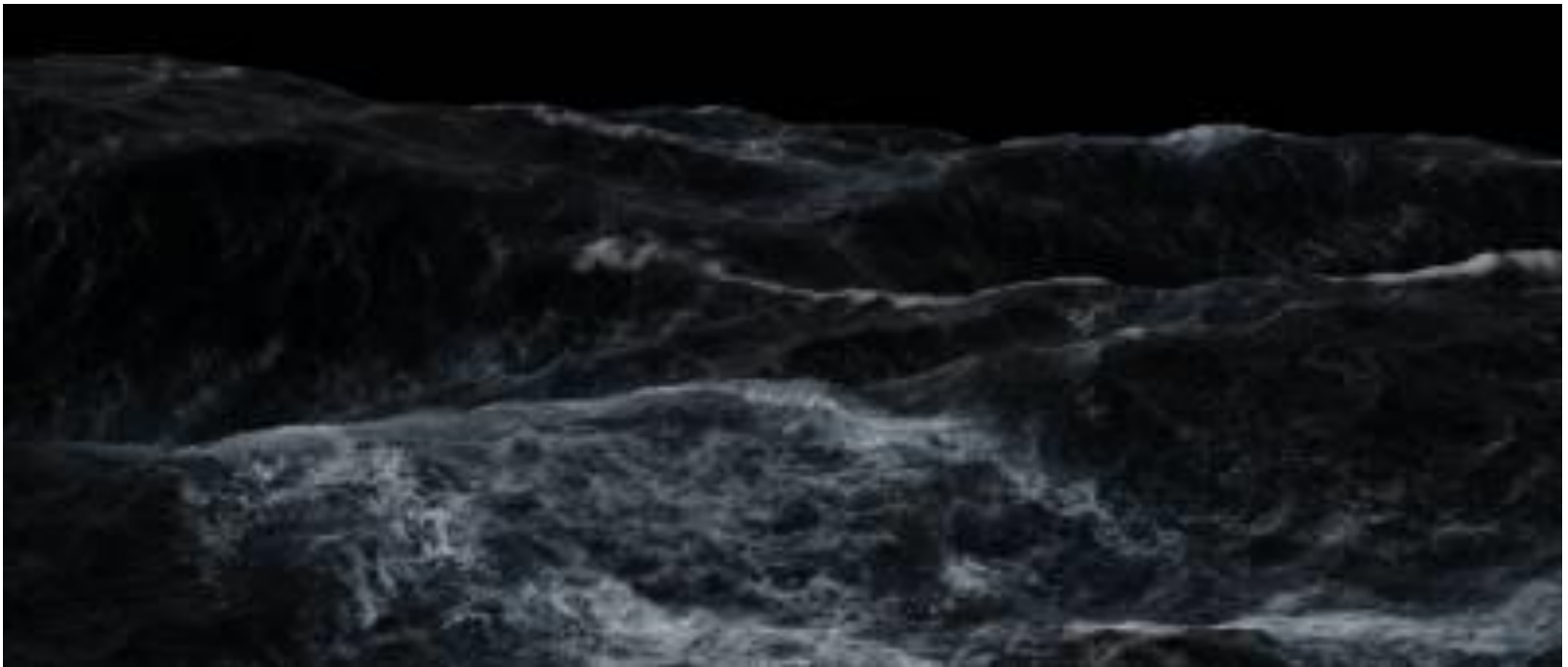
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- Particle systems are the standard way of doing smoke and water spray
- Examples from Perfect Storm (lots of water)
  - All images from Industrial Light and Magic (ILM)

# Basic Ocean

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- Ocean created with *Computational Fluid Dynamics*



# Flowing Water

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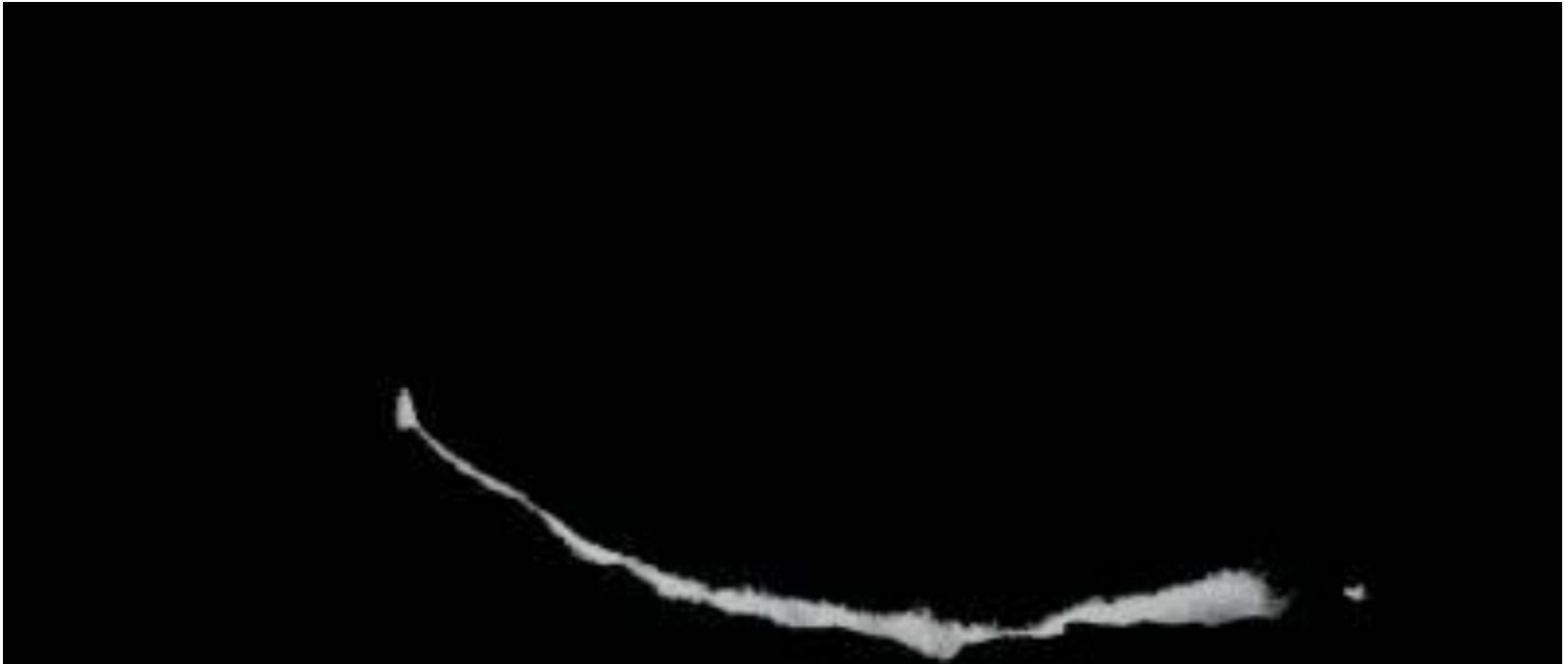
- ❑ Water from previous frame flowing over boat



# Boat's Spray

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- Particles are created where the boat meets the ocean



# Impact Spray

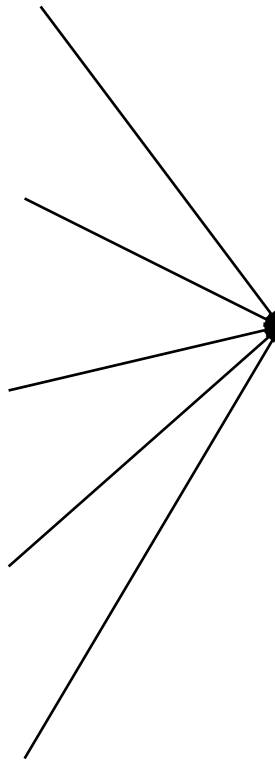
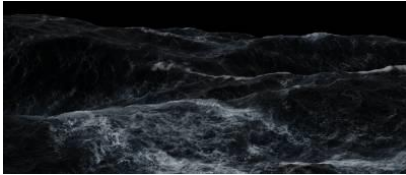
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- Particles created where boat and ocean hit hard



# Perfect Storm - Composite

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# Spring-Mass Systems

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- ❑ Model objects as systems of springs and masses
- ❑ The springs exert forces, and you control them by changing their rest length
- ❑ A reasonable, but simple, physical model for muscles
- ❑ Advantage: Good looking motion when it works
- ❑ Disadvantage: Expensive and hard to control

# Spring mass fish

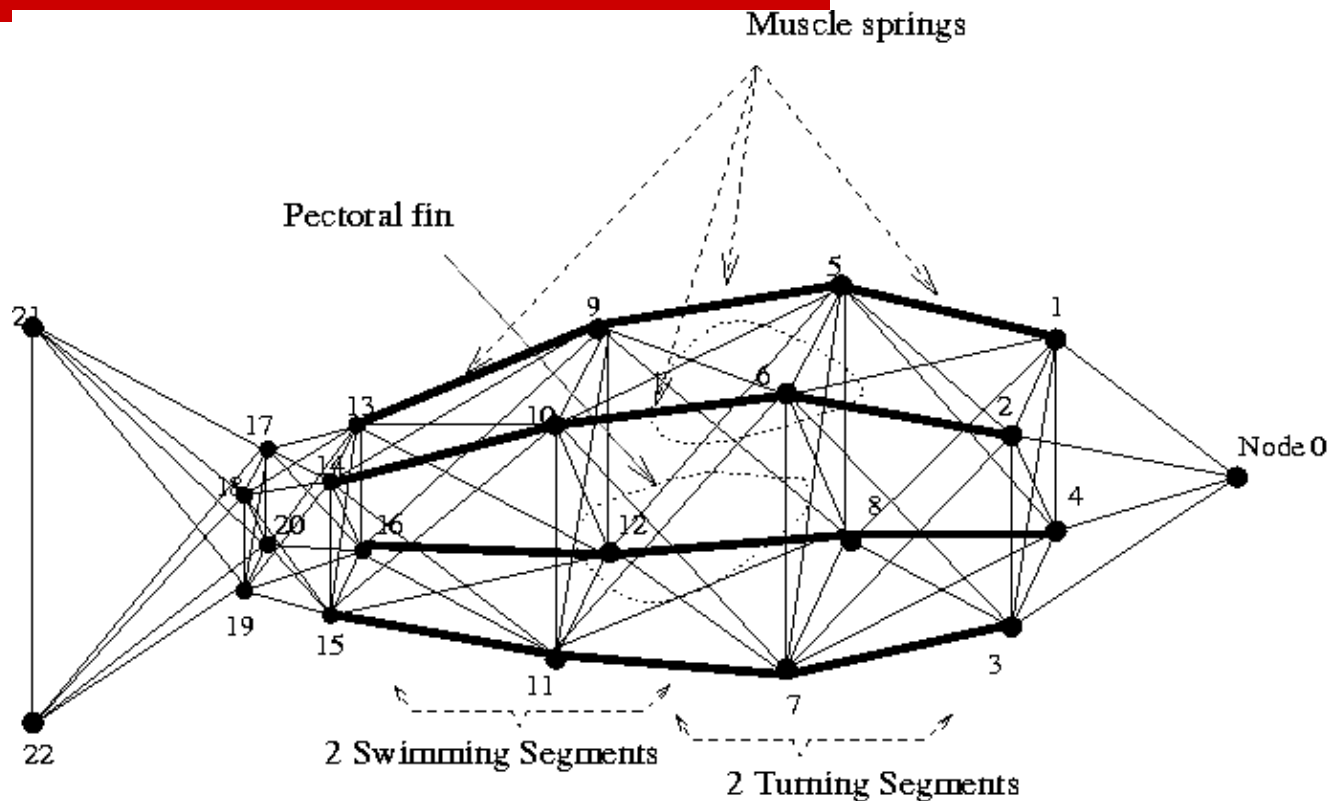
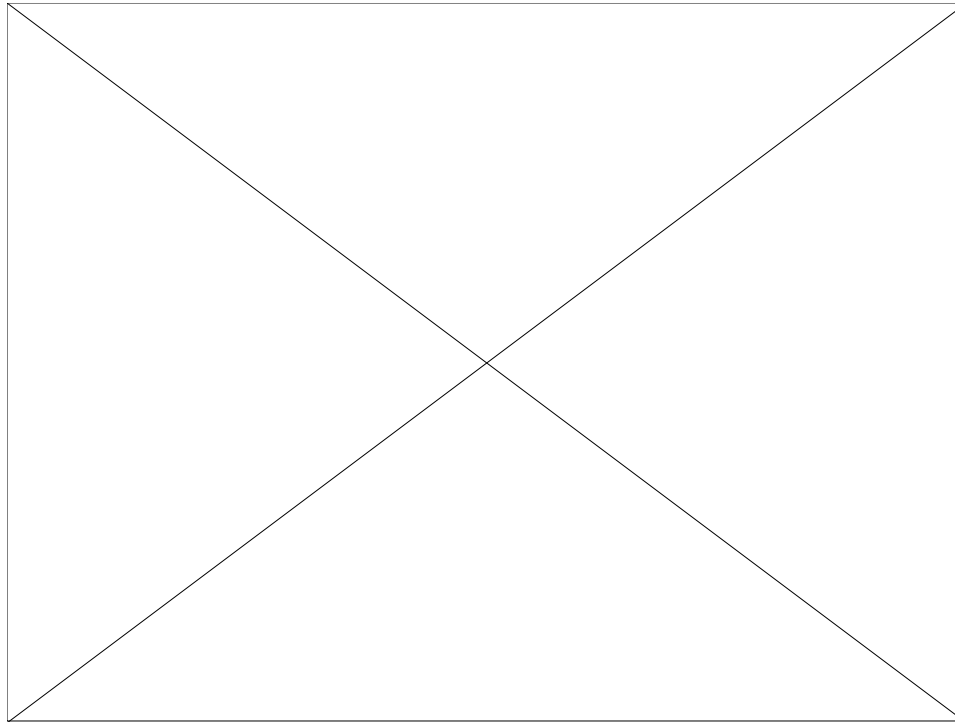


Figure 4.1: The biomechanical fish model. Black dots indicate lumped masses. Lines indicate deformable elements at their natural, rest lengths.

# Spring mass fish

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<http://www.dgp.toronto.edu/~tu/animations.html>

# Physically-Based Models

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- Create a model based on the physics of a situation, and just solve for what happens
  - Has been applied to:
    - Colliding rigid objects
    - Cloth
      - [An example:](http://www.youtube.com/watch?v=04nXlhdPxB4&noredirect=1)  
<http://www.youtube.com/watch?v=04nXlhdPxB4&noredirect=1>
    - Water
    - Smoke
      - [https://www.youtube.com/watch?v=7cC-\\_-aqx18](https://www.youtube.com/watch?v=7cC-_-aqx18)
    - Squishy objects
    - Humans
    - New ones every year
  - Problem: Expensive, hard to control, and not necessarily realistic
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# Mixing Techniques

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- Techniques can be mixed and matched in the same animation
- For example, apply physical secondary motion on top of key-framed primary motion
  - Particularly appropriate for cloth
- Mix motion capture and physics:
  - Motion captured person kicks a ball which is then physically simulated to find out where it goes

# Animation Summary (brief)

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Technique	Control	Time to Create	Computation Cost	Interactivity
Key-Framed	Excellent	Poor	Low	Low
Motion Capture	Good at time of creation, after that poor	Medium	Medium	Medium
Procedural	Poor	Poor to create program	High	High

# Current Challenges

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- ❑ Human characteristics
  - Hair animation and rendering
  - Skin rendering
  - Facial animation
  - Walking, running, climbing
- ❑ High quality real time
  - Fluids, hair, physics
  - Realistic lighting and shading
- ❑ Control with quality
  - Making it easier for artists and directors to get the results they want



# Next Time

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Final Exam