Topic 14:

Animation

1911: Winsor McCay (1867-1934) makes his first film, LITTLE NEMO. McCay, already famous for comic strips, used the film in his vaudeville act. His advice on animation:

*Any idiot that wants to make a couple of thousand drawings for a hundred feet of film is welcome to join the club.*

1928: Walter Disney (1901-1966) working at the Kansas City Slide Company creates Mickey Mouse.

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Squash and Stretch

Rigid objects look robotic: deformations make motion natural

Accounts for physics of deformation

- Think squishy ball...
- Communicates to viewer what the object is made of, how heavy it is, ...
- Usually large deformations conserve volume: if you squash one dimension, stretch in another to keep mass constant

Also accounts for persistence of vision

- Fast moving objects leave an elongated streak on our retinas
Anticipation

The preparation before a motion

- E.g. crouching before jumping, pitcher winding up to throw a ball

Often physically necessary, and indicates how much effort a character is making

Also essential for controlling the audience’s attention, to make sure they don’t miss the action

- Signals something is about to happen, and where it is going to happen.
## Animation Principles

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What can be animated?

Lights
Camera
Jointed figures
Deformable objects
Clothing
Skin/muscles
Wind/water/fire/smoke
Hair

...any variable, Given the right time scale, almost anything...
Elements of CG (animation)

How does one make digital models move?

- **Keyframing**
- **Physical simulation**
- **Motion capture**
- **Behavior rules**
Keyframes, also called extremes, define important poses of a character:

- Jump example:
  - the start
  - the lowest crouch
  - the lift-off
  - the highest part
  - the touch-down
  - the lowest follow-through

- Frames in between (“inbetweens”) introduce nothing new to the motion.
- May add additional keyframes to add some interest, better control the interpolated motion.
Keyframe Animation

The task boils down to setting animated variables (e.g. positions, angles, sizes, ...) at each frame.

**Straight-ahead:** set variables in frame 0, then frame 1, frame 2, ... forward in time.

**Pose-to-pose:** set the variables at keyframes, let the computer smoothly interpolate values for frames in between.
How do we interpolate between two values?

Hold
How do we interpolate between two values?

Linear
How do we interpolate between two values?
How do we interpolate between two values?

Ease-in Ease-out
How do we interpolate between two values?

Ease-in Ease-out
Physical Simulation

Particles

Position $x$
Velocity $v = \frac{dx}{dt}$
Acceleration $a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$

Forces

Gravity $f = mg$
Spring-damper $f = -kx - cv$

... Simulation: $x, v, a$ used to compute forces yielding total force $F$. $F = ma$ used to update $a$, $a$ used to update $v$, to update $x$...