

ECE 595 / CS 491 / CS 591  
**Real-Time Rendering &  
Graphics Hardware**

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Class 22  
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### Announcements

- Project has been handed out (check online)

### Last time

- Procedural geometry

### Today

- Discussion of the project
- Physical simulation and particle systems

### Final project

- Due Wednesday May 9<sup>th</sup> at 11:59pm
- Open-ended project. Choose an area of real-time rendering that interests you!

### Potential topics

- Soft shadow algorithms
- Pre-computed radiance transfer
- Procedural graphics
- Physics on the GPU
- GPGPU
- Real-time ray tracing

### The role of physics

- Physics is important in real-time applications

### Basic Physics

- Most game physics is really only mechanics
- Governed by the following simple equations we learned in high school:

$$F = m a$$

$$a = dv/dt$$

$$x = x_0 + v t$$

- So we can integrate the acceleration to get the velocity

### Euler integration

- Perform discrete integration to calculate velocity and position

$$v_n = v_p + a \bullet \Delta t$$

$$p_n = p_p + v_n \bullet \Delta t$$

- Simple, but it needs to store both position and velocity

## Verlet integration

- You can integrate twice to avoid computing velocity

$$p_n = 2p_p - p_{pp} + a \cdot \Delta t^2$$

- Does not need to store velocity
- Step size needs to be constant

## Particle simulation on the GPU

- See slides from GDC

## Simulating cloth

- Cloth simulated like a mesh of masses and springs