EE 4702-1, GPU Programming

When / Where

- Here (3141 P. Taylor Hall), MWF 8:30-9:20 Fall 2012
- http://www.ece.lsu.edu/koppel/gpup/

Offered By David M. Koppelman

- Room 3191 P. Taylor Hall
- Office Hours: Monday-Friday 14:00-15:00

Prerequisites by topic: C++.

GPU Definition

GPU: Graphics Processing Unit

- Runs 3D graphics in place of CPU...

  ... because it's much better at it.

- Also runs scientific-style computation in place of CPU.

GPU is Main Component of Video Cards

Major Companies and Brands

- NVIDIA
- ATI (Compaq/HP)

This Course

Focus is on GPU programming

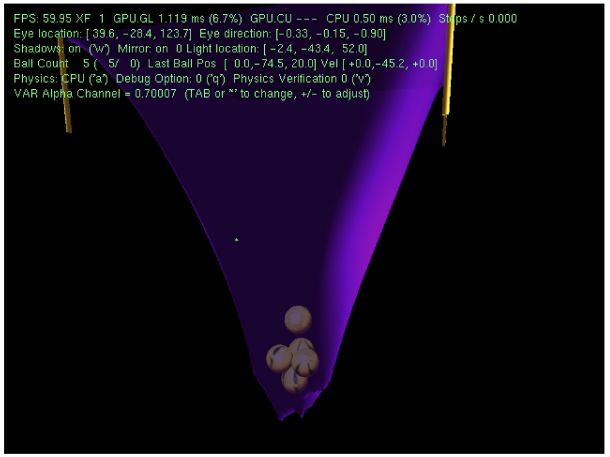
- *Shader* programming with *OGSL*.
- *GPGPU* programming with *CUDA*.

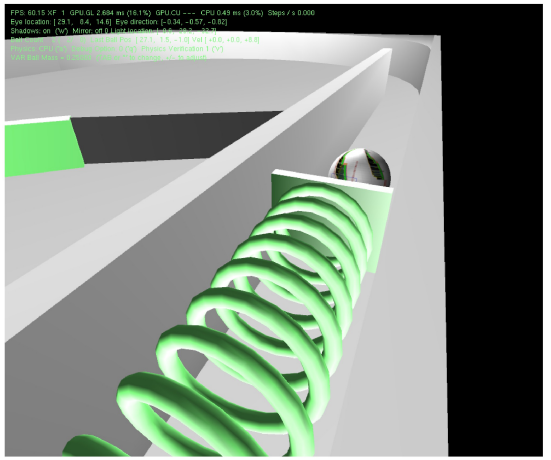
Also Some 3D Graphics, Game Physics

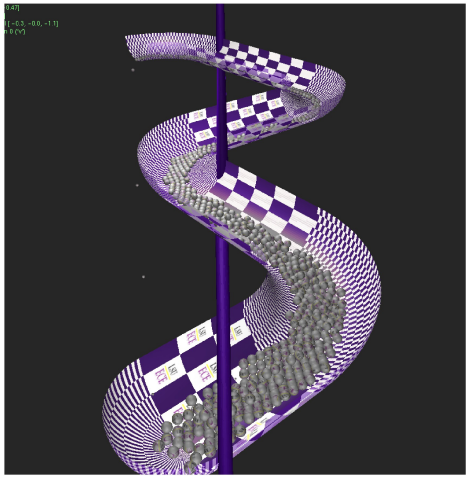
- Will cover enough graphics, OpenGL, and CUDA to do cool stuff.

Game Physics Term Project

Past Student Project Screenshots:







AVATAR

LSU AVATAR

- *AVATAR*: Arts, Visualization, Advanced Technologies and Research
- http://www.avatar.lsu.edu
- AVATAR includes several initiatives in the area of digital media.
- Includes research and instructional components.
- First product is the minor in Digital Media.
- This course, and others, count towards that minor.

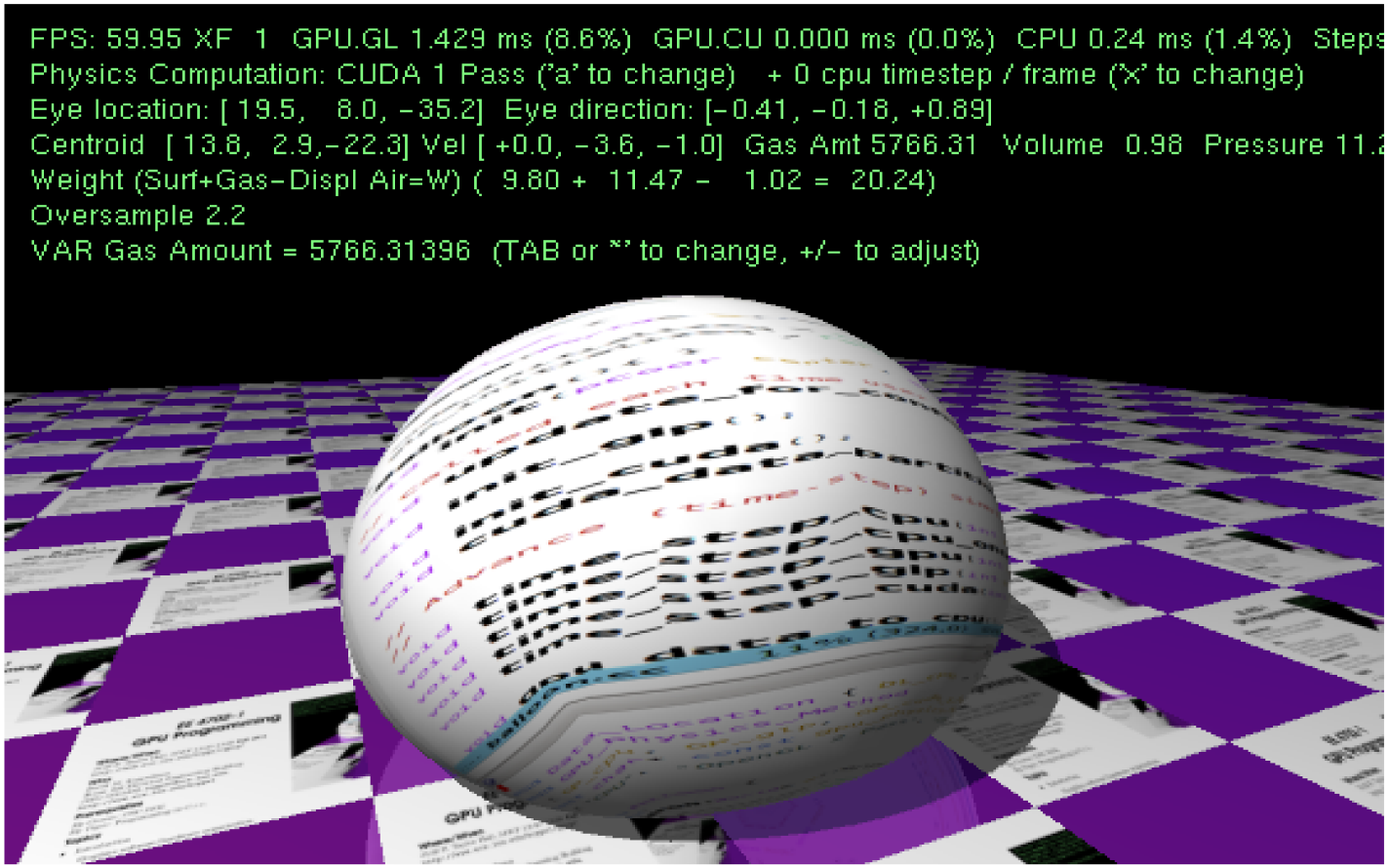
Balloon Demo

Simulation of a balloon.

GPU always runs 3D graphics.

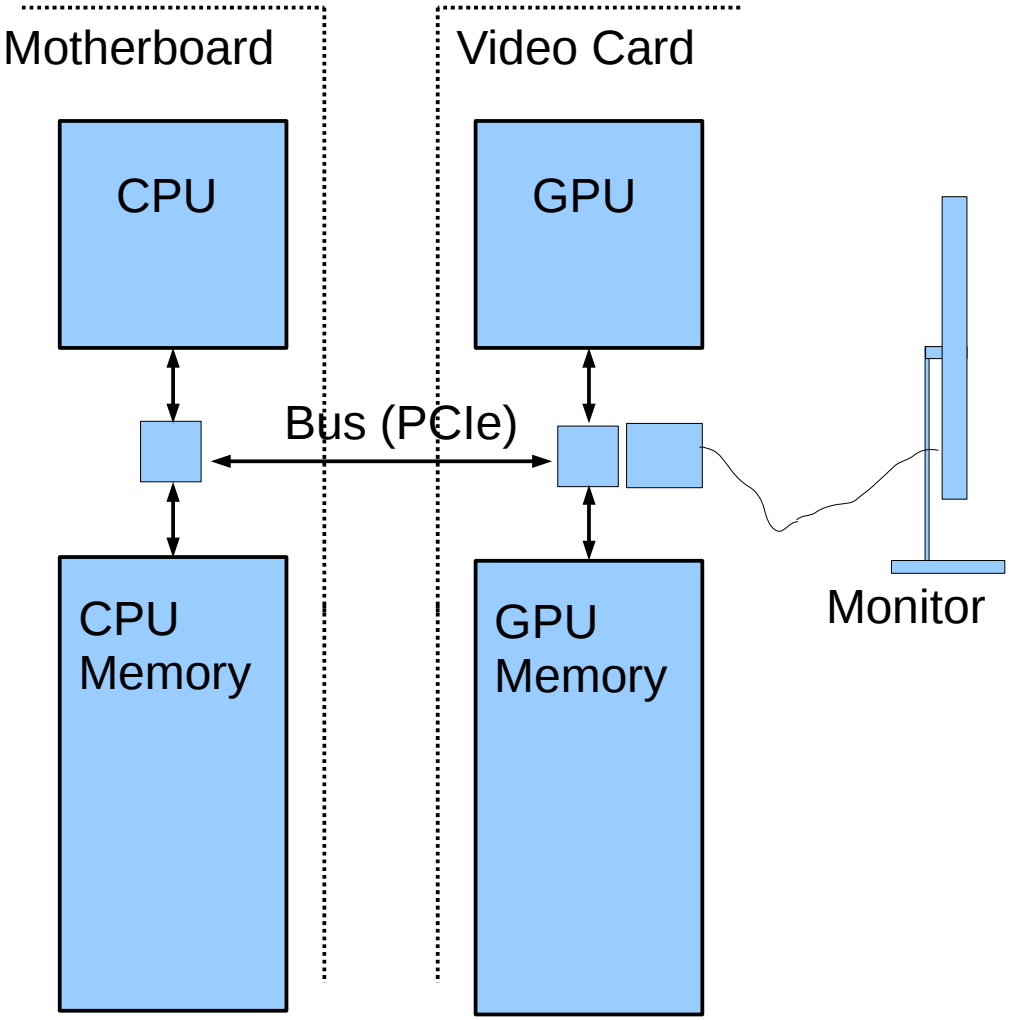
Code can switch between CPU-only and CPU/GPU physics.

Term project can be an extension of this code.



System Overview

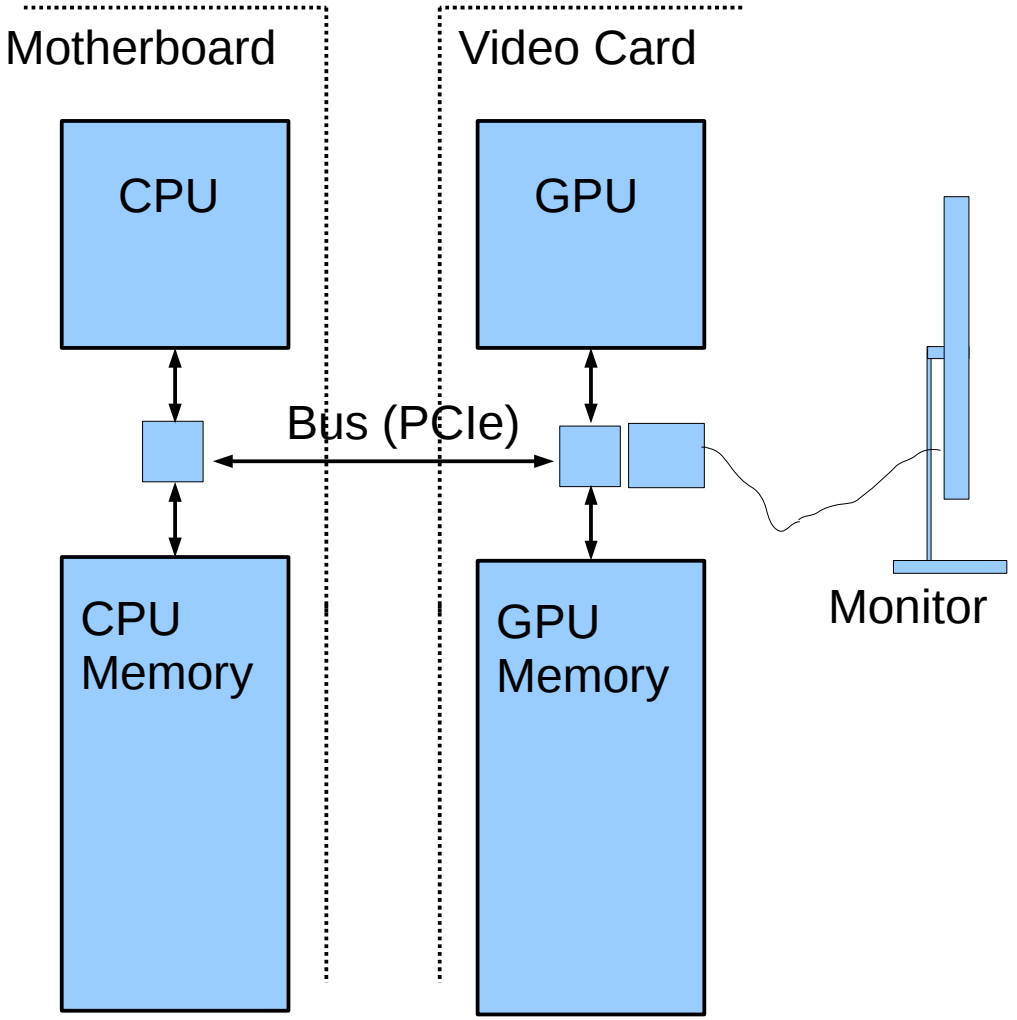
Quick look at how the GPU fits into the larger system...



System Overview: Hardware

Typical Hardware

- On Computer motherboard: CPU, CPU Memory
- On Video Card GPU, GPU Memory
- Connection between CPU/GPU via Bus, e.g., PCI Express (PCIe).
- Connection from video card to monitor.



System Overview: Frame Buffer

Frame Buffer

- Area of memory continuously converted to a video signal.
- Simple mapping from memory address to pixel coordinate.

Older Systems

- Frame buffer in CPU memory.
- Application programs wrote frame buffer directly.

Typical Current Systems

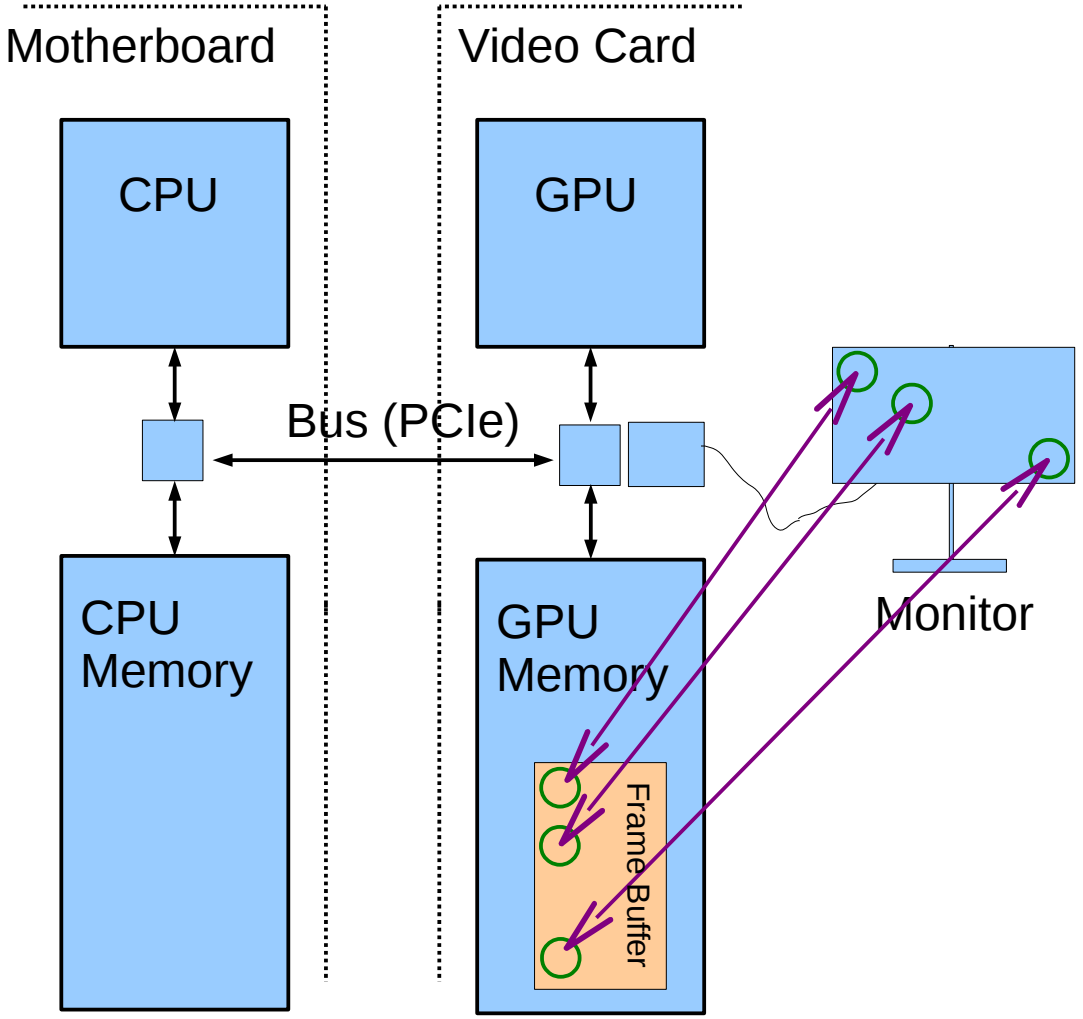
- Frame buffer in GPU memory.
- Frame buffer written by GPU hardware (typical)...

  … at end of long chain of events initiated by application.

System Overview: Frame Buffer

Frame Buffer Contents

- Position in FB corresponds to particular pixel on display.
- In illustration, first FB element is upper-left pixel.
- A common FB element size is 32 bits.
- Frame buffer format varies with video mode and of course system.

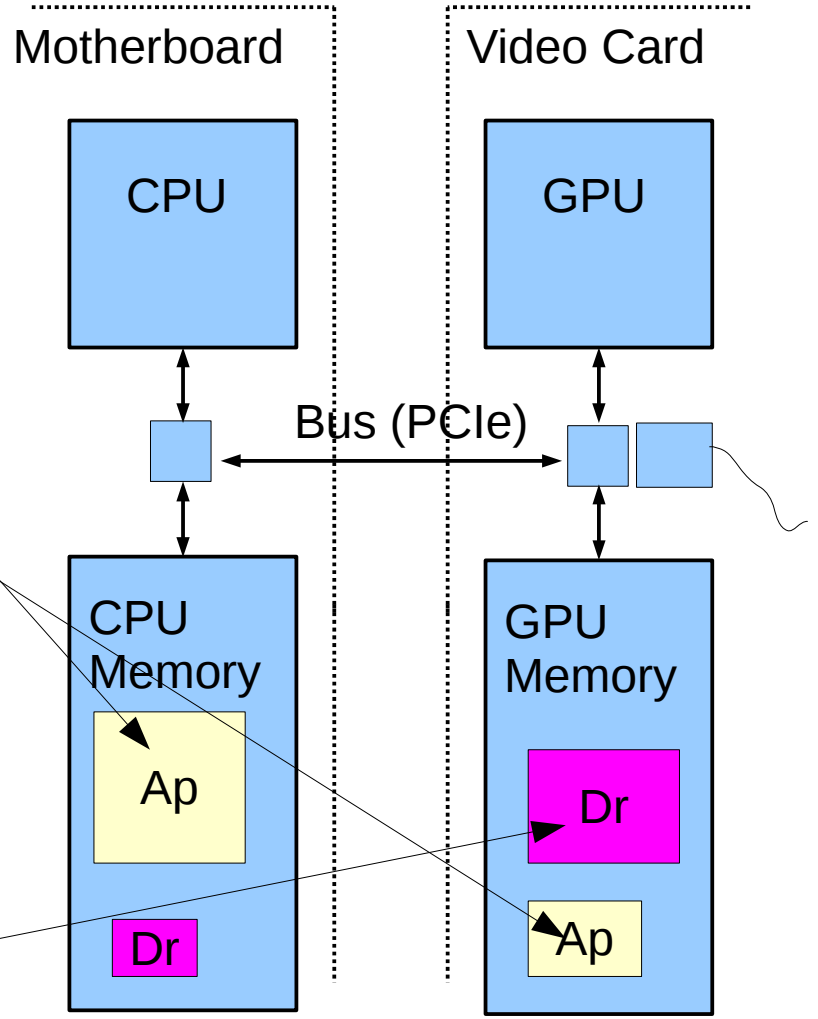


System Overview: Software

Just For Today, Oversimplify to Two Kinds of Software

- *Application Program* (Ap for short*)
  - Written by ap. programmer.
  - E.g., Balloon Demo
  - Most of Ap runs on CPU.
  - Part of Ap may also run on GPU.

- *GPU Driver* (Driver or Dr for short)
  - Written by GPU manufacturer.
  - E.g., NVIDIA 185.18.14
  - Driver code runs on both CPU and GPU.
  - Most work done by driver code that runs on GPU.



*Don't confuse Ap with App.

System Overview: Running of Application

Typical Execution

- Application, running on CPU, ready to emit next frame.
- App. calls driver on CPU...

  ...driver on CPU starts more driver code on GPU...

  ...application resumes on CPU (while GPU driver code still running).
- Process above repeated many times for a frame.
- Driver code ultimately will write frame buffer.

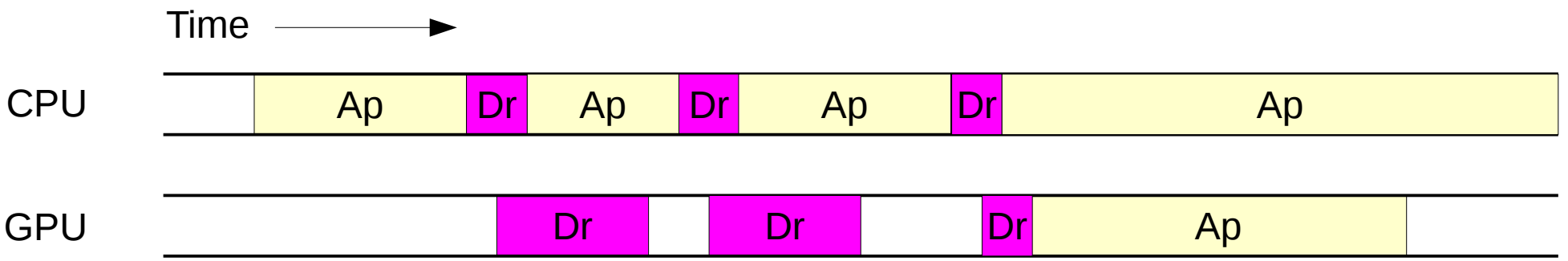
Important Points

- CPU and GPU can run code at same time.

System Overview: Execution Activities

Example Below

- Ap calls driver three times.
- First two times, driver does all work, mostly on GPU.
- Third time that ap calls driver, driver starts some ap code on GPU.



Course Coverage

Emphasis: GPU coding for high performance.

Topics Needed For Term Project (a dynamic simulation)

Topics

- Rudiments of Animation by Dynamic Simulation
- Term Project
- 3D Graphics basics: coordinates, transforms, primitives, colors, textures.
- Data movement and staging, efficiency.
- Coding with GPU *shader* model, CPU/GPU load balancing.
- Coding with CUDA, GPU physics.