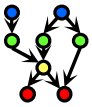
Lecture 0 of 41:
Part B – Course Content

Advanced Computer Graphics:
Course Organization and Survey

William H. Hsu
Department of Computing and Information Sciences, KSU

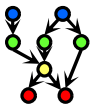
KSOL course page:
Course web site: http://www.kddresearch.org/Courses/CIS736
Instructor home page: http://www.cis.ksu.edu/~bhsu

Reading for Next Class:
Syllabus and Introductory Handouts
CIS 736 students: *Advanced CG Topics 1* slides
Chapter 1, Eberly (2006) *3D Game Engine Design, 2e*



Course Overview

- Graphics Systems and Techniques
  - Main emphasis: shaders, lighting, mappings (textures, etc.) in OpenGL
  - Photorealistic rendering and animation (*Maya 2011, Blender*; *Ogre3D*)
  - 2-D, 3-D models: curves, surfaces, visible surface identification, illumination
  - Special topics: global illumination (ray tracing, radiosity), particle systems, fractals, scientific visualization (sciviz) and information visualization (infoviz)
- Operations
  - Surface modeling, mapping
  - Pipelines for display, transformation, illumination, animation
- Computer Graphics (CG): Duality with Computer Vision
- Visualization and User Interfaces
- Applications
  - CAD/CAM/CAE: object transformations, surface/solid modeling, animation
  - Entertainment: 3-D games, photorealistic animation, *etc.*
  - Analysis: info visualization, decision support, intelligent displays

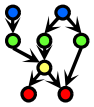


Advanced CG Syllabus, Part 1 of 2

Lecture	Topic	Primary Source(s)
0	Course Overview	Chapter 1, Eberly 2e
1	**CG Refresher: Transformations; Lab 0**	**Sections (§) 2.1, 2.2**
2	Viewing 1; Linear and Affine Transformations	§ 2.2.3 – 2.2.4, 2.8
3	Viewing 2; Parametric Equations	§ 2.3 esp. 2.3.4; FVFH slides
4	Lab 1a: 3-D Refresher; Flash, GL, Direct3D	Chapters 2, 16[1], Angel *Primer*
5	Viewing 3: Scene Graphs: State, MVT	§ 2.3; 2.6, 2.7; 4.1 – 4.3
6	Scan Conversion 1: Lines & Antialiasing	§ 2.5.1, 3.1; FVFH slides
7	**Viewing 4: Clipping, Culling, OBBs; Lab 1b**	**§ 2.3.5, 2.4, 3.1.3**
8	Scan Conversion 2: Polygons, Clipping Intro	§ 2.4, 2.5 esp. 2.5.4, 3.1.6
9	Surface Detail 1: Phong Illumination	§ 2.5, 2.6.1 – 2.6.2, 4.3.2, 20.2
10	**Lab 2a: Direct3D / DirectX Intro**	**§ 2.7, Direct3D handout**
11	Surface Detail 2: OGLSL; Many Mappings	§ 2.6.3, 20.3 – 20.4, *Primer*
12	Surface Detail 3: Advanced Texture Mapping	§ 20.5 – 20.13
13	**Surface Detail 4: Pixel/Vertex Shad.; Lab 2b**	**§ 3.1**
14	Surface Detail 5: Writing Shaders; RenderMan	§ 3.2 – 3.4, Direct3D handout
15	Demos 1: CGA; Scene Graphs: Traversal	§ 4.4 – 4.7, **CGA handout**
16	**Lab 3a: Alpha in Flash *vs.* GL, Direct3D**	**§ 2.6, 20.1, *Primer***
17	**Animation 1: Keyframes, Interpolation**	**§ 5.1 – 5.2, OGLSL handout**
	Exam 1 review; Hour Exam 1 (evening)	**Chapters 1 – 4, 16, 20**
18	**Scene Graphs: Rendering; Lab 3b: OGLSL**	§ 11.1, **mesh handout**
19	**Demos 2: SFX; Inverse Kinematics**	**§ 5.3 – 5.5,CGA handout**
20	Demos 3: Bézier, NURBS; CSG, Solid Models	§ 10.4, 11.3, 11.8, 12.2, 12.7

Lightly-shaded entries denote the due date of a written problem set; heavily-shaded entries, that of a machine problem (programming assignment); blue-shaded entries, that of a paper review; and the green-shaded entry, that of the term project.

Green, **blue** and **red** letters denote **exam review**, **exam**, and **exam solution review** dates.

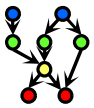


Advanced CG Syllabus, Part 2 of 2

21	**Lab 4a: Animation Basics; Maya Modeling**	**Flash animation handout**
22	Animation 2: Euler Angles *vs.* Quaternions	Chapter 17, esp. §17.1 – 17.2
23	Demos 4: Modeling & Simulation; Smoothness	Chapter 10[1], 13[2], §17.3 – 17.5
24	**Collisions 1: capsules/lozenges, Lab 4b**	**§2.4.3, 8.1, GL handout**
25	Spatial Sorting: BSP and Portals	Chapter 6, esp. §6.1
26	**Demos 5: More CGA; Picking Modes**	**Chapter 7[2]; § 8.4**
27	**Lab 5a: Picking in OpenGL, Flash**	**§ 8.3 – 8.4; 4.2, 5.0, 5.6, 9.1**
28	Collisions 2: Dynamic, Particle Systems	§ 9.1, particle system handout
	Exam 2 review; Hour Exam 2 (evening)	**Chapters 5 – 6, 7[2] – 8, 12, 17**
29	**Lab 5b: Advanced Particle Systems**	**Particle system handout**
30	**Animation 3: Control & IK, PBM**	**§ 5.3, CGA handout**
31	Ray Tracing 1: intersections, recursion, trees	Chapter 14
32	Lab 6a: Ray Tracing w/POV-Ray	RT handout
33	Ray Tracing 2: refraction, supersampling	Chapter 15, **RT handout**
34	Visualization 1: Graphical Integrity, Data-Ink	Tufte handout (1)
35	**Lab 6b: More Ray Tracing**	**RT handout**
36	Visualization 2: Small Multiples, Macro/Micro	Tufte handout (2 & 4)
37	Fractals & fBm; Term Project Prep	**Color handout**
38	Lab 7: Fractals & Terrain Generation	**Fractals/Terrain handout**
39	**Visualization 3: Confections, HCI; Review 1**	Tufte handout (3)
40	**Term project presentations 1; Review 2**	–
41	Term project presentations 2	–
	Final Exam	**Ch. 1 – 8, 10 – 15, 17, 20**

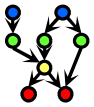
Lightly-shaded entries denote the due date of a written problem set; heavily-shaded entries, that of a machine problem (programming assignment); blue-shaded entries, that of a paper review; and the green-shaded entry, that of the term project.

Green, **blue** and **red** letters denote **exam review**, **exam**, and **exam solution review** dates.



Online Recorded Lectures for CIS 736 (Computer Graphics)

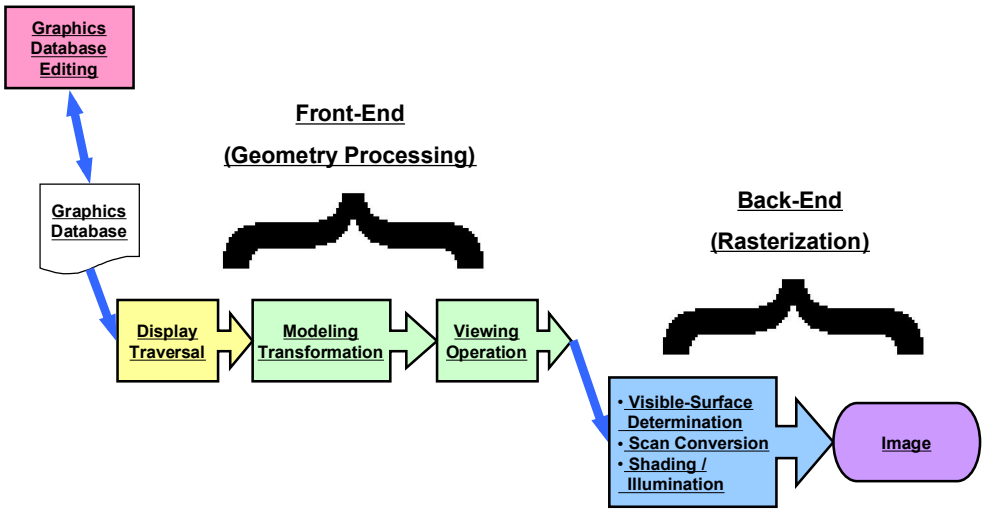
- Project Topics for CIS 736
- Advanced Topics in Computer Graphics (10)
  - 1. Filters for Texturing – Week 2
  - 2. Level-of-Detail Algorithms and Terrain – Week 3
  - 3. More Mappings – Week 6
  - 4. More on Animation – Week 8
  - 5. Character Modeling and IK – Week 9
  - 6. Global Illumination: Photon Maps (Radiosity) – Week 10
  - 7. Advanced Lighting Models – Week 11
  - 8. Advanced Ray-Tracing – Week 12
  - 9. More on Scientific, Data, Info Visualization – Week 13
  - 10. Fractals and L-Systems – Week 14
- Recommended Background Reading for CIS 736
- Shared Lectures with CIS 536/636 (*Introduction to Computer Graphics*)
  - Regular in-class lectures (30) and labs (7)
  - Guidelines for paper reviews – Week 6
  - Preparing term project presentations, CG demos – Weeks 11-12



Why Computer Graphics?

- Developing Computational Capability
  - Rendering: synthesizing realistic-looking, useful, or interesting images
  - Animation: creating visual impression of motion
  - Image processing: analyzing, transforming, displaying images efficiently
- Better Understanding of Data, Objects, Processes through Visualization
  - Visual summarization, description, manipulation
  - Virtual environments (VR), visual monitoring, interactivity
  - Human-computer intelligent interaction (HCII): training, tutoring, analysis, control systems
- Time is Right
  - Recent progress in algorithms and theory
  - Rapidly emergence of new I/O (display and data acquisition) technologies
  - Available computational power, improving price-performance-ratio of hardware
  - Growth and interest of graphics industries (*e.g.*, games, entertainment, computer-aided design, visualization in science and business)

Rendering (Image Synthesis) Pipeline



"Polygons-to-Pixels" Pipeline

User Interfaces & Hypermedia

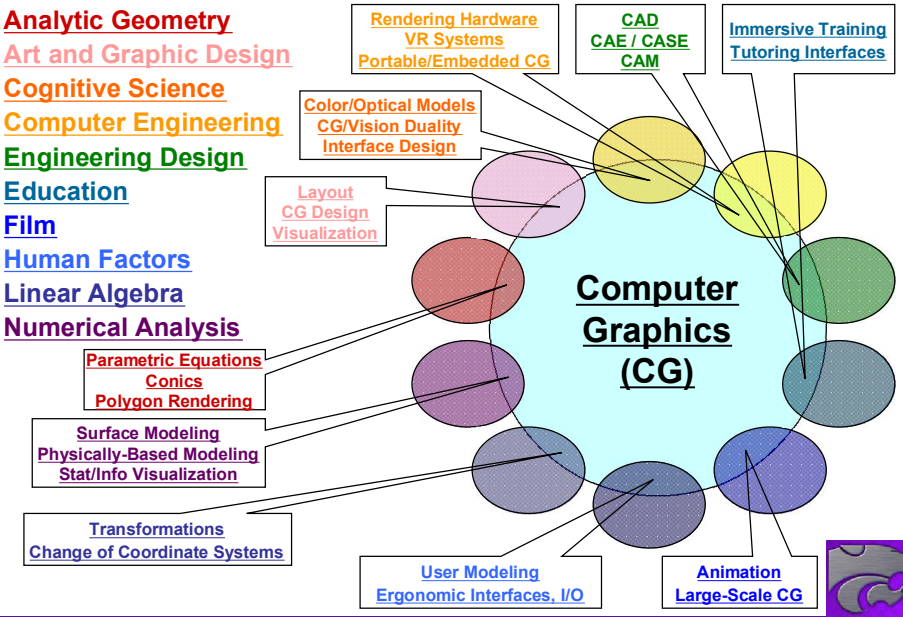
D2K © 1999-2004 National Center for Supercomputing Applications
http://alg.ncsa.uiuc.edu/do/tools/d2k

NCSA SEASR/MEANDRE (2008 – present): http://seasr.org
Visual programming systems for high-performance knowledge discovery in databases (KDD), cloud computing, and more

- Hypermedia & Web 2.0
  - Web 2.0: SLATES (search, links, authoring, tags, extensions, signals)
  - *Database format (similar to hypertext): internetworked multimedia*
  - Display-based access to text, image, audio, video, *etc.*
- Virtual Environments
  - Immersion: interactive training, tutoring systems
  - Entertainment hypermedia
- Graphical User Interfaces (GUIs)
  - Visualization: scientific, data/information, statistics
  - GUIs: Computer-Aided Design/Engineering (CAD/CAE/CAM/CASE), *etc.*

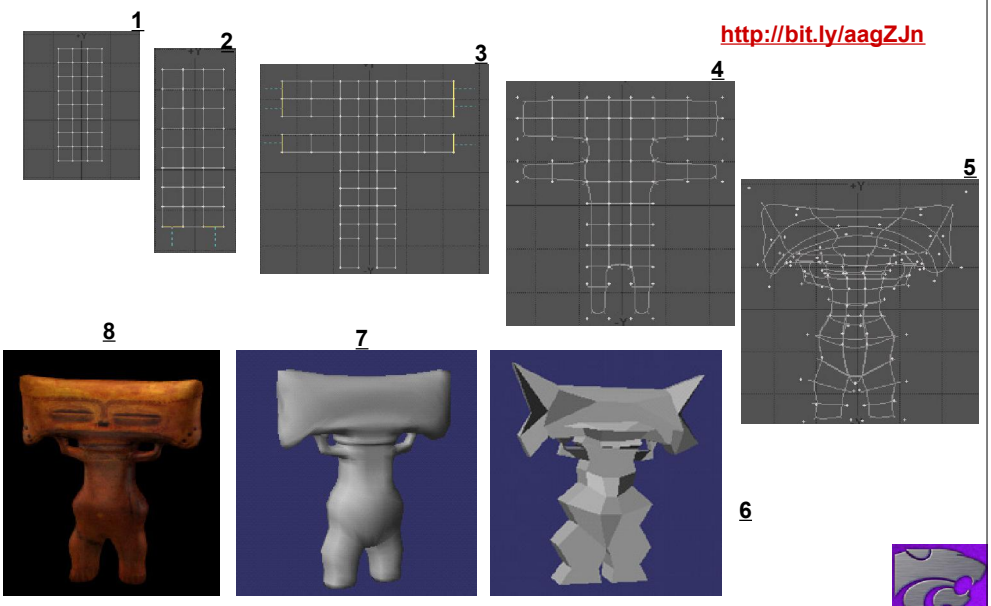
Relevant Topic Areas

- Analytic Geometry
- Art and Graphic Design
- Cognitive Science
- Computer Engineering
- Engineering Design
- Education
- Film
- Human Factors
- Linear Algebra
- Numerical Analysis

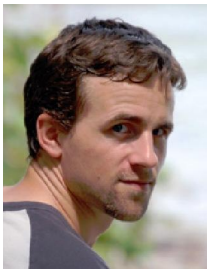


Shading Pipeline & Surface Modeling (Boundary Representations)

http://bit.ly/aagZJn



Special Topics: Multitexturing & Mappings



Stefan Jeschke
Research Assistant
http://bit.ly/hUUM94

Eduard Gröller
Associate Professor
Director, Visualization Working Group
http://bit.ly/hUUM94

Institute of Computer Graphics and Algorithms
Technical University of Vienna

TECHNISCHE UNIVERSITÄT WIEN
Institut für Computergraphik und Algorithmen
Arbeitsbereich Computergraphik

Texturing material from slides © 2002 E. Gröller & S. Jeschke, Vienna University of Technology
http://bit.ly/dJFYq9

Mapping material from slides © 1995 – 2009 P. Hanrahan, Stanford University
http://bit.ly/hZfsjZ (CS 348B, Computer Graphics: Image Synthesis Techniques)

Computer-Generated Animation (CGA)

Monsters Inc. (2001)
Monsters Inc. 2 (2012)
© Disney/Pixar

Toy Story (1995)
Toy Story 2 (1999)
Toy Story 3 (2010)
© Disney/Pixar

Tron: Legacy
© 2010
Walt Disney Pictures

Kung-Fu Panda
© 2008 DreamWorks Animation SKG

Happy Feet
© 2006
Warner Brothers

Shrek (2001)
Shrek 2 (2004)
Shrek the Third (2007)
Shrek Forever After (2010)
© DreamWorks Animation SKG

Wall-E
© 2008 Disney/Pixar

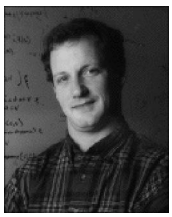
Luxo Jr.
© 1986 Pixar Animation Studios

Special Topics: Computer-Generated Animation (CGA)

Jason Lawrence
Assistant Professor
Department of Computer Science
University of Virginia
http://www.cs.virginia.edu/~jdl/

Computer Science at the University of Virginia

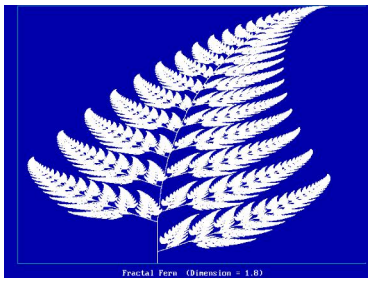
Acknowledgment: slides by Misha Kazhdan, Allison Klein, Tom Funkhouser, Adam Finkelstein and David Dobkin
http://bit.ly/eB1Oj4

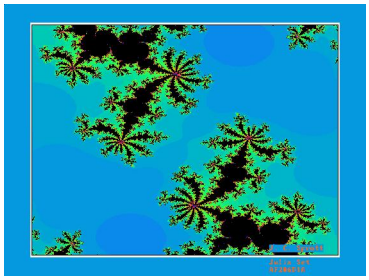


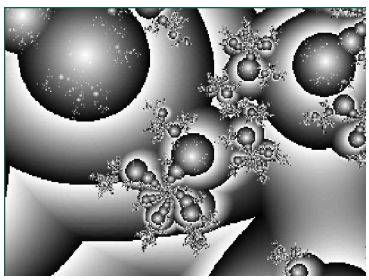
Thomas A. Funkhouser
Professor
Department of Computer Science
Computer Graphics Group
Princeton University
http://www.cs.princeton.edu/~funk/

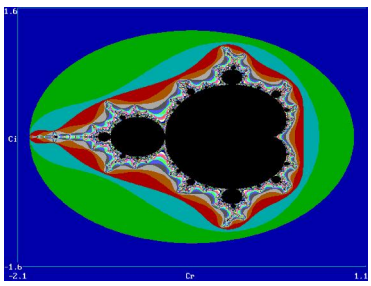
PRINCETON UNIVERSITY

Fractals : Iterated Function Systems (IFSs)



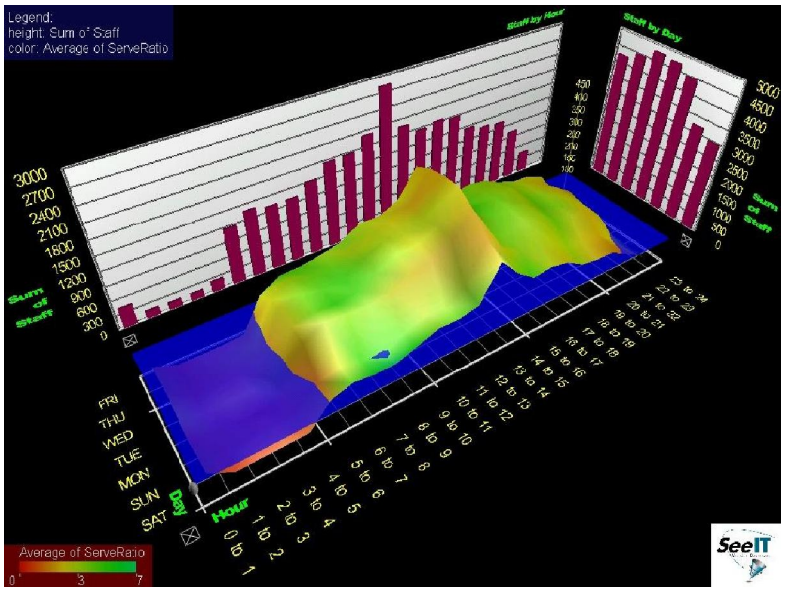






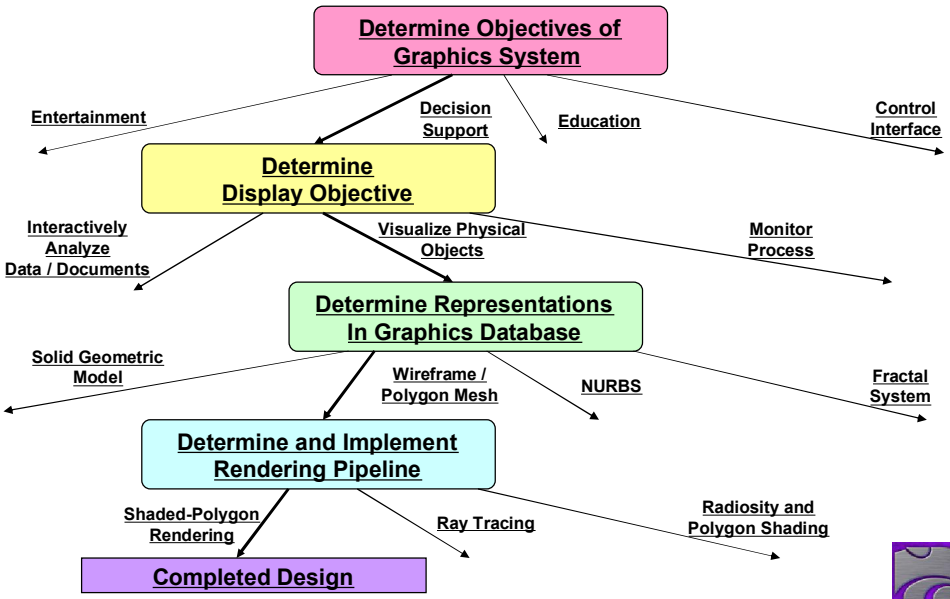
Fractal of the Day: http://sprott.physics.wisc.edu/fractals.htm

Information Visualization

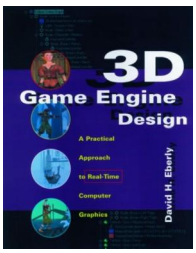


Visible Decisions *SeeIT* © 1999 VDI http://www.advizorsolutions.com

Design Choices & Issues In Computer Graphics

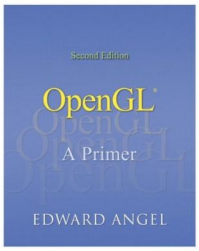


Textbook and Recommended References

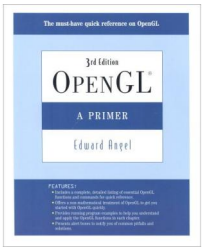


1st edition (outdated)

2nd edition



2nd edition (OK to use)



3rd edition

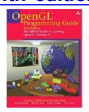
Required Textbook

Eberly, D. H. (2006). *3D Game Engine Design: A Practical Approach to Real-Time Computer Graphics, second edition.* San Francisco, CA: Morgan Kauffman.

Recommended References

Angel, E. O. (2007). *OpenGL: A Primer, third edition.* Reading, MA: Addison-Wesley. [2nd edition on reserve]

Shreiner, D., Woo, M., Neider, J., & Davis, T. (2009). *OpenGL® Programming Guide: The Official Guide to Learning OpenGL®, Versions 3.0 and 3.1, seventh edition.* ["The Red Book": use 7th ed. or later]



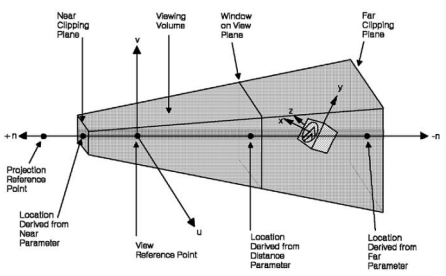
Next Class

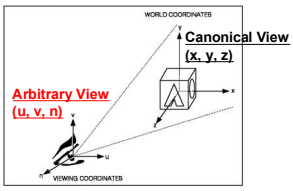
- **Photorealism**

http://realismstudio.com

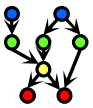
© 2001 Square Enix Studios http://bit.ly/9YzCZy

- **3-D Camera Model**



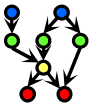


The GraPHIGS Programming Interface: Understanding Concepts
© 2007 IBM
http://bit.ly/cS4h7g



Summary

- This course is a lot of work
  - Reading: Eberly *2e* – big book, like Foley *et al.*
  - Programming assignments (4): expect to spend 10+ hours on each
  - Written assignments (4): about 6-10 hours
  - Term project: at least 30 hours (people have spent up to 60 or more)
- … but it can also be fun
  - Visible results
  - Nifty algorithms, high-performance hardware
  - "Putting it all together": very interdisciplinary field
  - Decent job market for people with right development skills, ideas
  - Applicable to many other areas of CS and IT
- Emphasis
  - "Polygons to pixels pipeline": viewing, VSD, lighting, shading, texturing
  - Other topics to be covered: animation, curves and surfaces, collisions
  - Brief survey of: ray tracing, visualization and color, fractals
- Tutorials (GameDev *aka* Nehe): http://nehe.gamedev.net



Terminology

- Computer Graphics: Digital Synthesis, Manipulation of Visual Content
- Graphics Problems (see "Computer Graphics", Wikipedia)
  - Geometry: representation and processing of surfaces
  - Animation: representation and manipulation of motion
  - Rendering: computationally reproducing appearance of light in scenes
  - Imaging: image acquisition, editing, processing
- Different Approaches to Graphics
  - Raster (bitmaps, picture elements *aka* pixels) *vs.* vector (lines)
  - Sample-based (cf. *Photoshop*) *vs.* geometry-based (cf. *OpenGL*, *Direct3D*)
- Purpose of Graphics
  - Entertainment – games, visual effects in movies and television
  - Communications – advertising, journalism
  - Modeling / simulation – displaying objects, events *via* graphical user interfaces (GUIs)
  - Visualization – displaying events for analysis and understanding
- Dual Problem: Inverse Input and Output
  - Graphics (rendering): geometry to sample (image)
  - Vision: sample to geometry