CSCI 4229/5229
Computer Graphics
Fall 2007

Instructor

- Willem A (Vlakkies) Schreüder
- Email: willem@prinmath.com
  - Begin subject with 4229 or 5229
  - Resend email not answered promptly
- Office Hours:
  - Before and after Class
  - By appointment
- Weekday Contact Hours: 6:30am - 9:00pm

Course Objectives

- Class: Theory and principles
  - Attendance is encouraged
- Assignments: Practical OpenGL
  - Applications
- No tests or exams
- By the end of the course you will:
  - Be conversant in computer graphics principles
  - Be well versed in the use of OpenGL
  - Understand what OpenGL does internally

Course Outline

- Basics (1/3)
  - Projections, transformations, clipping, rendering, text, color, hidden edge and surface removal, and interaction
- Advanced (1/3)
  - Illumination, shading, transparency, texture mapping, parametric surfaces, shaders
- Project (1/3)
  - Whatever you're interested in: games, modeling, visualization, 'Google Earth', ...

Why OpenGL?

- Modern, widely used and actively supported
  - Games
  - 3D visualization
- Cross platform
  - Windows
  - Mac
  - *NIX
- Open source and vendor implementations
  - MESA 3D (source code available)
- Many language bindings

Assumptions

- You need to be fluent in C
  - Examples are in C
  - You can do assignments in any language
    - I may need help getting it to work on my system
- You need to be comfortable with linear algebra
  - Matrix and Vector multiplication
  - Dot and cross products
  - Rotation matrices

Grading

- Satisfactory complete all assignments => A
  - The goal is to impress your friends
- Assignments must be submitted on time unless prior arrangements are made
  - Due Thursday evening 11:59 pm
  - Grace period until Friday morning at 06:30am
- Assignments must be completed individually
  - Stealing ideas are permitted
  - OpenGL code fragments from the web may be used

Text

- OpenGL: A Primer, 3/E
  - Edward Angel
  - An excellent and very accessible introduction to OpenGL –and inex pensive
  - Third edition adds new material including shaders
  - Recommended but not required
- Computer Graphics: Principles & Practice (2ed)
  - Foley, van Dam, Feiner & Huges
  - Avoid 1ed (Pascal), 2ed also a bit dated
  - Get it if you want to know more of the theory

Other Texts

- OpenGL Programming Guide (5ed)
  - Shreiner, Woo, Neider & Davis
  - “OpenGL Red Book”
  - Download previous editions as PDF
- OpenGL SuperBible: Comprehensive Tutorial and Reference (4ed)
  - Wright, Lipchak & Haemel
  - Good all-round theory and applications

And More Texts

- OpenGL Shading Language (2ed)
  - Randi J. Rost
  - “OpenGL Orange Book”
  - Introduces both OpenGL and Shaders
- OpenGL Reference Manual (4ed)
  - OpenGL Architecture Review Board & Dave Shreiner
  - “OpenGL Blue Book”
  - Official Reference Document to OpenGL, Version 1.4
  - A bit dated, very similar to man pages

OpenGL Resources

- www.google.com
  - Need I say more?
- www.opengl.org
  - Code and tutorials
- nehe.gamedev.net
  - Excellent tutorials
- www.mesa3d.org
  - Code of “internals”

Assignment 0

- Due: **Wednesday** Sep 5, 2007
- Sign up with moodle.cs.colorado.edu
  - Enrollment key: 42295229
  - A picture will help me learn your names
- Submit
  - Your name and study area
  - Platform (Hardware, Graphics, OS, ...)
  - Background and interests in computer graphics
  - Project ideas (if you have one already)

My information

- Mathematical modeling and data analysis
  - PhD Computational Fluid Dynamics [1986]
  - PhD Parallel Systems (*CU Boulder*) [2005]
  - President of *Principia Mathematica*
- Use graphics for scientific visualization
- Open source bigot
- Program in C, C++, Fortran and Perl

Assignment 1

- Due: Thursday Sep 13, 2007
- Get OpenGL to work on your platform
  - Compile and run *gears.c*
  - Report frame rate for 1x1, 300x300 and full screen
  - Explain your results
- If you are on an X based (*NIX) platform:
  - Run glxinfo and check if *direct rendering: yes*
  - Look into enabling hardware support

Assignment 2

- Due: Sep 20, 2007
- Write an OpenGL based visualization of the Lorenz Attractor
  - At a minimum show a static line path in 3D
  - Add rotation using cursor keys
  - Use your imagination
- The purpose is scientific visualization
  - Do some science

http://mathworld.wolfram.com/LorenzAttractor.html

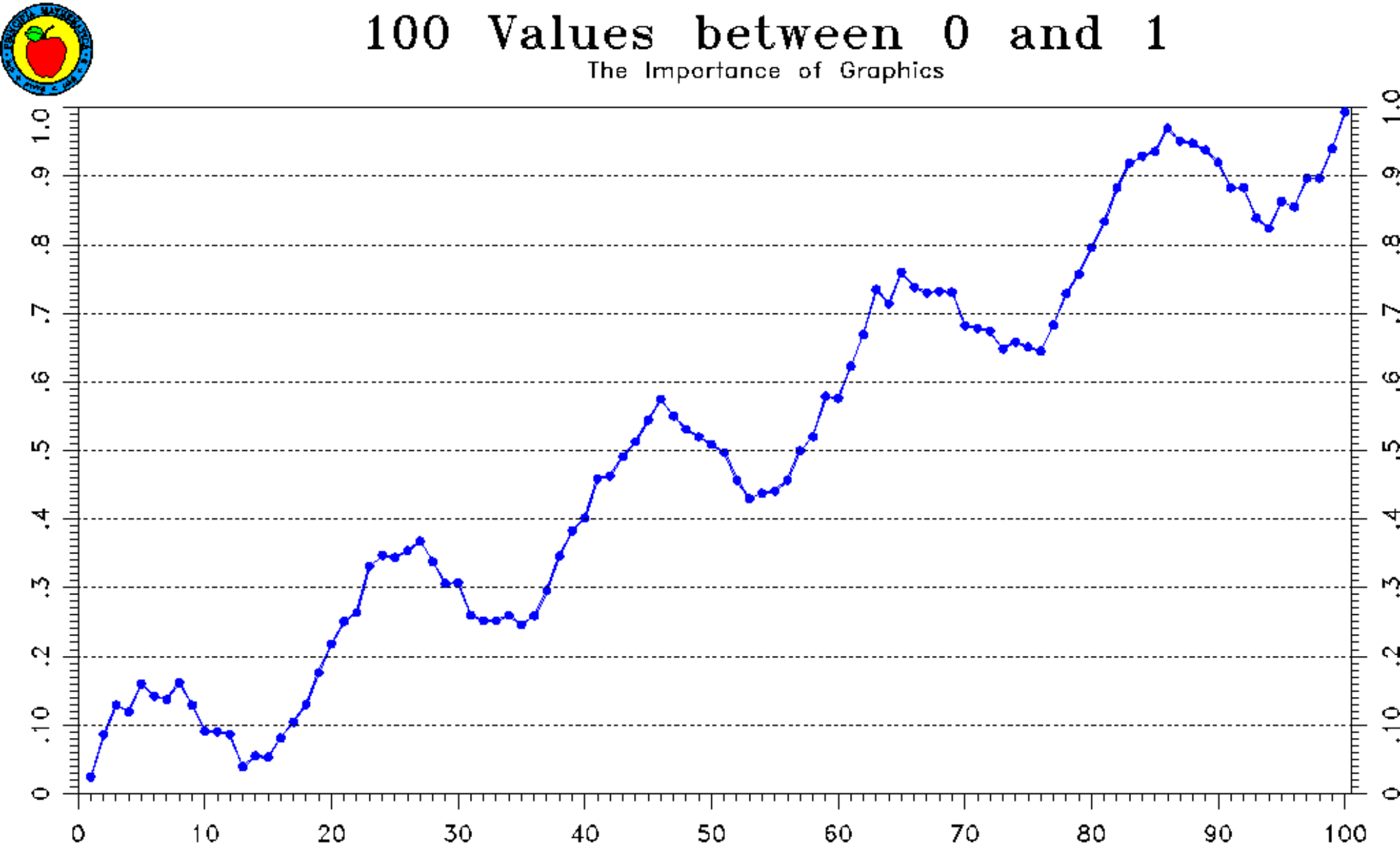
Nuts and Bolts

- Complete assignments on any platform
  - Assignments reviewed under Fedora Core
  - Set #ifdef so I can compile and run it
- Submit using moodle.cs.colorado.edu
  - ZIP or TAR
  - Name executables hw1, hw2, ...
  - Set makefile so I can do *make LINUX=1*
  - Set window title to *Assignment X: Your Name*
- Include number of hours spent on assignment

A few hints

- My machine runs Fedora Core x86_64
  - gcc/g++ with Mesa3D & GLX
    - -Wall is a really good idea
  - case sensitive file names
  - int=32bit, long=64bit
  - little-endian
  - fairly good performance
- How to make my life easier
  - Try it in CSEL or a Linux box
  - Stick to C/C++ unless you have a good reason

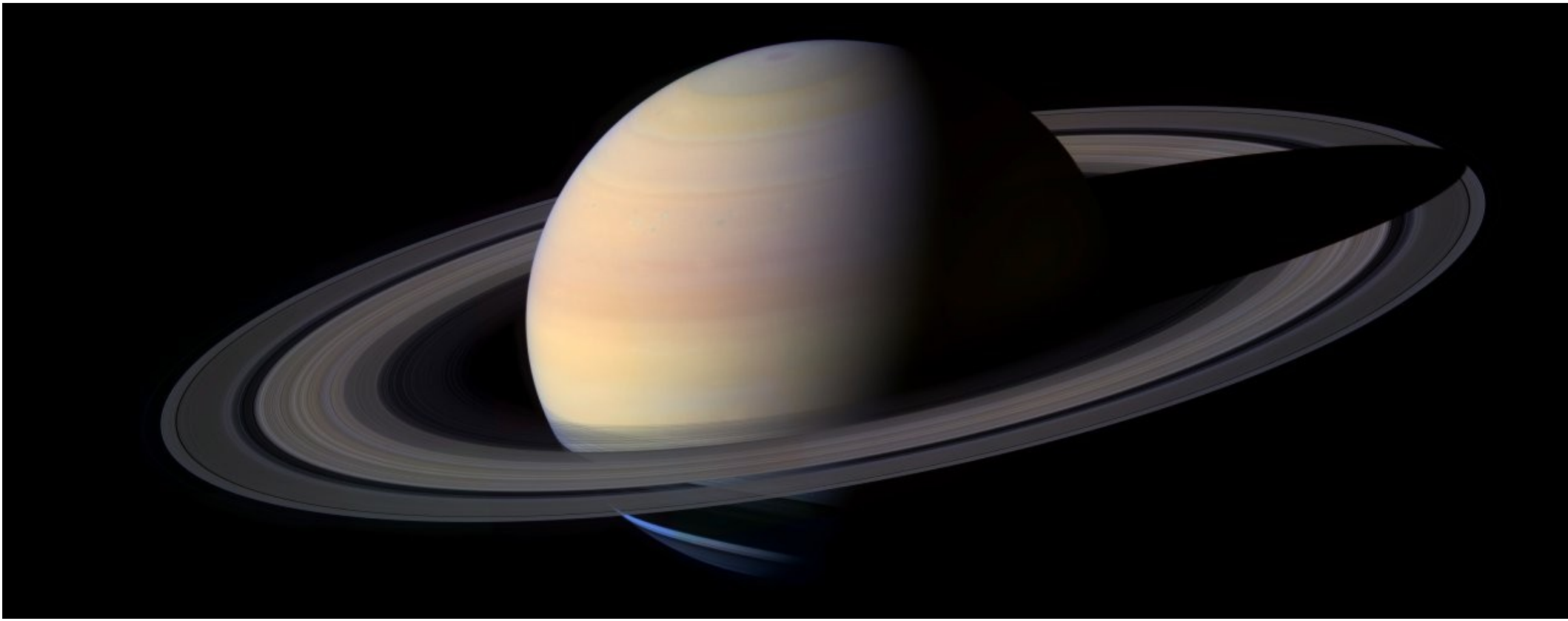
The Importance of Graphics: 100 Values between 0 and 1


100 Values between 0 and 1
The Importance of Graphics
0
.10
.2
.3
.4
.5
.6
.7
.8
.9
1.0
0
10
20
30
40
50
60
70
80
90
100

Graphic Design

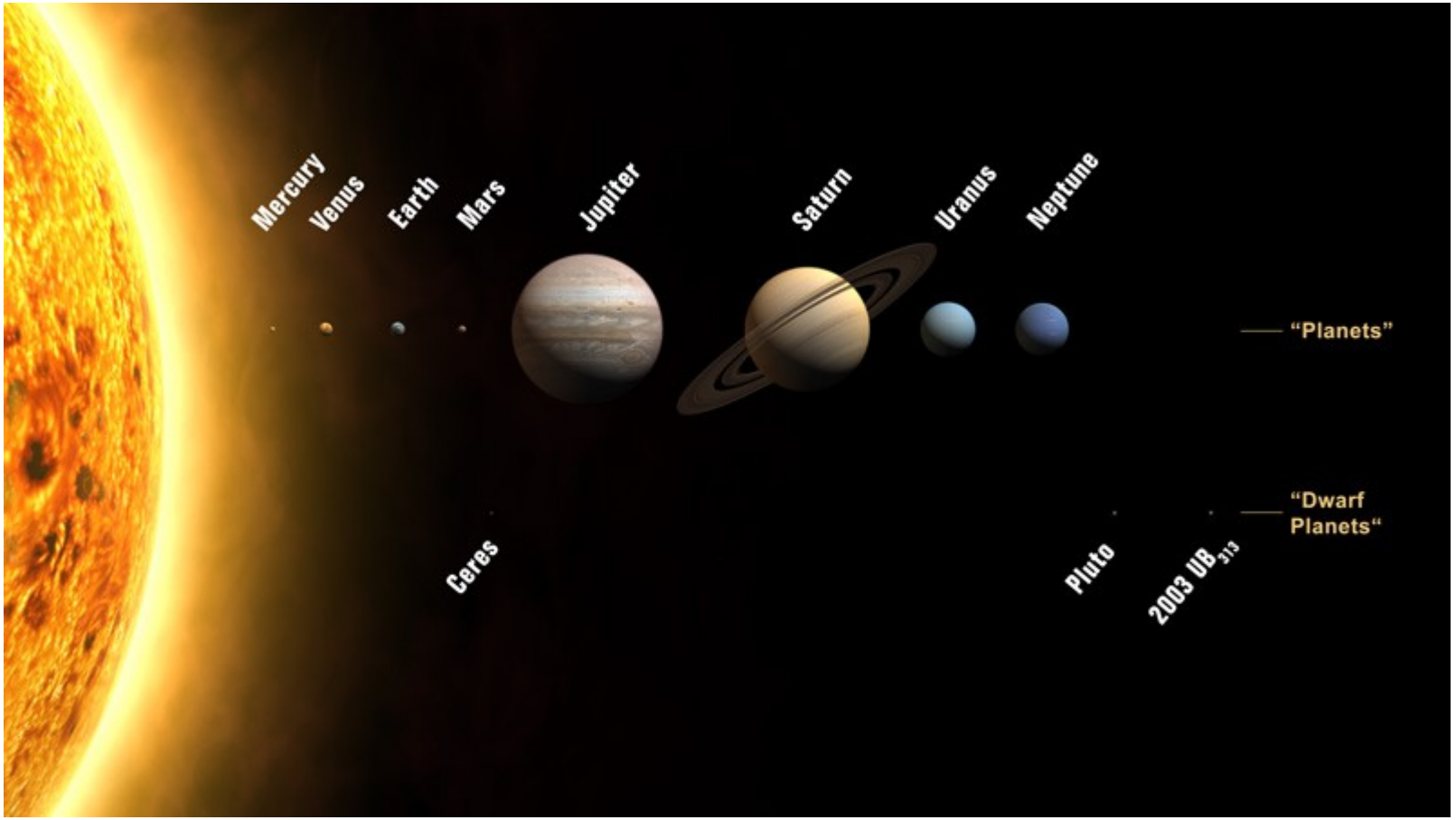
- 2D vs. 3D
  - Cool vs. informative
- Edward R. Tufte
  - Visual Explanations
  - Envisioning Information
  - The Visual Display of Quantitative Information
  - Beautiful Evidence

Saturn from Cassini Probe



Colorado Fall Colors

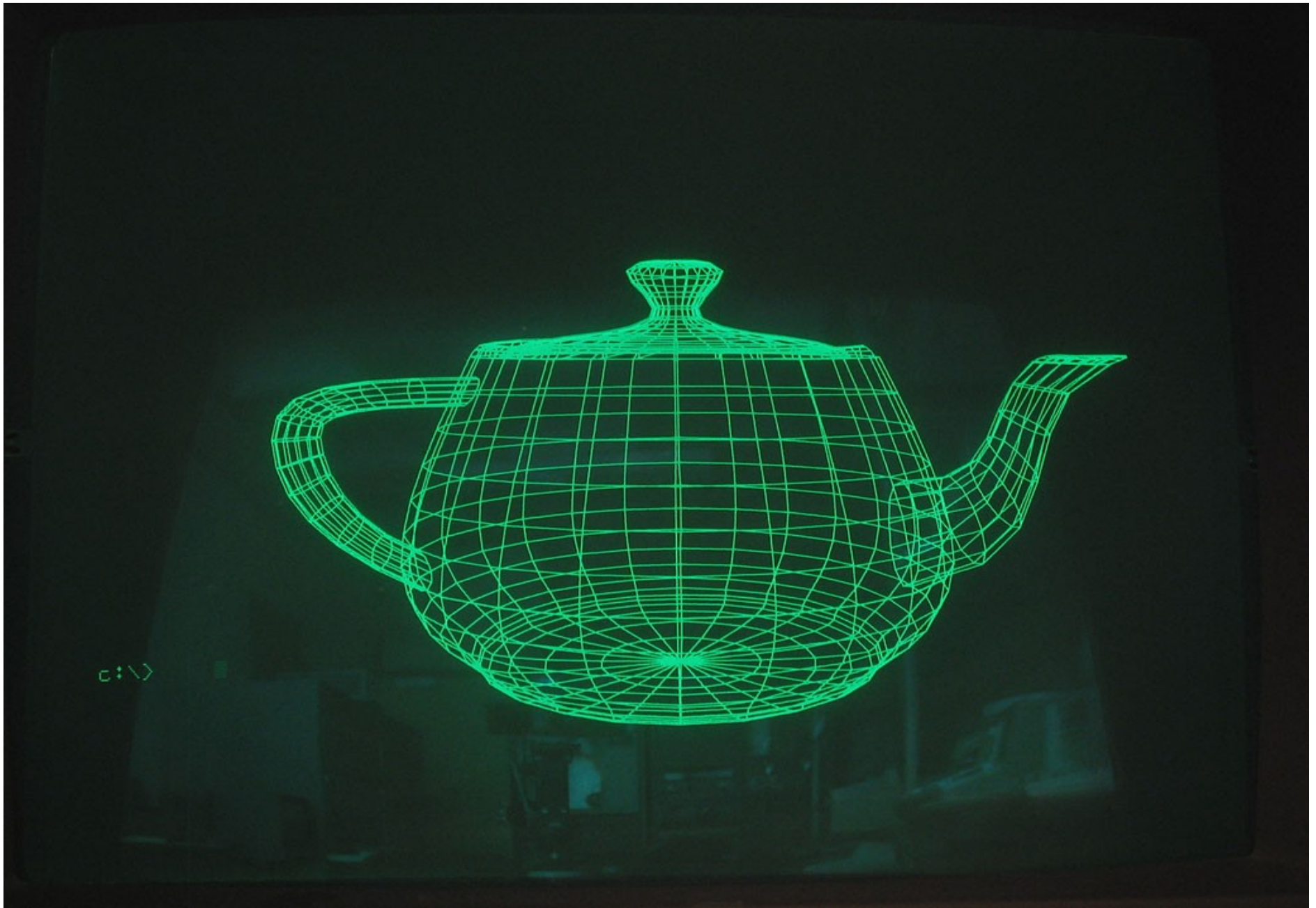
What is wrong with this picture?



In the beginning....

Storage Tube Terminals

Storage Display Images

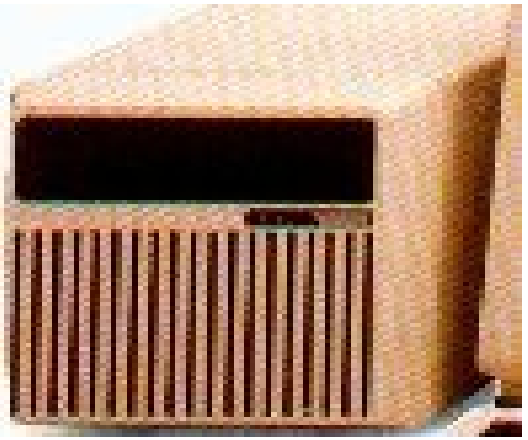


Color: Multiple Pen Plotters

Raster Graphic Terminals

Color Inkjets

Workstations: Apollo DN 330
12 MHz 68020, 3MB RAM, 70MB disk



Plotting Packages

- PLOT-10: Tektronix 4010 graphics
- PLOT88: PC graphics
- DISSPLA: NCAR graphics
- GINO: Portable graphics
- DIGLIB: LLNL device-independent, open source
- GKS: Graphics Kernel System (2D vector)
- PHIGS: 3D Interactive Graphics

The rise of OpenGL

- Originated as SGI IrisGL
- Vendor-neutral OpenGL controlled by ARB
- Hides the details of hardware
  - Software emulation when necessary
  - Hardware acceleration when possible
- Supports 2D to advanced 3D graphics
- Portable to most hardware and OS with WGL, AGL and GLX

Gaming and Graphics

- Text based/ASCII graphics (Pong, PacMan)
- 2D monochrome line graphics (Astroids)
- 2D images & sprites (Mario)
- 3D graphics
  - Flight Simulators (2D -> 3D)
  - First Person Shooters
  - Multi-player games
- Games push the envelope
  - Realism
  - Speed