

# **Fundamentals and Overview of Computer Graphics**

**ORGANIZED BY**  
Olin Lathrop

## **Speakers**

**Dr. Norman I. Badler**  
Computer and Information Science Department  
University of Pennsylvania  
Philadelphia, Pennsylvania 19104-6389

**Richard M. Fichera**  
Marketing & Planning for Technology Companies  
39 Laurel Lane  
Groton, Ma. 01450

**Olin Lathrop**  
Apollo Computer, Inc.  
330 Billerica Road  
Chelmsford, Mass. 01824

**Carl Machover**  
President, Machover Associates  
199 Main Street  
White Plains, New York 10601

**Course #1**

# Table of contents

## Section I - Course overview

Table of Contents .....	I-2
Course Description .....	I-8

## Section II - Fundamentals

History .....	II-2
Basic Display Technologies .....	II-4
Storage Tube .....	II-5
Vector Refresh .....	II-6
Raster Scan .....	II-7
Some Basic Concepts .....	II-8
The Pixel .....	II-8
Colors .....	II-8
LUT (look up table) .....	II-9
True Color / Pseudo Color .....	II-10
2D and 3D Coordinate Spaces .....	II-11
2D Drawing Fundamentals .....	II-12
Drawing Primitives .....	II-12
Transformations .....	II-13
Who Uses Graphics and Where - The Current Market .....	II-15
The Market - Not Simple to Define .....	II-15
A Sample Market Segmentation .....	II-15

## Section III - Modeling

3D Object Modeling .....	III-2
Computer Animation Techniques .....	III-10
Outline of Talk .....	III-16
Reprint of <i>Three-Dimensional Representations for Computer Graphics and Computer Vision</i> .....	III-23

Glossary on Modeling and Rendering .....	III-31
--	--------

## Section IV - Rendering

What is Rendering .....	IV-2
Viewing Geometry .....	IV-2
Flat Projection .....	IV-2
Perspective Projection .....	IV-2
Common Methods of Rendering .....	IV-3
Wire Frame .....	IV-3
Depth Buffer (or Z Buffer) .....	IV-7
Ray Tracing .....	IV-9
Color Determination .....	IV-13
Direct Evaluation (The Phong Model) .....	IV-13
Color Interpolation .....	IV-18
Flat Shading .....	IV-18
Bi-Linear (Gouraud) Shading .....	IV-19
Phong Shading .....	IV-19
Mach Bands .....	IV-21
Compositing .....	IV-21
Overlay Where Not Zero .....	IV-22
Alpha Buffer .....	IV-22
Chroma-keying .....	IV-22
Aliasing .....	IV-23
Very Brief Theoretical Background .....	IV-23
How to Keep the Jaggies out of Your Image .....	IV-24
Temporal Anti-Aliasing .....	IV-24
Dithering .....	IV-25
Data Requirements for an Image .....	IV-26
Run Length Encoding .....	IV-27

## Section V - User Issues

Supplier List:	
Computer Aided Design and Drafting Systems .....	V-2
Supplier List:	
Interactive Graphics Displays .....	V-15

Supplier List:	
Computer Graphics I/O Devices .....	V-26
Supplier List:	
Software .....	V-42
<i>A Brief, Personal History of Computer Graphics</i> .....	V-51
Computer Graphics Market Forecast for U.S. Manufacturers ..	V-59
Supplier List:	
Slide Making Systems .....	V-62
Hard Copy Comparison Chart .....	V-66
CAD/CAM Systems Growth Forecast .....	V-67
Color Considerations .....	V-68
Business Graphics Market Study Questionnaire Summary .....	V-69
Cost Recovery Model .....	V-74
CAD/CAM System Typical Block Diagram .....	V-81
<i>Basics of Slide Making</i> .....	V-82
How is CAD/CAM justified? .....	V-85
How is Business Graphics justified? .....	V-86
Graphics Software Evaluation Checklist .....	V-88
<i>Choosing the Right Chart</i> .....	V-105
Supplier List:	
Digital Paint Systems .....	V-122
<i>Computer Graphics for Management Decision Making and Productivity Enhancements</i> .....	V-128
<i>Unlimited Potential: Business Graphics</i> .....	V-140
<i>Engineering Workstations, an Overview</i> .....	V-145
Potential Sites, Slide Making and Digital Paint Systems .....	V-158
Computer Graphics Software Model .....	V-159
Supplier List:	
Workstations .....	V-160
<i>Twenty-Five Years of Computer Graphics, an Interview with Carl Machover</i> .....	V-166
Supplier List:	
PC CAD/CAM .....	V-173
Current CAD/CAM environment .....	V-181
<i>User Issues in Computer Graphics</i> .....	V-182
CAD/CAM/CIM Evolution .....	V-188
<i>Interactive Computer Graphics</i> .....	V-189
Technical Publishing Systems .....	V-207
Graphics Display Forecasted Installations .....	V-209

Carl Machover: An Interview .....	V-210
<i>Hardware Directions</i> .....	V-211
<i>CAD and Productivity</i> .....	V-217
How Graphics is Used in Business .....	V-226
Designing the Ideal Workstation .....	V-227
A User's View of Engineering Workstations — Putting a Workstation on Every Engineer's Desk .....	V-230
Selection Factors, PC-based Business Graphics Software .....	V-233
Graphics Design System Checklist .....	V-235
Supplier List:	
Graphics Art Systems .....	V-247
Potential Sites — Design Stations .....	V-249
Dumb/Smart/Intelligent Workstations .....	V-251
Centralized versus Distributed Computing Poser .....	V-252
Forecasted Application Share .....	V-253
How Networks are Built .....	V-254
<i>Computer Software for Graphics</i> .....	V-261
Supplier List:	
PC Based Business Graphics Software .....	V-273
CRT-Generated Display Evaluation Checklist .....	V-278
<i>PC Graphics: Perspective on a Revolution in Progress</i> An interview with Carl Machover .....	V-289
<i>Trends in Microcomputer CAD</i> .....	V-302
<i>CIM's Impact on Engineering</i> .....	V-314
<i>Drawing on the PC, an interview with Carl Machover</i> .....	V-322
Supplier List:	
CAB .....	V-327
Supplier List:	
CASE (Computer Aided Software Engineering) .....	V-336
Glossary of Representative Computer Graphics Terms .....	V-343

## Section VI — Watching Demos

## Section VII — Where to go for More Information

Reference Index .....	VII-2
-----------------------	-------

Bibliography (Norman Badler) ..... VII-29  
Bibliography (Carl Machover) ..... VII-34  
CAE/CAD/CAM/CIM Bibliography (Carl Machover) ..... VII-47

# Course Description

This course will start with a historical perspective of computer graphics and an introduction to the *fundamental* concepts. The current state of the industry and important trends will then be briefly discussed. The remaining 3/4 of the course is a survey of topics. Emphasis is on breadth of coverage, rather than on teaching the technical details. The guiding principle will be to give attendees an intuitive understanding of many concepts instead of the details of introductory issues.

Although this course will not supply the details, it will supply references to them. More will be done than just simply listing references at the end of the course notes. The course notes are intended to be useful as a reference source to determine where to look for an in-depth discussion of particular topics.

## Who Should Attend?

This course is for technical professionals and managers who are unfamiliar with computer graphics, and who have a need for a general understanding. It is also for those people that have heard terms like "pixel", "CSG", "Z buffer", and "trackball", and would like a more global context in which to make sense of them and understand how they fit together. This course is not for those who want to learn specifics like how a Bresenham vector algorithm works, or how to best code a 3D transform.

## Recommended Background

No background in computer graphics is required. It would be helpful to have some exposure to computers and programming. A sophisticated background in mathematics is not required.