

Lectures on **Computer Graphics**

by

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Duration: 43 Hours

COMPUTER GRAPHICS

Section – I

INTRODUCTION

Various fundamental concepts and principles in Computer Graphics are

Display Systems

Storage displays, Random scan, Raster refresh displays, CRT basics, video basics, Flat panel displays.

Transformations

Affine (2-D and 3-D): Rotation, Translation, Scale, Reflection and Shear.

Viewing: The Camera Transformations - perspective, orthographic, isometric and stereographic views, Quaternion.

Scan Conversion and Clipping

Drawing of Points, Lines, Markers, Curves, Circles, Ellipse, Polyline, Polygon. Area filling, fill-style, fill pattern, clipping algorithms, anti-aliasing etc.

Hidden Surface Removal

Back face culling, Painter's algorithm, scan-line algorithm, BSP-trees, Z-buffer/sorting, Ray tracing etc.

Shading & Illumination

Phong's shading model, texture mapping, bump mapping, Gouraud shading, Shadows and background, Color models etc.

Solid Modeling

Wire-frame, Octrees, Sweep, Boundary representations. Regularized Boolean set operations, Constructive Solid Geometry.

Curves and Surfaces

Bezier (Bernstein Polynomials) Curves, B-Splines, Cubic-Splines, Quadratic surfaces, parametric and non-parametric forms, Hermite Curves etc.

Miscellaneous

Animation, Fractals, Projection and Viewing, Geometry, Modeling, Image File formats, Image Morphing, Interaction (sample and event-driven) etc.

Advanced Raster Graphics Architecture

Display Processors, Pipeline and parallel architectures, multi-processor systems, hybrid architectures.

References

- 1. Computer Graphics; Principles and practice; 2nd edn. in C; J. Foley, A. Van Dam, Feiner and Hughes; Addison Wesley, 1997.**
- 2. Mathematical elements for Computer Graphics; 2nd edn.; D. F. Rogers and J. A. Adams; McGraw-Hill International. Edn., 1990.**
- 3. Computer Graphics - C version; D. Hearn and M. P. Baker; Pearson Education, 2004.**
- 4. Computer Graphics using OpenGL; 2nd edn.; F. S. Hill Jr.; Pearson Education, 2003.**
- 5. Procedural Elements for Computer Graphics; 2nd Edn., D. F. Rogers, Tata McGraw-Hill, 2002.**

Typical Distribution of marks for Evaluation/grading

Quiz (50 mins.) -	15 - 20
End Sem exam (120-150 mins.) -	35 - 40
TPA -	35 - 40
TUTS -	05 - 10
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Total	100

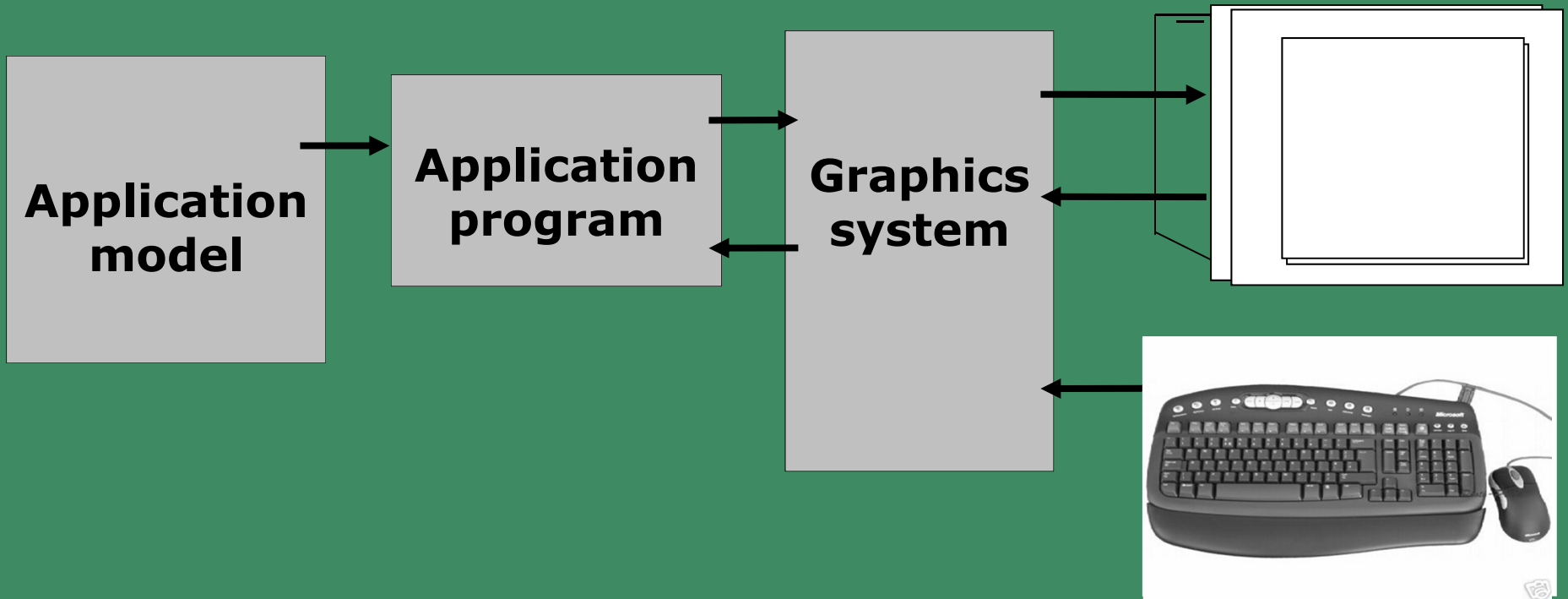
**+/- 05 marks variation at any part;
To be finalized well before end sem exam.**

Introduction to COMPUTER GRAPHICS

Computer Graphics involves display, manipulation and storage of pictures and experimental data for proper visualization using a computer.

Typical graphics system comprises of a host computer with support of fast processor, large memory, frame buffer and

- **Display devices** (color monitors),
- **Input devices** (mouse, keyboard, joystick, touch screen, trackball)
- **Output devices** (LCD panels, laser printers, color printers. Plotters etc.)
- **Interfacing devices** such as, video I/O, TV interface etc.



**Conceptual framework for
interactive graphics**

Typical applications areas are

- **GUI**
- **Plotting in business**
- **Office automation**
- **Desktop publishing**
- **Plotting in science and technology**
- **Web/business/commercial publishing and advertisements**
- ***CAD/CAM design (VLSI, Construction, Circuits)***
- ***Scientific Visualization***

- **Entertainment**
(movie, TV Advt., Games etc.)
- **Simulation studies**
- **Cartography**
- **Virtual reality**
- **Process Monitoring**
- **Digital Image Processing**
- **Education and Training**
- **Simulators**
- **Multimedia**

Various application packages and standards are available:

- **Core graphics**
- **GKS**
- **SRGP**
- **PHIGS, SPHIGS and PEX 3D**
- **OpenGL (with ActiveX and Direct3D)**
- **X11-based systems.**

On various platforms, such as

DOS,

Windows,

Linux,

OS/2,

SGI,

SunOS,

Solaris,

HP-UX,

Mac,

DEC-OSF.

Various utilities and tools available for web-based design include: **Java, XML, VRML and GIF animators.**

Certain compilers, such as, **Visual C/C++, Visual Basic, Borland C/C++, Borland Pascal, Turbo C, Turbo Pascal, Gnu C/C++, Java** provide their own graphical libraries, API, support and help for programming 2-D/3-D graphics.

Some these systems are

- device-independent (X11, OpenGL)
- device-dependent (Solaris, HP-AGP).

Four basic output primitives (or elements) for drawing pictures:

- **POLYLINE**
- **Filled POLYGONS (regions)**
- **ELLIPSE (ARC)**
- **TEXT**
- **Raster IMAGE**

Four major areas of Computer Graphics are:

- **Display of information,**
- **Design/Modeling,**
- **Simulation and**
- **User Interface.**

Computer Graphics systems could be active or passive.

In both cases, the input to the system is the scene description and output is a static or animated scene to be displayed.

In case of *active* systems, the user controls the display with the help of a GUI, using an input device.

Computer Graphics is now-a-days, a significant component of almost all systems and applications of computers in every field of life.

Some current areas of research in CG and VR

- **Wearable Computing**
- **Deformation modeling**
- **Simulating Nature**
- **Fluid simulation**
- **Collision modeling**
- **Motion Capture & Locomotion**
- **Haptics & Interaction**
- **Eyes, Nose, Mouth, & Body**
- **Texture & Gigapixel mapping**
- **Archeological Reconstruction**
- **STEM to STEAM initiatives**
- **Discrete Stochastic Microfacet models, Glints ;**
- **Performance Transfer and Character Articulation**
- **Aesthetically stimulating real-time live simulations**
- **Advanced MPM for phase-change and varied materials**
- **Visualization in HPC – Social networks, nature modeling**
- **Caustic Design; 3-D Hair styles; Tearing and Cracking;**
- **Games – Stunning visuals, game models, animation sequence**
- **Rendering**
- **Augmented Reality**
- **Visual Innovations**
- **Building Character**
- **Mobile reality**
- **Surface Reconstruction**
- **Interaction**
- **Video Techniques**
- **Hardware and Devices**
- **Immersive Reality**
- **Digital Art and Sound**
- **Collaborative Envmt.**
- **Inflatable Structures**
- **Fabrication**

Haptics

Haptics (pronounced HAP-tiks) is the science of applying touch (tactile) sensation and control to interaction with computer applications (the word derives from the Greek *haptain* meaning "to fasten.").

By using special input/output devices (joysticks, data gloves, or other devices), users can receive feedback from computer applications in the form of felt sensations in the hand or other parts of the body.

In combination with a visual display, haptics technology can be used to train people for tasks requiring hand-eye coordination, such as surgery and space ship maneuvers.

It can also be used for games in which you feel as well as see your interactions with images.

For example, you might play tennis with another computer user somewhere else in the world.

Both of you can see the moving ball and, using the haptic device, position and swing your tennis racket and feel the impact of the ball.

A number of universities are experimenting with haptics. The Immersion Corporation offers a joystick product that is used in laboratories and in arcade games. Haptics offers an additional dimension to a virtual reality or 3-D environment.

USER INTERACTION HANDLING

Sampling

vs.

Event Driven

- PICK CORRELATION
- DEVICE MEASURE AND ATTRIBUTES

Introduction

Display Devices - *self study*

2D Transformations – *self study*

3D Graphics and Viewing Transformations

Line Drawing ;

Ellipse & Circles ;

Polygon filling;

Clipping lines & Polygons

QUIZ – I () – March 2nd week (tentative)

Curves and Surfaces

Solid modeling

Visible Surface Determination

Illumination and Shading

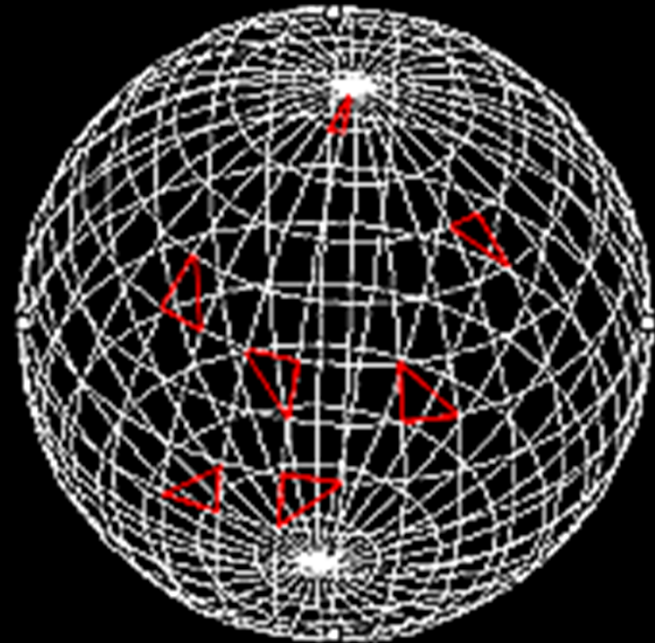
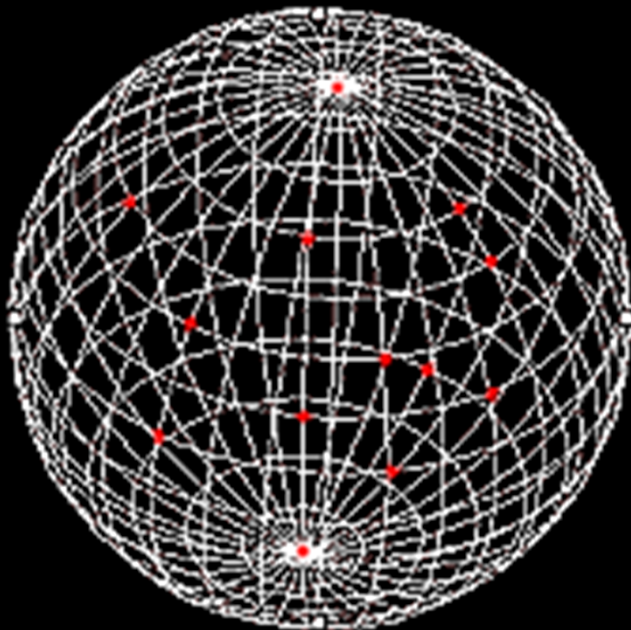
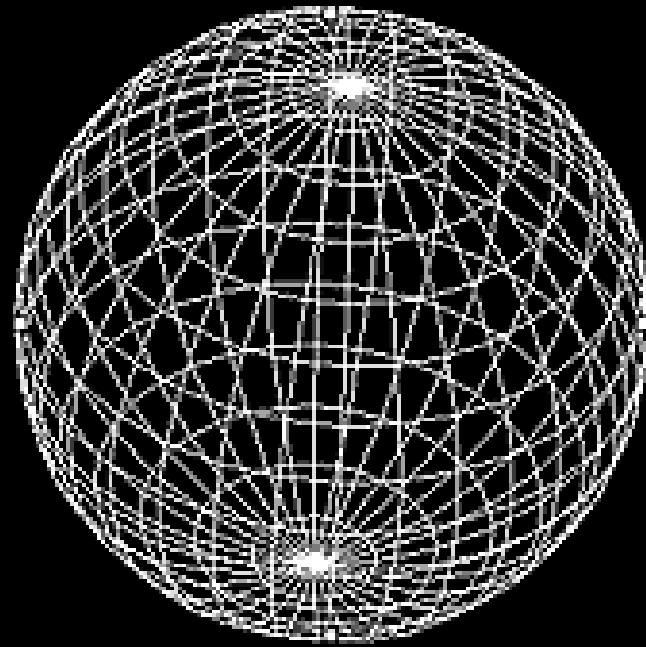
MISC & Adv. Topics

END-SEM (May 1st week)

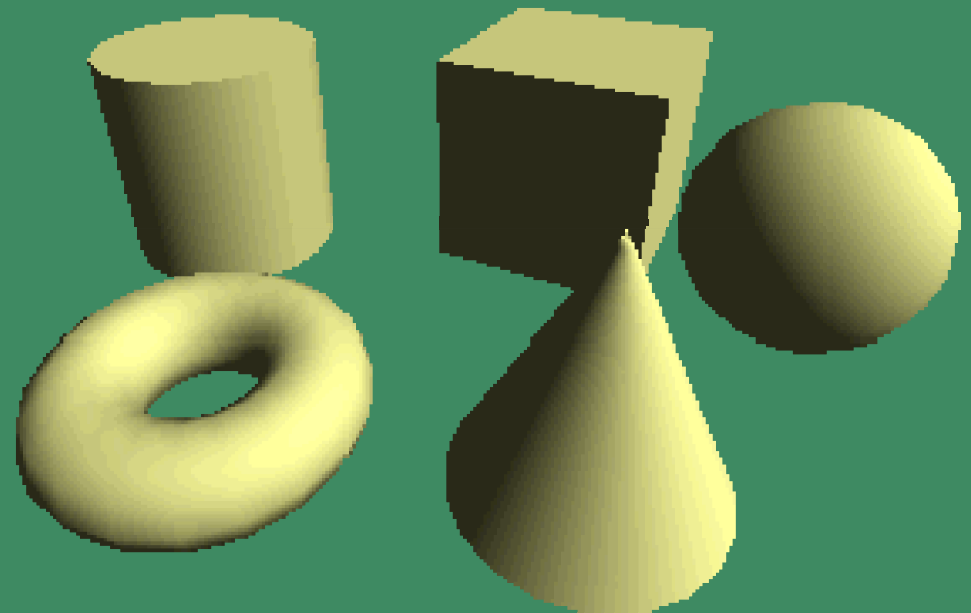
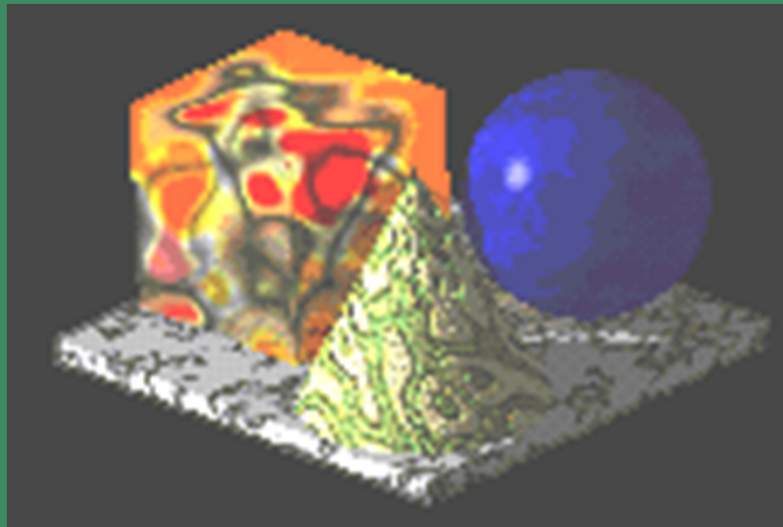
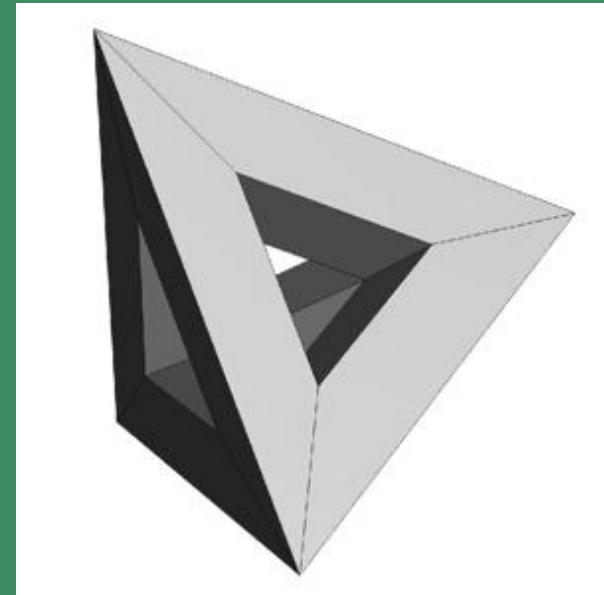
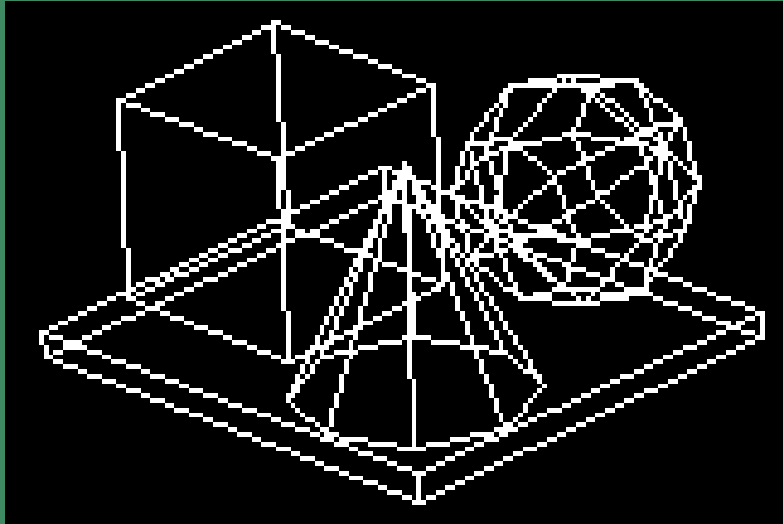


**Some examples and illustrations
of Graphical objects**

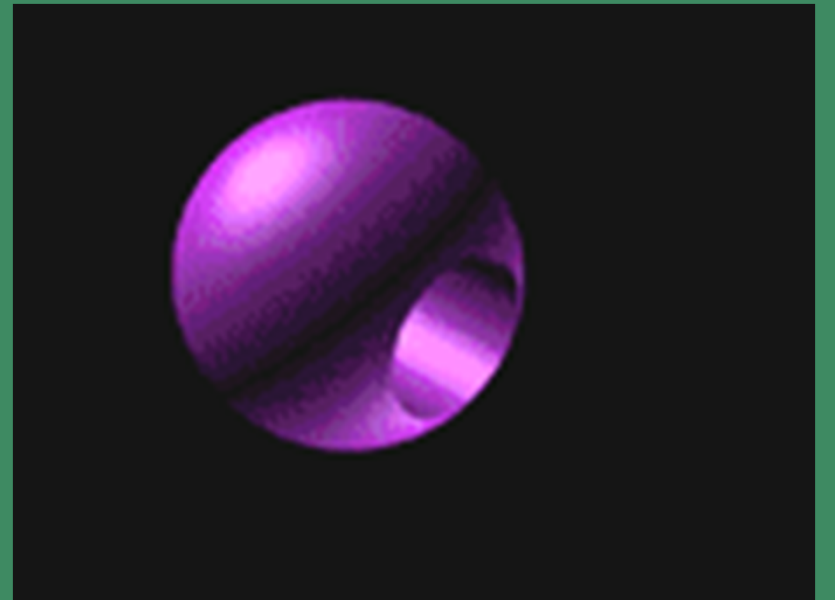
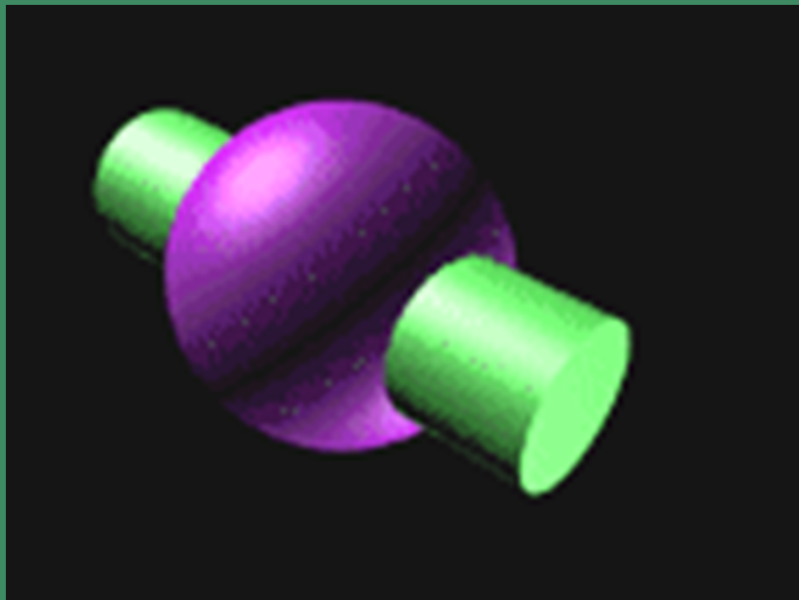
Wire-frame model
of a sphere, using
sweep representation



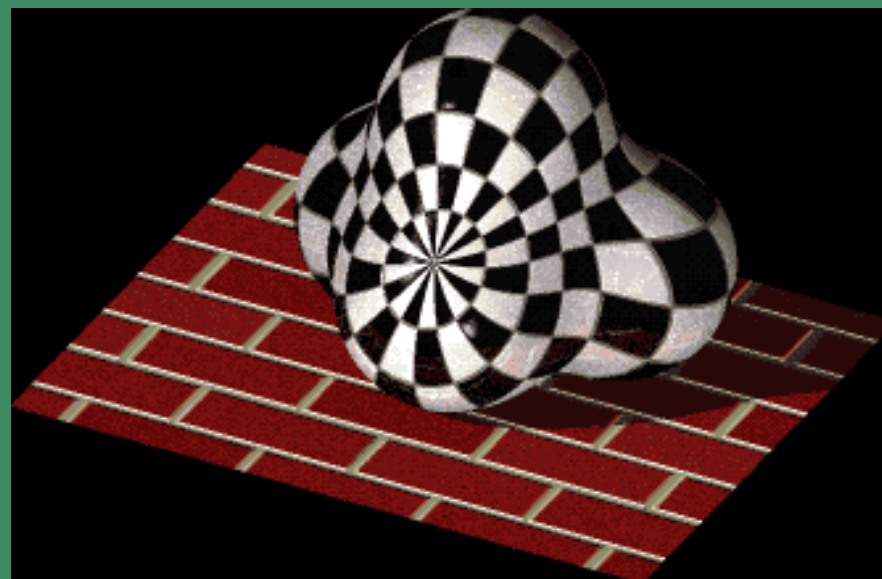
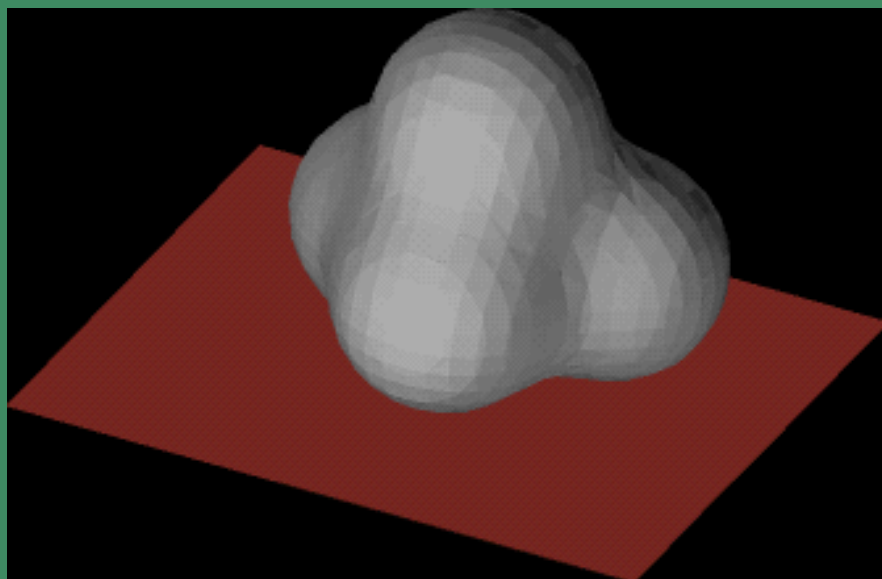
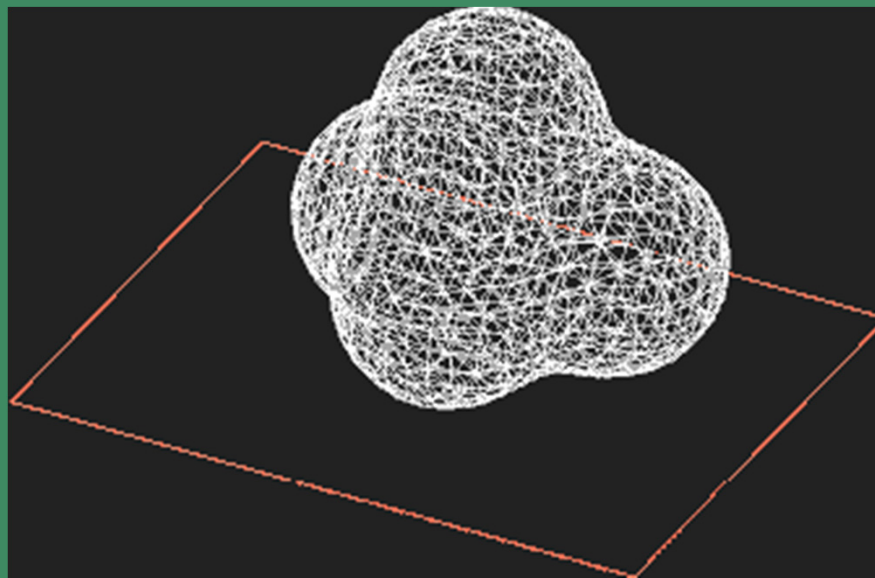
Simple 3D solid objects



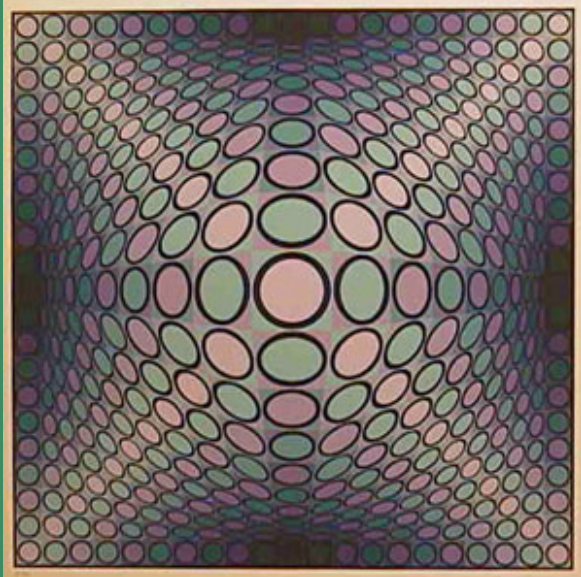
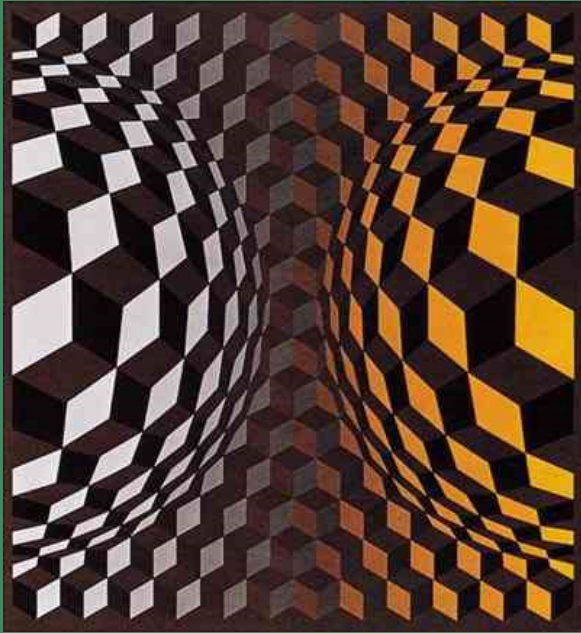
3D Solid object (with hole) generated using Constructive Solid Geometry



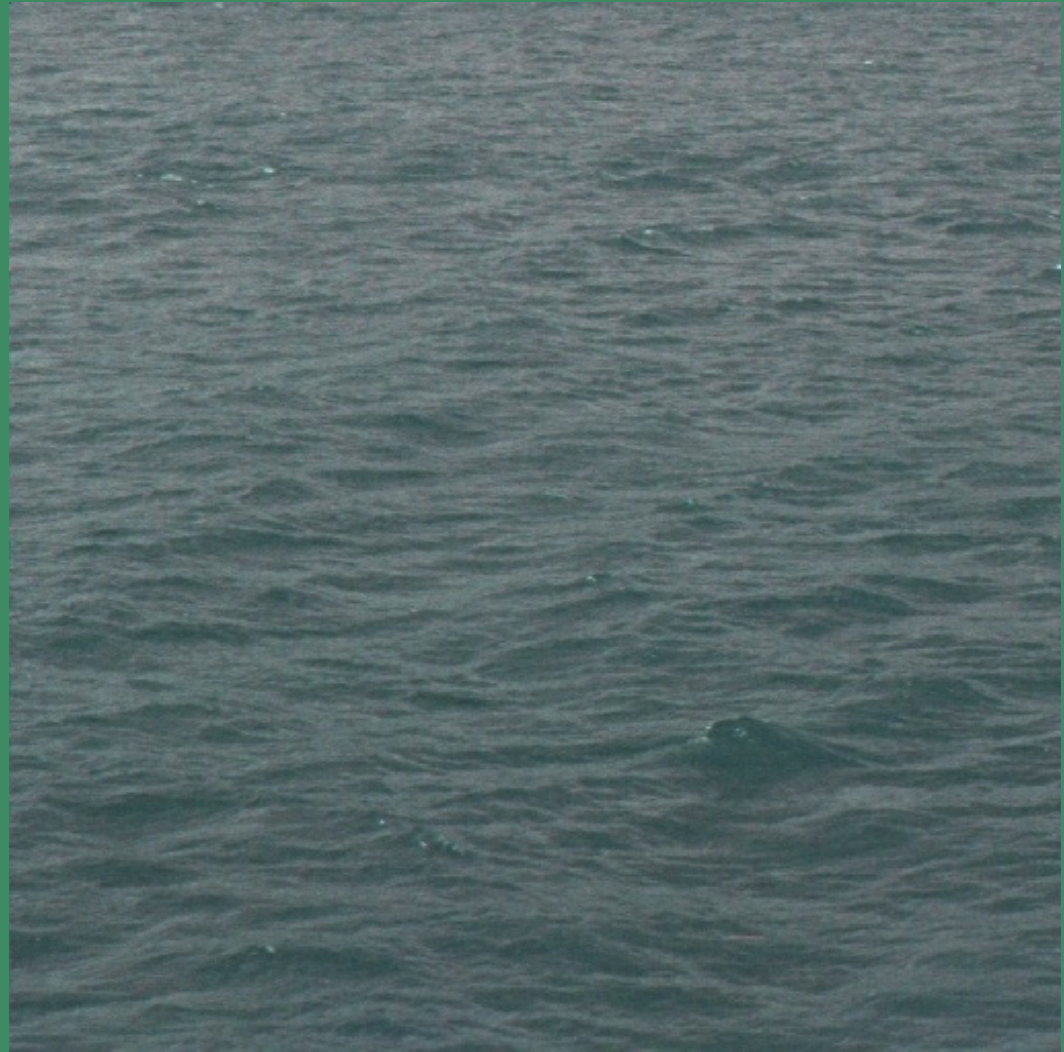
Shading effects, texture mapping and shadows



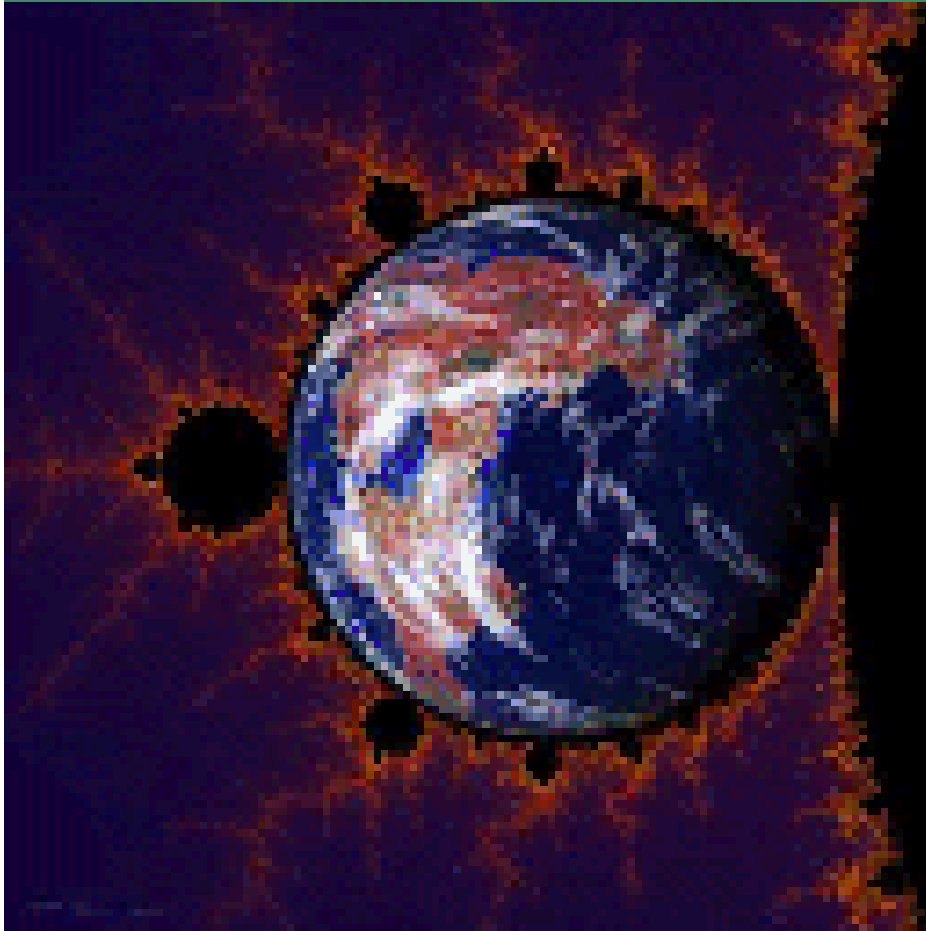
Textures help to visualize
shape and structure of 3D objects



Real world image of a
texture (stochastic)



Texture synthesis - using Fractals





**A realistic scene implemented using:
NURBS (Non-uniform Rational B-Splines),
image maps, bump maps, texture map,
procedural noise and depth of field.
Courtesy: <http://realsoft.fi/gallery/>**

End of Section - I