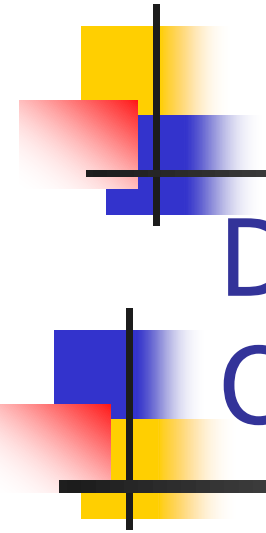
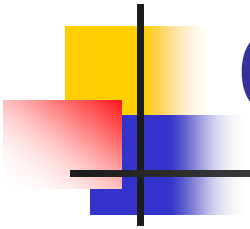


DMET 502/701
Computer Graphics

Introduction

Assoc. Prof. Dr. Rimon Elias



Contents

- Administrative stuff
- What You Need to Know to Proceed
- What is Computer Graphics?
- Related Fields
- Applications of Computer Graphics
- Vector Versus Raster Graphics
- Graphics Pipeline
- Topics to Cover

Course Staff

DMET502 ➔ 5DMET
DMET701 ➔ 7CSEN

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Marking Scheme

- Students will be evaluated based on the following:
  - Assignments (15%)
  - Project (15%)
  - 2 out of 3 Quizzes (10%)
  - Final exam (40%)
  - Midterm exam (20%)
- **There will be no cheat sheets. All the formulae needed will be included in the exam/quiz booklets.**

Class Time

- Course components (2+2+2):

	1st 8:15-9:45	2nd 10:00-11:30	3rd 11:45-13:15	4th 13:45-15:15	5th 15:45-17:15
Saturday	502 (T30): C3.101 701 (P010): D3.105	502 (P030): D3.105 701 (P011): D3.104	**DMET 502/701 H19** 701 (P022): D3.306 701 (T023): C5.208	701 (P020): D4.105 701 (T018): C3.101	**DMET 701 H13** 701 (P013): D3.205
Sunday			502 (P029): D3.306		
Monday				502 (T029): C4.101	
Tuesday	701 (P018): C7.220 701 (T021): C5.208	701 (P014): C7.220 701 (T013): C5.204 701 (P024): D3.301 701 (T017): D3.203	701 (T009): D4.205	701 (T014): C5.304 701 (T015): D3.104 701 (P025): D3.105	
Wednesday	701 (P006): C7.217 701 (P012): D3.105 701 (T008): C5.102	701 (P015): D3.205 701 (T005): D4.105 701 (T010): D3.104 701 (P023): D3.306	701 (P026): D3.301 701 (T019): C4.103 701 (T020): C4.101 701 (T025): D4.210	701 (P008): D3.105 701 (T007): C3.110 701 (T012): C2.312	
Thursday	701 (P021): C7.220 701 (P017): D3.105 701 (T022): C5.201	701 (T016): C5.311 701 (T026): C5.312	701 (P016): D3.105 701 (P019): D3.205 701 (T024): D4.204	701 (P005): D3.205 701 (T006): D4.108 701 (T011): C5.302	701 (P009): D3.301 701 (P007): D3.306

DMET 502/701: Computer Graphics

- During **lectures**, we will cover the **theoretical aspects** of Computer Graphics with hints on how to implement algorithms.
- The **tutorials** will focus mainly on practice questions.
- The **labs** will be dedicated to **implementing code**.

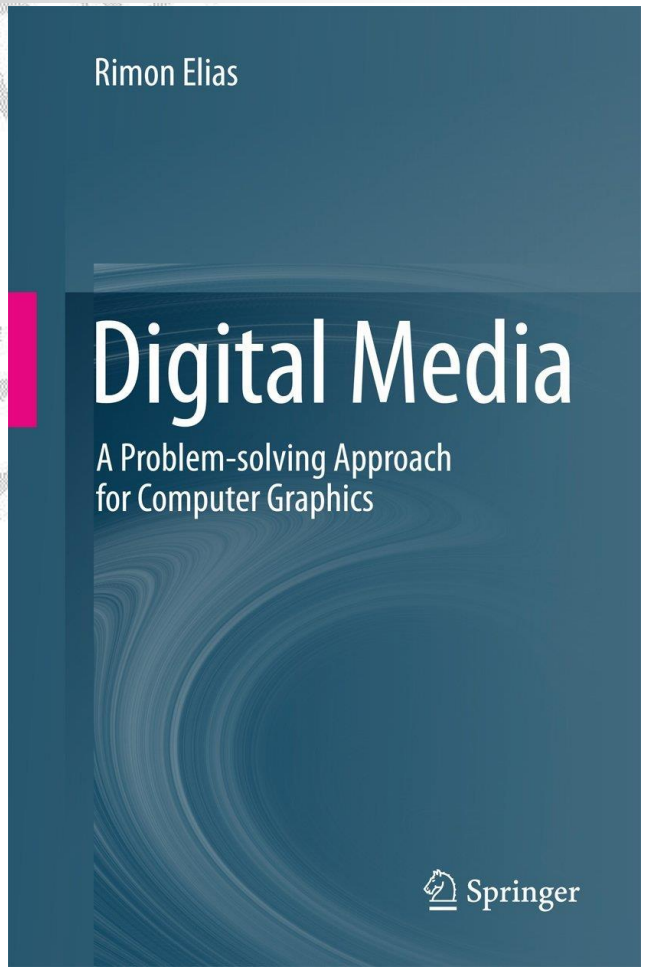
- We will use **C/C++** to write our programs.
- We will use a graphics library called **OpenGL.**

What You Need to Know to Proceed

- Prerequisites:
  - Knowledge of simple Linear Algebra
  - Programming experience
- In terms of courses:
  - MUST:
    - Introduction to Computer Programming (CSEN 202)
    - Data Structures (CSEN 301)
  - Nice to have:
    - Mathematics II (MATH 203)
    - Concepts of Programming Languages (CSEN 401)

DMET 502/701: Textbook

- Rimon Elias, "Digital Media: A Problem-solving Approach for Computer Graphics," ISBN: 978-3-319-05136-9 (Print) 978-3-319-05137-6 (Online), 2014.
- We will follow the contents closely.

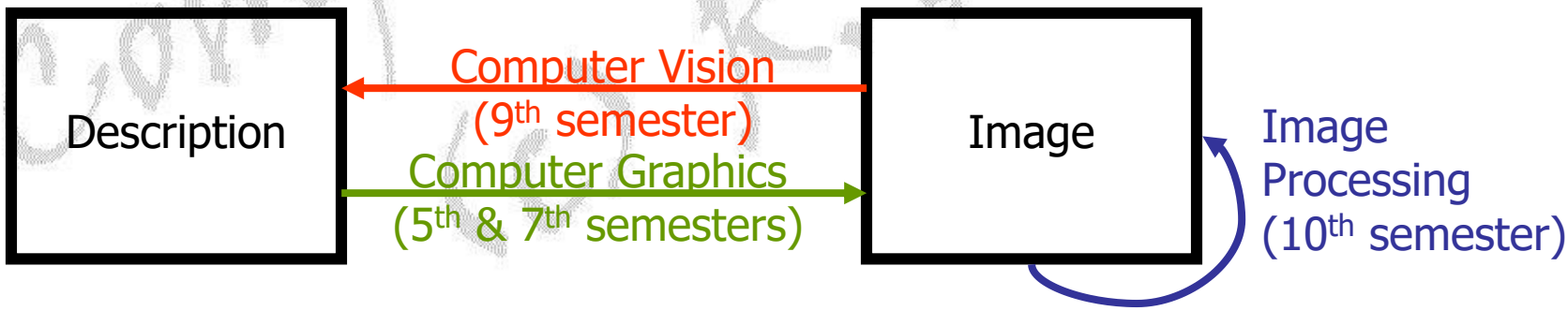


What is Computer Graphics?

- **Computer graphics** (**CG**) is the field of visual computing, where one utilizes computers both to generate visual images synthetically and to integrate or alter visual and spatial information sampled from the real world.

Related Fields

- There are different fields of research that deal with images. Each of them is mainly characterized by the inputs and outputs of its operations.
  - Computer Graphics (5th & 7th semesters): Description ➔ Images
  - Computer Vision (9th semester): Images ➔ Description
  - Image Processing (10th semester): Images ➔ Images



- Related fields: Virtual reality, visualization..

Computer Graphics: An Example

Input

Description

- Building dimensions
- Window sizes
- Materials
- etc…

Output

Computer generated images

Computer Graphics

Computer Graphics: An Example

- Animation of computer generated images is considered an important part of Computer Graphics.

Applications of Computer Graphics

- Many applications are present:
  - Entertainment: games, commercials, movies, virtual reality
  - Training: simulated environment, virtual reality
  - Scientific visualization and data analysis:
    - Molecular graphics
    - Geographic information systems (maps, topographic maps)
  - Computer-aided design (CAD)
  - User interfaces

- The Computer Graphics motto, "**If it looks right, it is right**," does not work for all applications.

Vector Versus Raster Graphics

- **Vector graphics** or **geometric modeling** is the use of geometrical primitives such as points, lines, curves, and polygons, which are all based upon mathematical equations to represent images in computer graphics.
- **Raster graphics** is the representation of images as a collection of pixels (picture elements or dots).

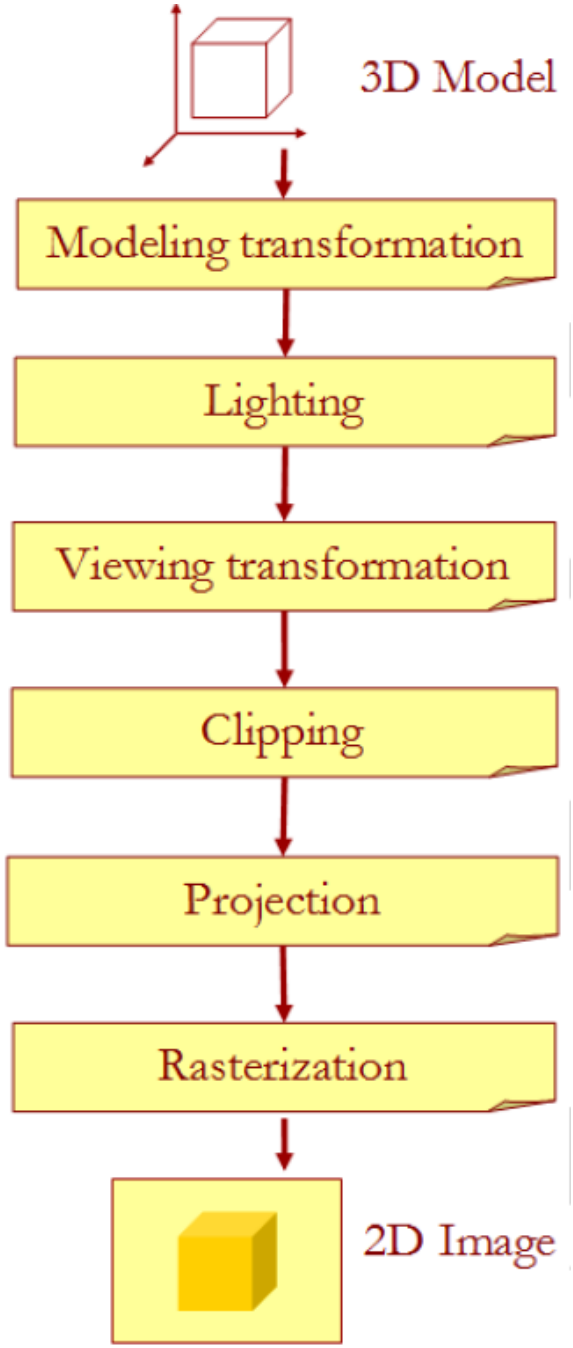
- For example, to draw a circle, you need

Vector graphics	Raster graphics
▪ Radius ▪ Center point ▪ Curve style and color ▪ Fill style and color	▪ Collection of pixels

Graphics Pipeline

- **Graphics pipeline** or **rendering pipeline** is a sequence of stages that accept some representation of a three-dimensional scene as an input and result in a 2D raster image as an output.

- Stages of graphics pipeline include:
  1. **Modeling transformation:** 3D geometry is provided in 3D world space.



Graphics Pipeline

2. **Per-Vertex Lighting:** Geometry in the complete 3D scene is lit according to the defined locations of light sources. Lighting is computed only at the vertices of the polygons being rendered. The lighting values between vertices are then interpolated during rasterization.

3. **Viewing transformation:** Objects are transformed from 3D world-space coordinates into a 3D coordinate system based on the position and orientation of a virtual camera.

4. **Clipping:** Objects that now fall outside of the viewing frustum will not be visible and are discarded at this stage.

Graphics Pipeline

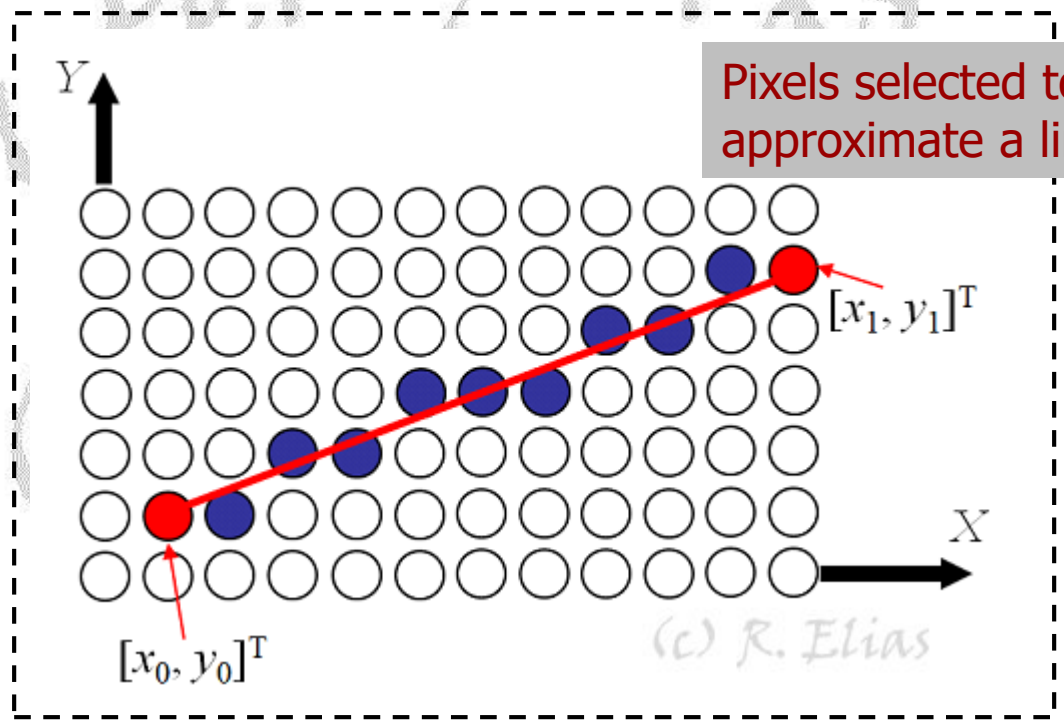
5. **Projection transformation:** Projection is applied to the 3D coordinates of the vertices remained after clipping.

6. **Rasterization:** The pixel values are determined. Shading and texturing are applied.

7. **Displaying:** Displaying on the screen.

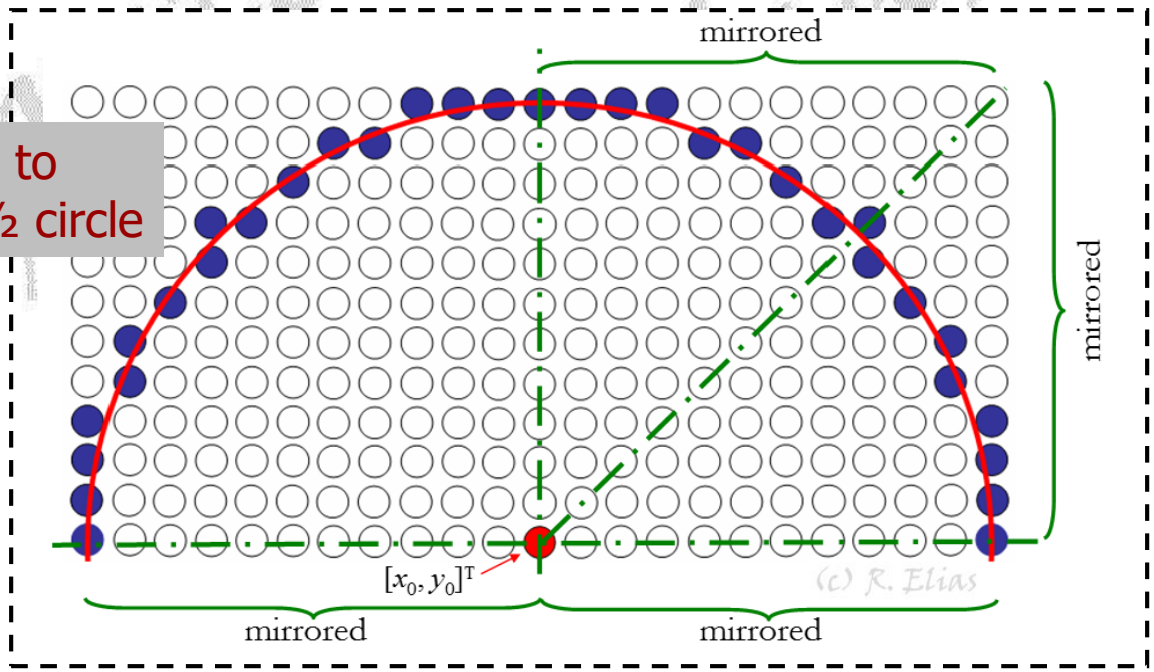
Topics to Cover

- Examples of the topics to be covered:
  - **2D Graphics**
    - How to draw a line? What pixels should be turned on along its path?



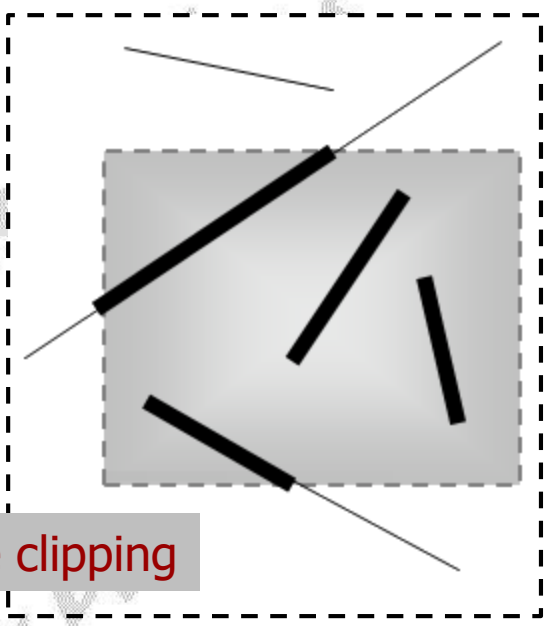
Topics to Cover

- Examples of the topics to be covered:
  - **2D Graphics**
    - How to draw a circle? What pixels should be turned on along its circumference?

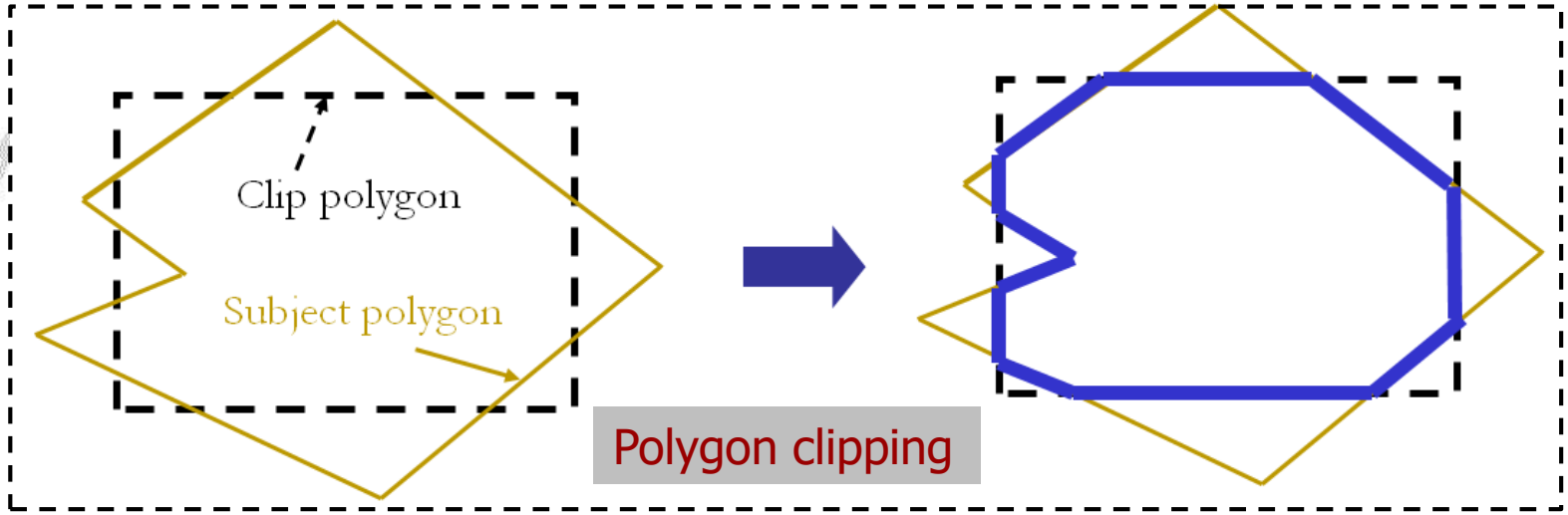


Topics to Cover

- Examples of the topics to be covered:
  - **2D Graphics**
    - How to clip lines?
    - … and polygons?



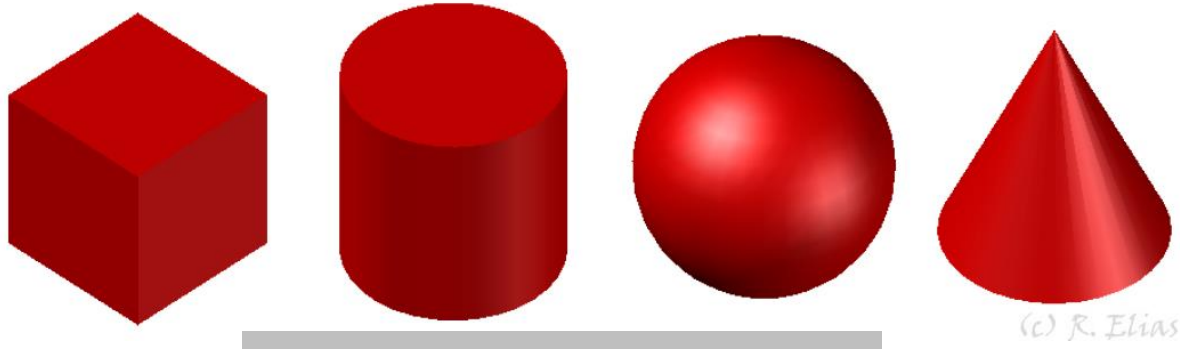
Line clipping



Polygon clipping

Topics to Cover

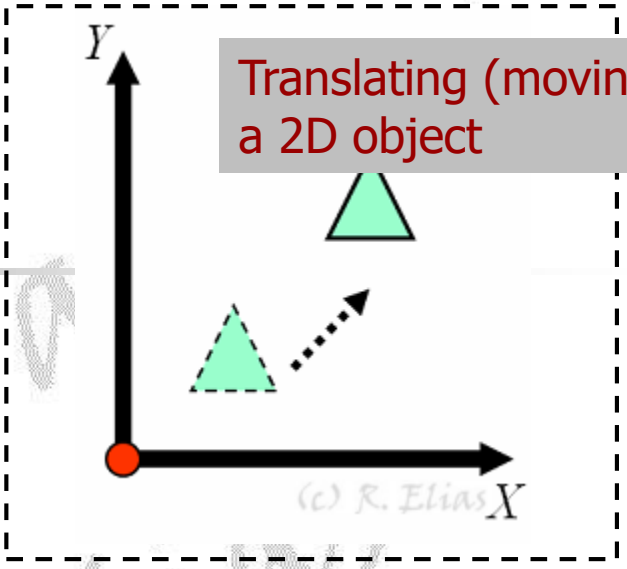
- Examples of the topics to be covered:
  - **Solid Modeling**
    - A solid is a 3D model that is used to represent objects in 3D space.
    - Examples of simple solids are cubes, cones, spheres, cylinders, etc.
    - We will discuss different ways to represent a solid.

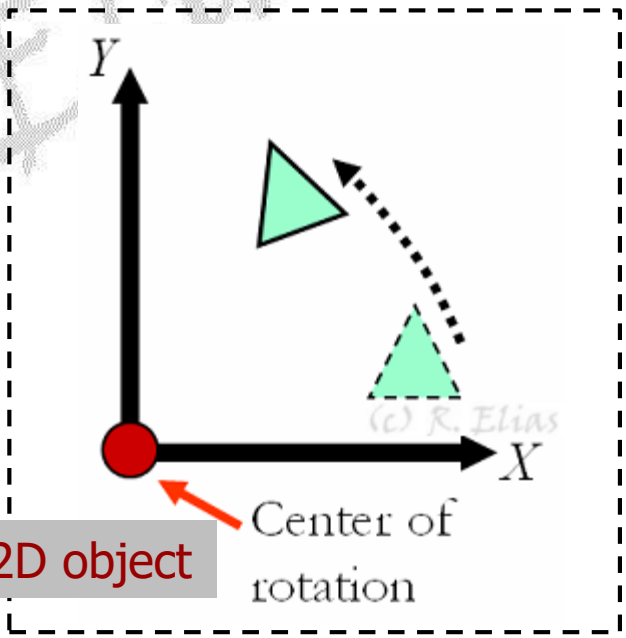


Examples of solid primitives

Topics to Cover

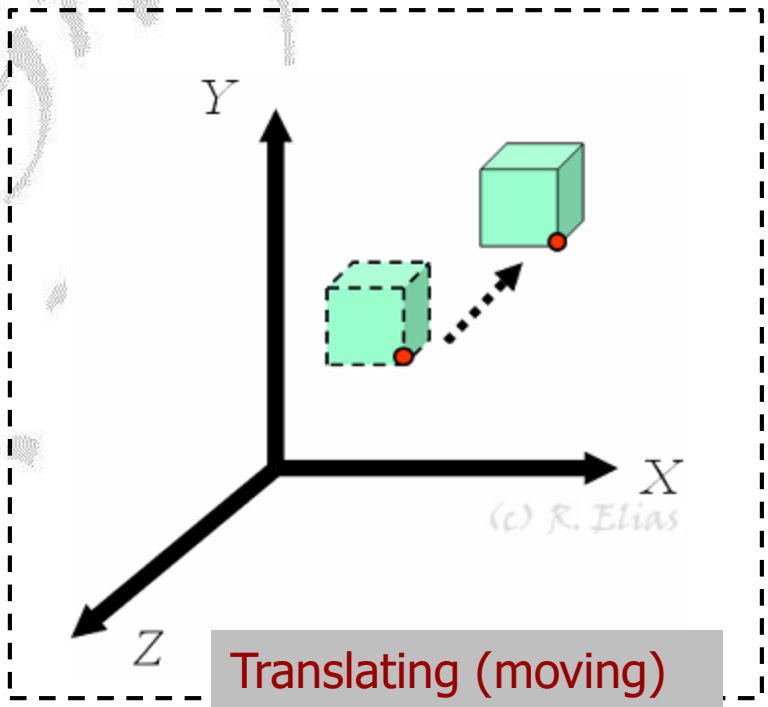
- Examples of the topics to be covered:
  - **2D Transformations**
    - A transformation operation is an operation used to alter the state of an object.
    - Examples include moving the object, rotating the object, scaling the object, etc.





Topics to Cover

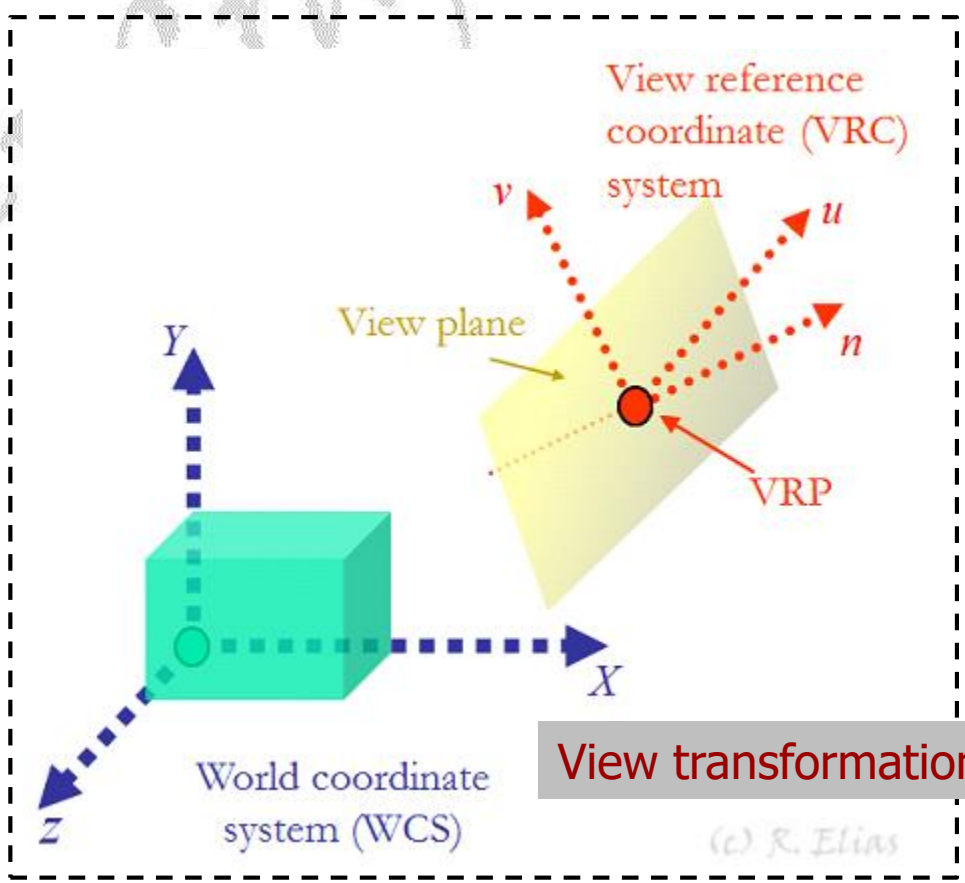
- Examples of the topics to be covered:
  - **3D Transformations**
    - Transformation operations may be applied in 3D space.



Translating (moving) a 3D object

Topics to Cover

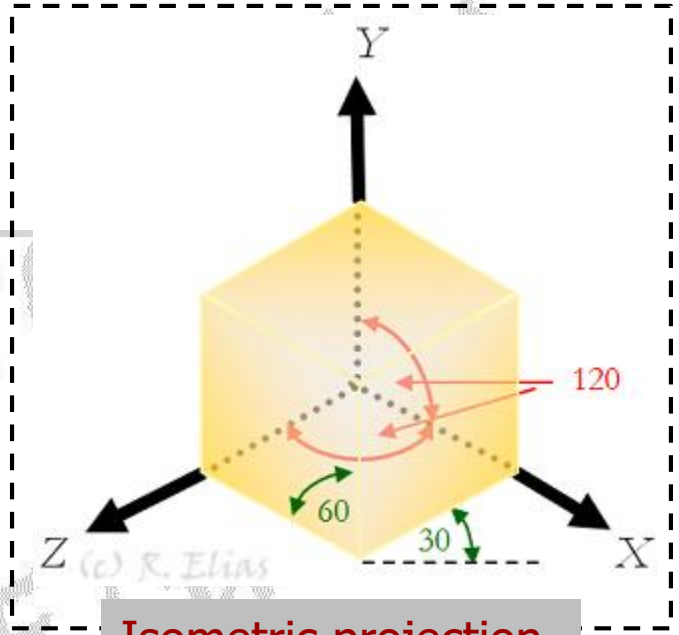
- Examples of the topics to be covered:
  - **View transformation**
    - A viewing surface has its own coordinate system.



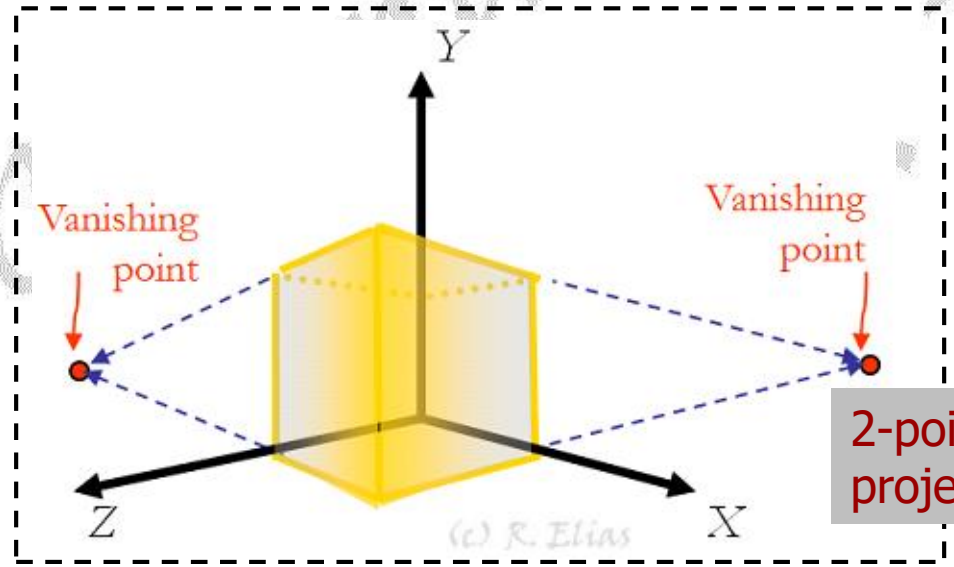
View transformation

Topics to Cover

- Examples of the topics to be covered:
  - **Projections**
    - There are many types of planar projections.



Isometric projection



2-point perspective projection

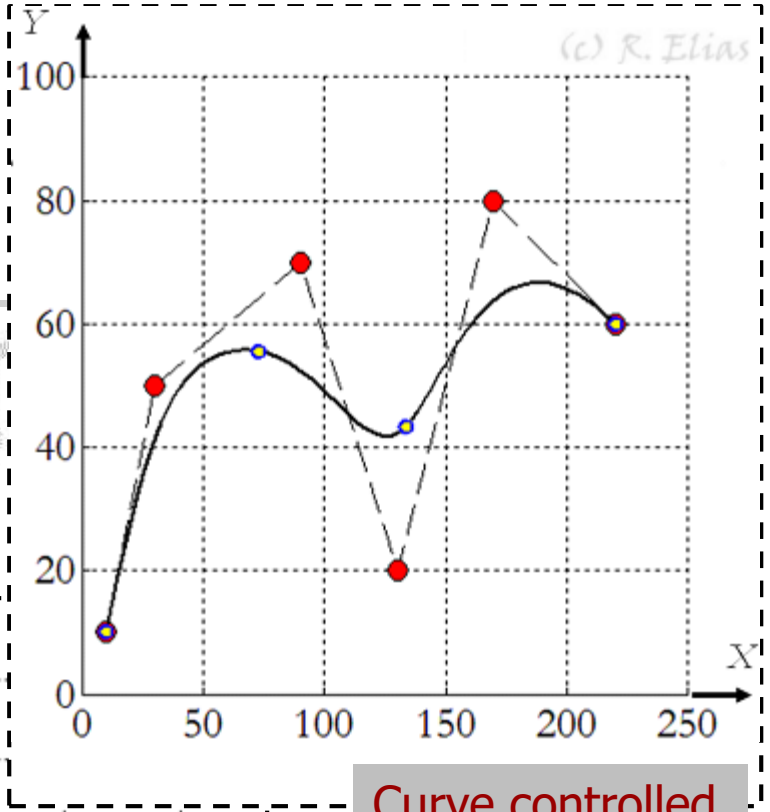
Topics to Cover

- Examples of the topics to be covered:
  - **Mapping techniques**
    - Mapping involves applying textures (or images) to a graphical object to achieve a more interesting image or add information and realism to the image without computing additional geometry.

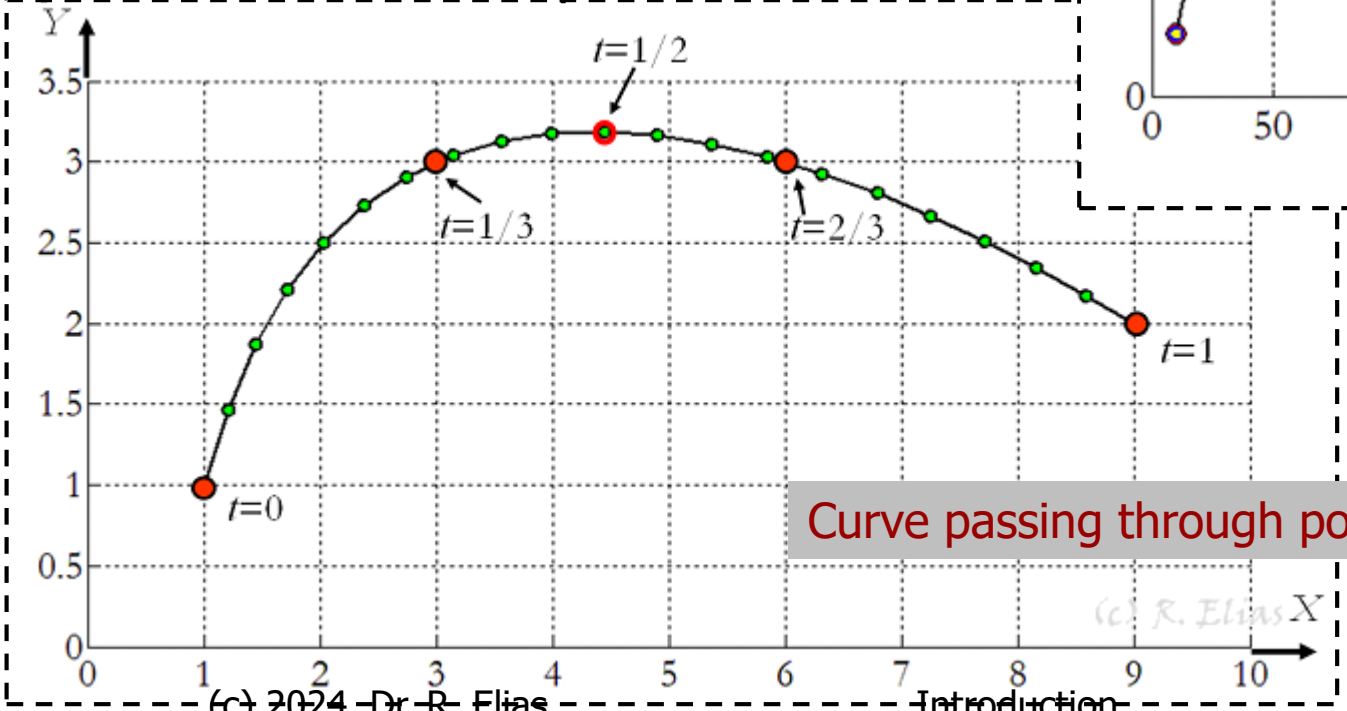
Texture/diffuse mapping

Topics to Cover

- Examples of the topics to be covered:
  - **Curves**
    - There are many ways we can use to represent curves.



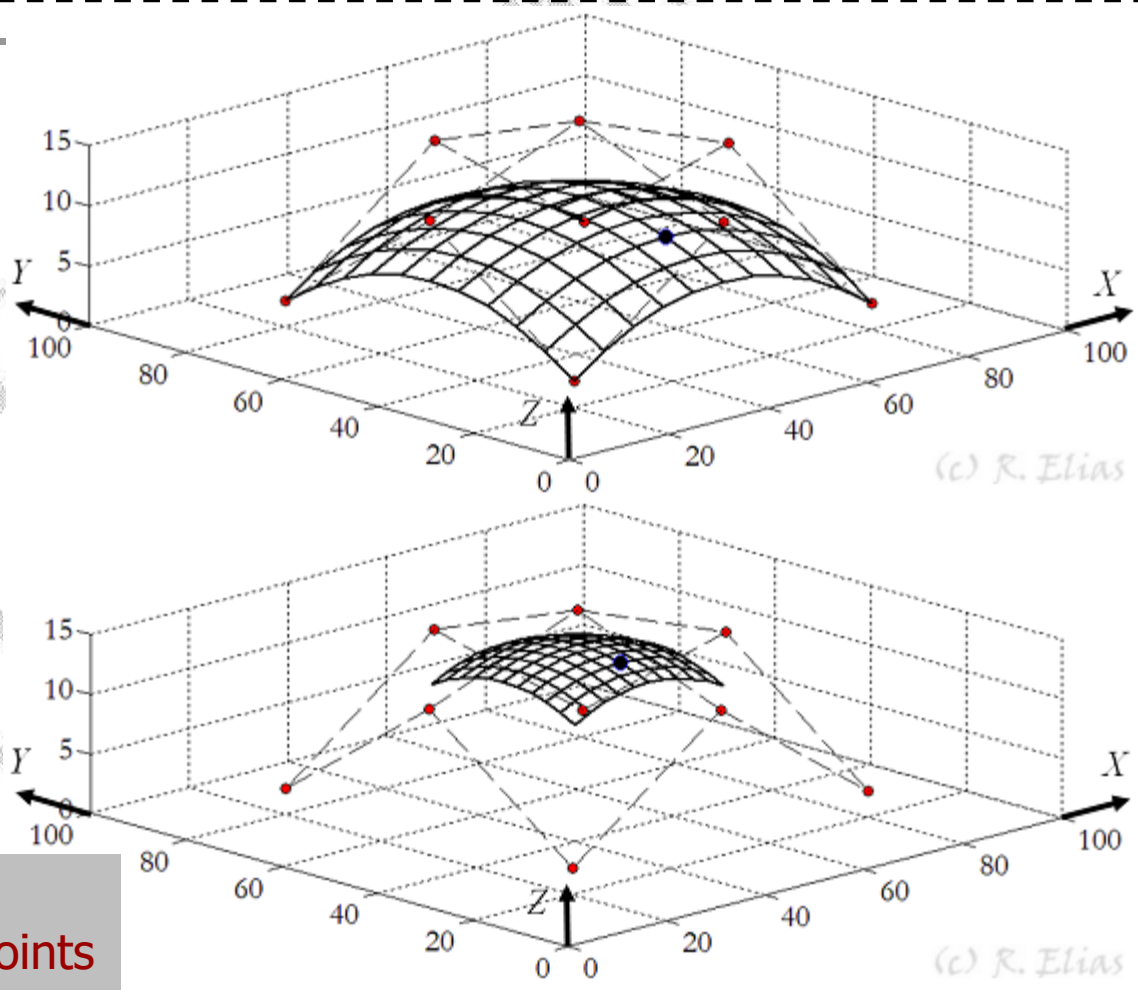
Curve controlled by points



Curve passing through points

Topics to Cover

- Examples of the topics to be covered:
  - **Surfaces**
    - There are many ways we can use to represent surfaces.



Different surfaces can be controlled by the same points

Topics to Cover

- Examples of the topics to be covered:
  - **Shading**
    - Different shading models exist.