Two –Dimensional Viewing

Two –Dimensional Viewing

- A graphics package allows a user to specify which part of a defined picture is to be displayed and where that part is to be displayed on the display device.
- The picture parts within the selected areas are then mapped onto specified areas of the device coordinates.
- The process of selecting and viewing the picture with different views is called **windowing.**
- A process which divides each element of the picture into its visible and invisible portions, allowing the invisible portion to be discarded is called **clipping**.

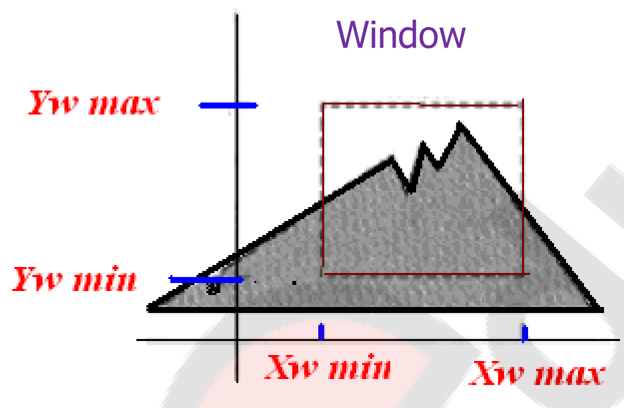
Viewing Pipeline

- A world-coordinate **area** selected for display is called a **window**.
- An area on a display device to which a window is mapped is called a **viewport**.
- The window defines what is to be viewed;
- The viewport defines where is to be displayed.
- Windows & viewport are rectangles in standard positions, with the rectangular edges parallel to the coordinate axes.

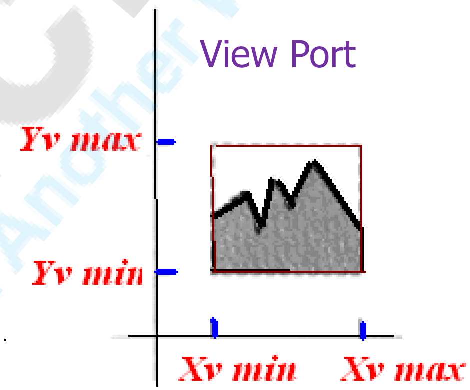
Viewing in 2D - Viewport

2D VIEWING

- The mapping of the part of a world coordinate scene to device coordinate is referred as a windowing transformation or window-to-viewport transformation or viewing transformation



World Coordinate



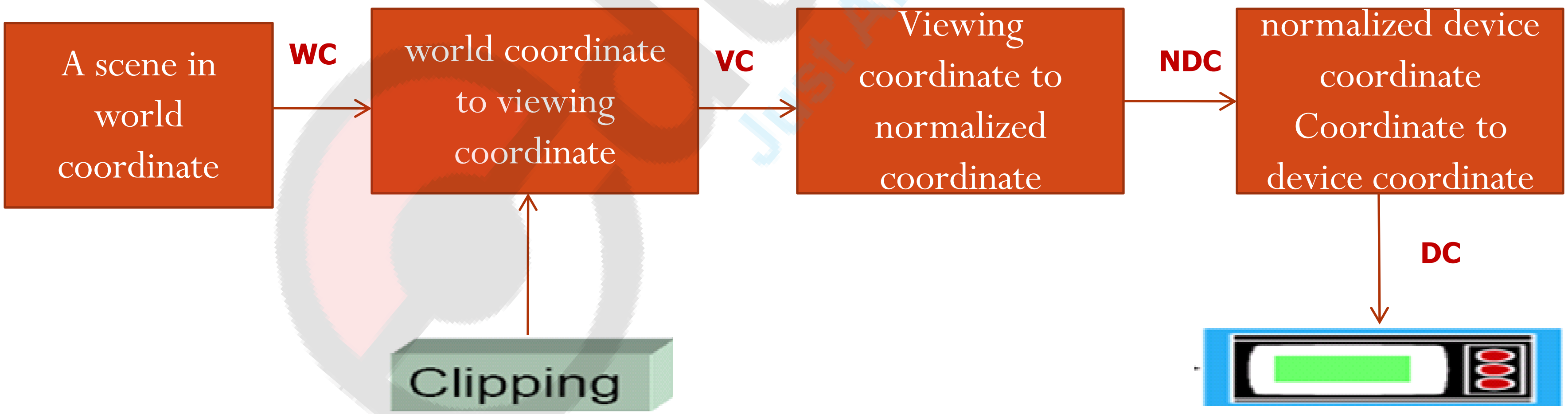
Device Coordinate

Viewing Pipeline: Window-Viewport Transformation
Window : What to display
Viewport : Where to display

2D VIEWING

Viewing transformation in 2D:

- Objects are given in world coordinate
- The world is viewed through window
- The window is mapped on to device window.

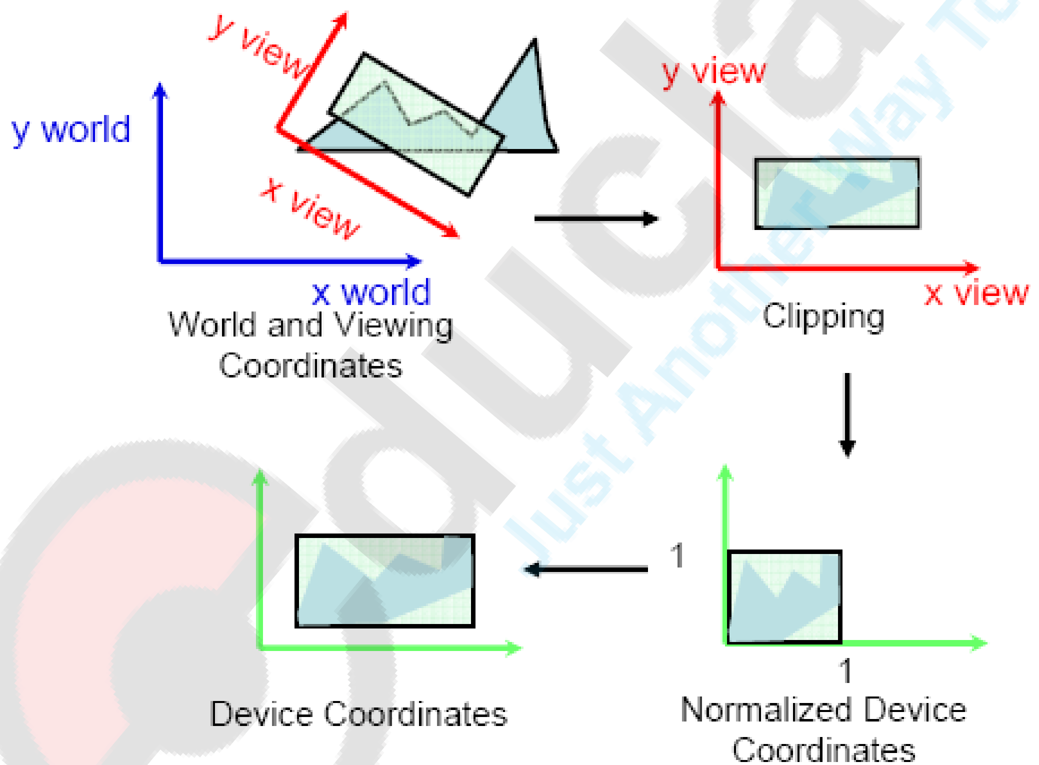


2D VIEWING :

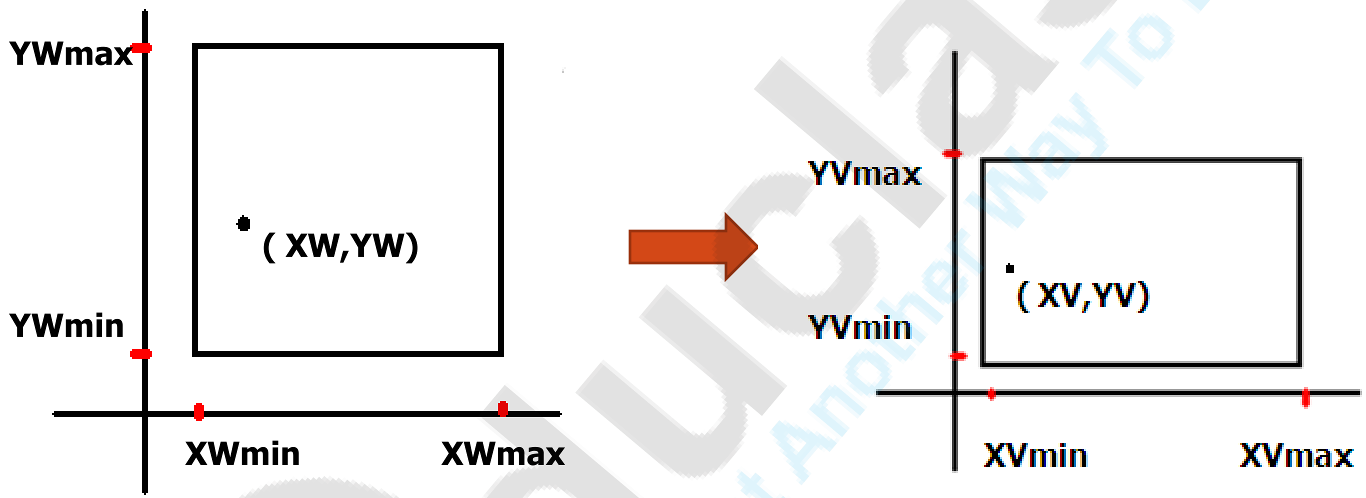
- Picture is store in to computer memory in any Cartesian coordinate system, referred to as the **world coordinate system (WC)**.
- A rectangular window with its edges parallel to the axes of the WC is used to select the portion of the scene for which an image is to be generated. This is referred as **viewing coordinate system (VC)**.
- Viewing Coordinate are then converted to Normalized device coordinate system.
- At the final step, these normalized device coordinates are converted to actual device coordinates.

2D VIEWING

Viewing Transformation in 2D



2D VIEWING



Point (XW , YW) in a designated window is mapped to viewport coordinates(XV,YV) so that relative positions in two area are same

2D VIEWING

- A point at position (xw, yw) in the window is mapped into position (xv, yv) in the associated viewport.
- To maintain the same relative placement in the viewport as in the window, we require that

$$\frac{(xv - xv_{min})}{(xv_{max} - xv_{min})} = \frac{(xw - xw_{min})}{(xw_{max} - xw_{min})}$$

$$\frac{(yv - yv_{min})}{(yv_{max} - yv_{min})} = \frac{(yw - yw_{min})}{(yw_{max} - yw_{min})}$$

Solving these expressions for the viewport position (xv, yv), we have

$$xv = xv_{min} + (xw - xw_{min})\, s_x$$

$$yv = yv_{min} + (yw - yw_{min})\, s_y$$

where the scaling factors are

$$s_x = \frac{(xv_{max} - xv_{min})}{(xw_{max} - xw_{min})} \qquad s_y = \frac{(yv_{max} - yv_{min})}{(yw_{max} - yw_{min})}$$

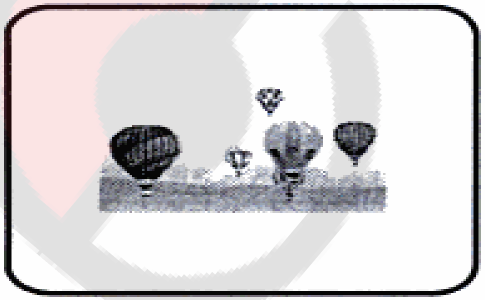
- The above equation converts the window area into the viewport area.
- This conversion is performed with the following sequence of transformation:
  - Perform a scaling transformation using a fixed-point position of that scales the window area to the size of the viewport.
  - Translate the scaled window area to the position of the viewport.

Viewing Transformation

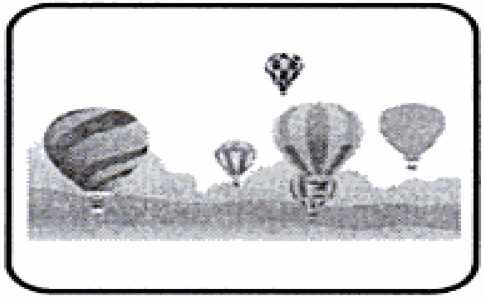
- Viewing Transformation which maps picture coordinates in world coordinate system to display device coordinate system is perform using 2 transformations:
  - Normalized transformation
  - Workstation transformation

Normalization transformation :

- Size of the screen represented in pixel.
- Size of the screen increases as resolution of the screen increases.
- When the picture is define in pixel values then
  - It is displayed small in size on high resolution screen
  - It is displayed large in size on low resolution screen
- To avoid this we require device independent program in which we define picture coordinate in some unit other than pixel
- Use interpreter to convert these coordinate to appropriate pixel values for particular display device
- This device independent unit is called normalized device coordinate.



(a) More resolution



(b) Less resolution

- **normalized device coordinate unit:**
- In this unit the screen measure 1 unit wide & 1 unit length. As shown in fig

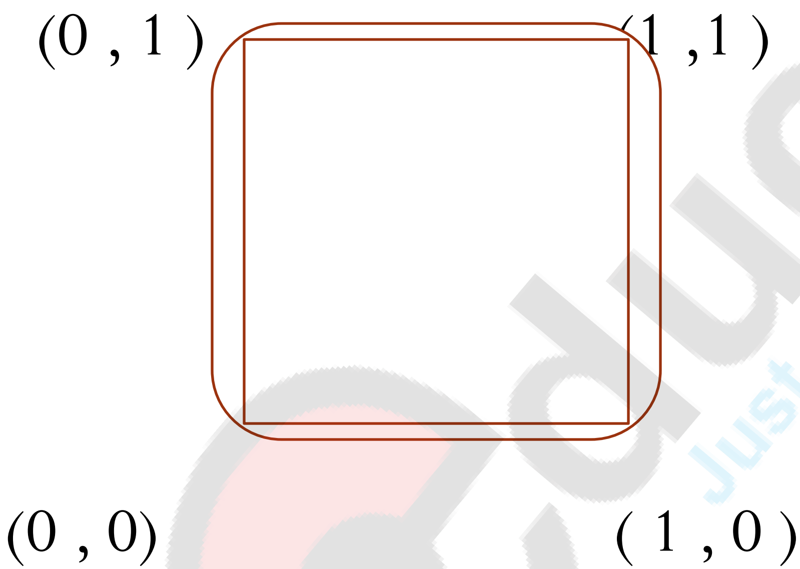


Fig. Picture definition in normalized device coordinate.

- Lower left corner of the screen is the origin & upper right corner is point (1 , 1) the point (0.5 , 0.5) is the center of the screen

- Formula to convert normalize device coordinate to actual device coordinate

$$x = x_n \times x_w \qquad y = y_n \times y_H$$

Where ,

x : Actual device x co ordinate

y : Actual device y co ordinate

x_n : normalized x coordinate

y_n : normalized y coordinate

x_w : width of actual screen in pixel

y_H : height of actual screen in pixel

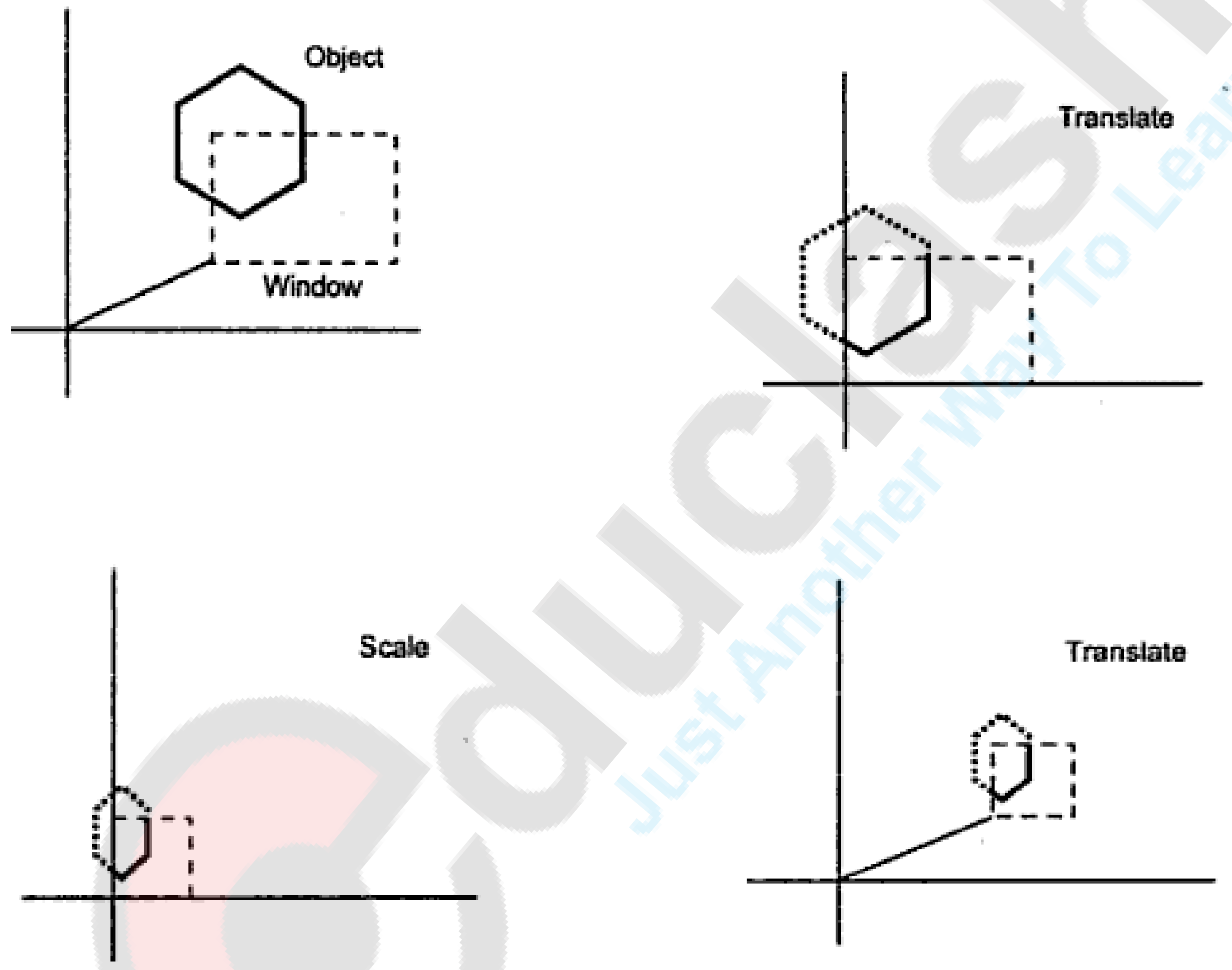
- The transformation that maps the world coordinate to normal device coordinate is called normalization transformation
- It involves scaling of x and y so it is also called scaling transformation.

WORKSTATION TRANSFORMATION

- The window defined in world coordinates is first **transformed** into normalized device coordinates.
- The normalized window is then **transformed** into the viewport coordinate.
- This window to viewport coordinate transformation is known as workstation transformation.

It is achieved by performing following steps:

1. The object together with its window is translated until the lower left corner of the window is at the origin.
2. Object and window are scaled until the window has the dimensions of the viewport.
3. Translate the viewport to its correct position on the screen.



Steps in workstation transformation

- Workstation transformation is given as,

$$W = T \cdot S \cdot T^{-1}$$

$$T = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ -xw_{min} & -yw_{min} & 1 \end{bmatrix} \qquad T^{-1} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ xv_{min} & yv_{min} & 1 \end{bmatrix}$$

$$S = \begin{bmatrix} S_x & 0 & 0 \\ 0 & S_y & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

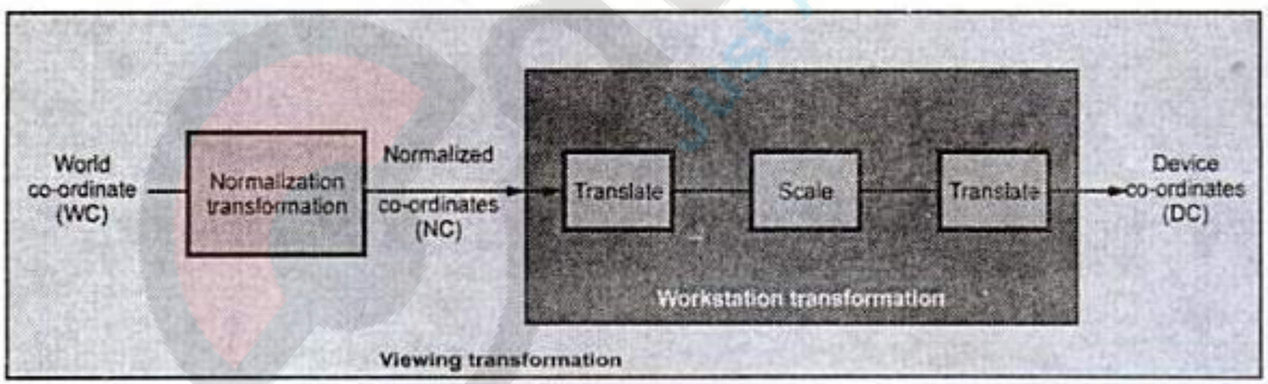
$$s_x = \frac{(xv_{max} - xv_{min})}{(xw_{max} - xw_{min})} \qquad s_y = \frac{(yv_{max} - yv_{min})}{(yw_{max} - yw_{min})}$$

The overall transformation matrix for W is given as

$$W = T \cdot S \cdot T^{-1}$$

$$= \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ -X_{w\,min} & -y_{w\,min} & 1 \end{bmatrix} \begin{bmatrix} S_x & 0 & 0 \\ 0 & S_y & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ x_{v\,min} & y_{v\,min} & 1 \end{bmatrix}$$

$$= \begin{bmatrix} S_x & 0 & 0 \\ 0 & S_y & 0 \\ x_{vmin} - x_{w\,min} \cdot S_x & y_{v\,min} - y_{w\,min} \cdot S_y & 1 \end{bmatrix}$$



complete viewing transformation.

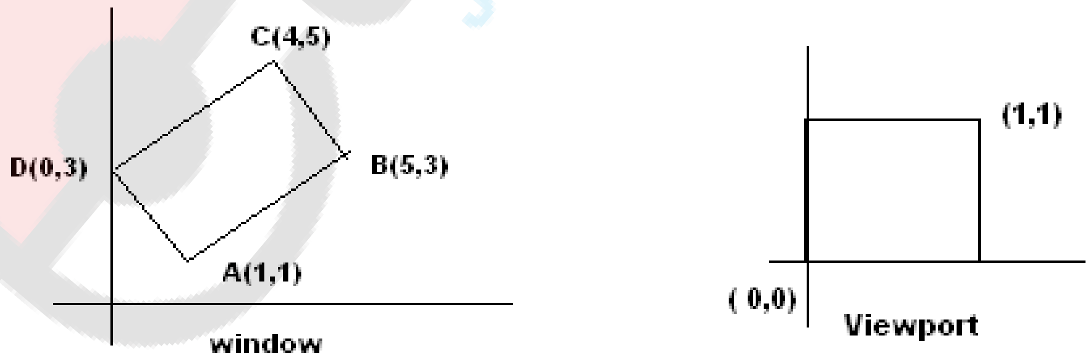
Examples:

1. Find normalized transformation from window to viewport with windows lower left corner at (1,1) and upper right corner at (3,5) on a view port with lower left corner at (0, 0) & upper right corner at (½ , ½).
2. Find normalized transformation from window to viewport with windows lower left corner at (2 , 2) and upper right corner at (5 ,5) on a view port with lower left corner at (1,1) & upper right corner at (3,3).
3. Find normalized transformation from window to viewport which uses rectangle whose lower left corner at (2 , 2) and upper right corner at (6,10) as window & view port with lower left corner at (0,0) & upper right corner at (1,1)

4. Find normalized transformation from window to viewport with windows lower left corner at (1 ,1) and upper right corner at (3,5) on a view port for entire normalized device screen.

5. Find normalized transformation from window whose coordinates are A(1,1) , B(5,3) , C(4,5), D(0 , 3)on a viewport with lower left corner at (0 ,0) & upper right corner at (1/2,1/2).

6. Find normalized transformation N which uses the rectangle A(1,1) , B(5,3) , C(4,5), D(0 , 3)as window and normalized device screen as viewport shown in figure.



Questions:

Q . Explain window to viewport transformation & 2D viewing pipeline ? 10m

Q. Explain & give use of Normalization transformation 5m

Q. Write a short note on viewing pipeline 5m

References:

Chap 6 : computer graphics by Donald

Chap 5: Windowing and clipping from computer graphics by A . P . Godse

Chap 5 : computer graphics by zhigang xiang - schaum's