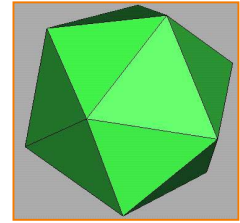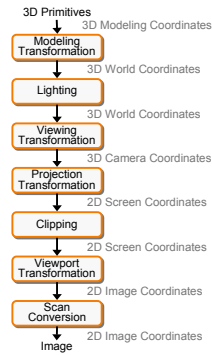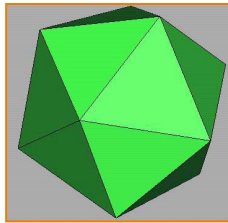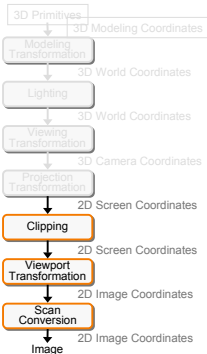# Clipping

Adam Finkelstein
Princeton University
COS 426, Spring 2003

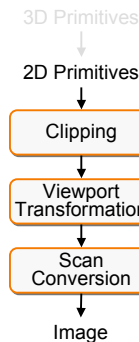## 3D Rendering Pipeline (for direct illumination)

```
3D Primitives
              3D Modeling Coordinates
  Modeling
  Transformation
              3D World Coordinates
  Lighting
              3D World Coordinates
  Viewing
  Transformation
              3D Camera Coordinates
  Projection
  Transformation
              2D Screen Coordinates
  Clipping
              2D Screen Coordinates
  Viewport
  Transformation
              2D Image Coordinates
  Scan
  Conversion
              2D Image Coordinates
Image
```

3D Rendering Pipeline (for direct illumination)

```
3D Primitives
              3D Modeling Coordinates
  Modeling
  Transformation
              3D World Coordinates
  Lighting
              3D World Coordinates
  Viewing
  Transformation
              3D Camera Coordinates
  Projection
  Transformation
              2D Screen Coordinates
  Clipping
              2D Screen Coordinates
  Viewport
  Transformation
              2D Image Coordinates
  Scan
  Conversion
              2D Image Coordinates
Image
```

2D Rendering Pipeline

```
3D Primitives
    ↓
2D Primitives
    ↓
  Clipping          Clip portions of geometric primitives
    ↓               residing outside the window
  Viewport          Transform the clipped primitives
  Transformation    from screen to image coordinates
    ↓
  Scan              Fill pixels representing primitives
  Conversion        in screen coordinates
    ↓
  Image
```

2D Rendering Pipeline

```
3D Primitives
    ↓
2D Primitives
    ↓
  Clipping          Clip portions of geometric primitives
    ↓               residing outside the window
  Viewport          Transform the clipped primitives
  Transformation    from screen to image coordinates
    ↓
  Scan              Fill pixels representing primitives
  Conversion        in screen coordinates
    ↓
  Image
```

Clipping

- Avoid drawing parts of primitives outside window
  - Window defines part of scene being viewed
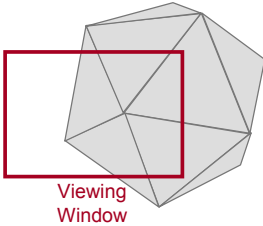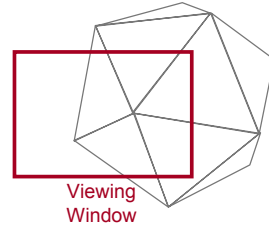 - Must draw geometric primitives only inside window

Window

Screen Coordinates

Clipping

- Avoid drawing parts of primitives outside window
  - Window defines part of scene being viewed
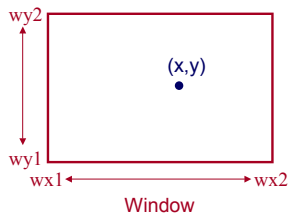 - Must draw geometric primitives only inside window

Viewing
Window

Clipping

- Avoid drawing parts of primitives outside window
  - Points
  - Lines
  - Polygons
  - Circles
  - etc.

Viewing
Window

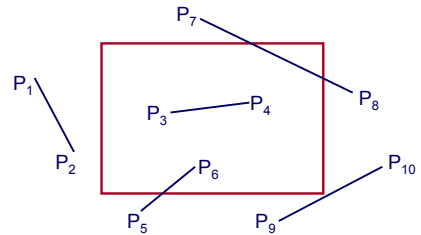# Point Clipping

- Is point (x,y) inside the clip window?

$wy2$

(x,y)

$wy1$

$wx1$ ← → $wx2$

Window

```
inside =
  (x >= wx1) &&
  (x <= wx2) &&
  (y >= wy1) &&
  (y <= wy2);
```

Line Clipping

- Find the part of a line inside the clip window

P_7

P_1

P_3 P_4

P_2 P_8

P_6

P_5 P_9 P_{10}

Before Clipping

Line Clipping

- Find the part of a line inside the clip window

P'_7

P'_8

P_3 P_4

P_6

P'_5

After Clipping
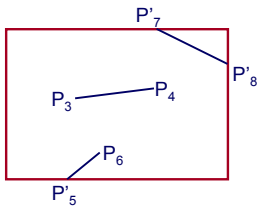
Cohen Sutherland Line Clipping

- Use simple tests to classify easy cases first

P_7

P_1

P_3 P_4

P_2 P_8

P_6

P_5 P_9 P_{10}

Cohen Sutherland Line Clipping

- Classify some lines quickly by AND of bit codes representing regions of two endpoints (must be 0)
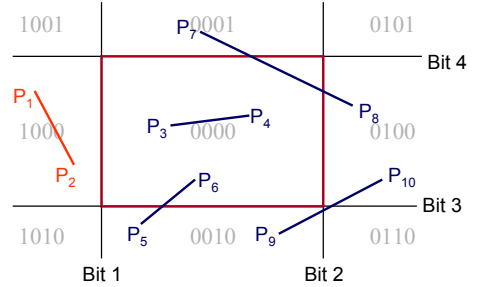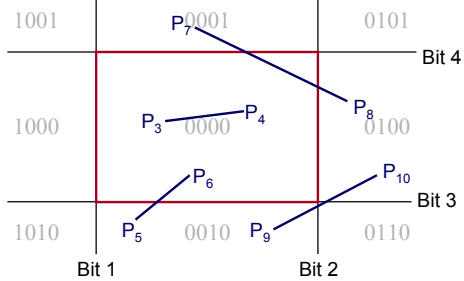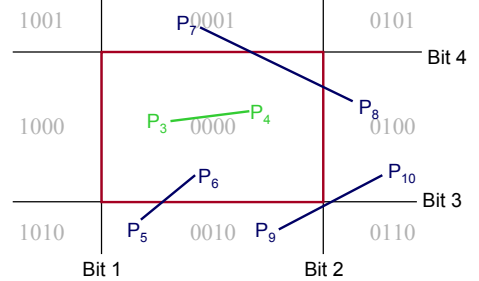

Cohen Sutherland Line Clipping

- Classify some lines quickly by AND of bit codes representing regions of two endpoints (must be 0)

Cohen Sutherland Line Clipping

- Classify some lines quickly by AND of bit codes representing regions of two endpoints (must be 0)
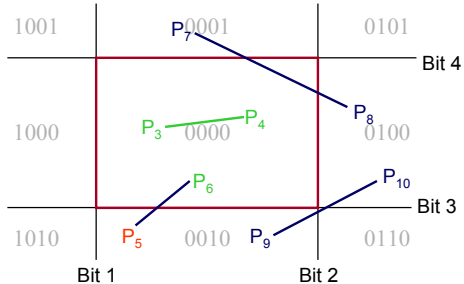

Cohen Sutherland Line Clipping

- Classify some lines quickly by AND of bit codes representing regions of two endpoints (must be 0)
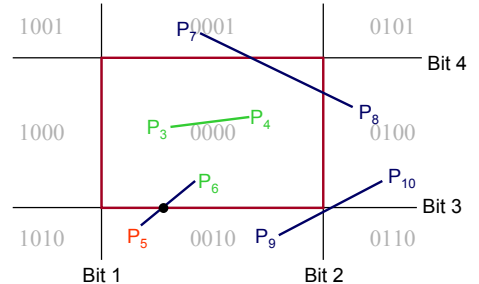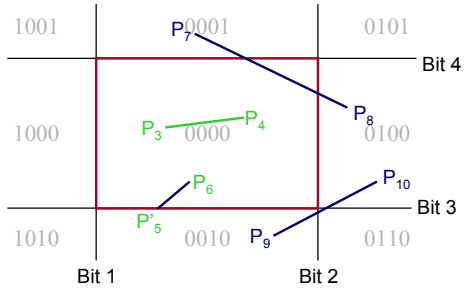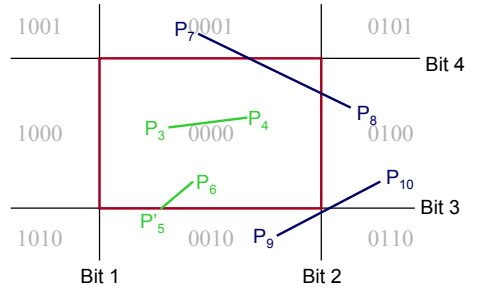

Cohen-Sutherland Line Clipping

- Compute interesections with window boundary for lines that can't be classified quickly

Cohen-Sutherland Line Clipping

- Compute interesections with window boundary for lines that can't be classified quickly
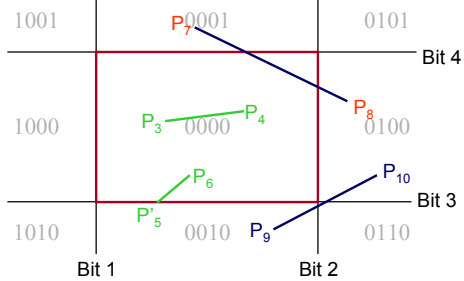
Cohen-Sutherland Line Clipping

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Cohen-Sutherland Line Clipping

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Cohen-Sutherland Line Clipping

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Cohen-Sutherland Line Clipping
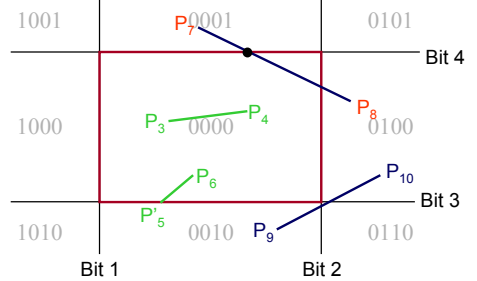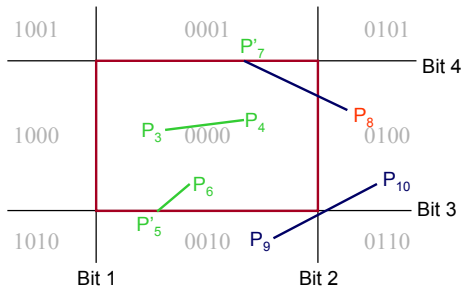
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Cohen-Sutherland Line Clipping

- Compute interesections with window boundary for lines that can't be classified quickly
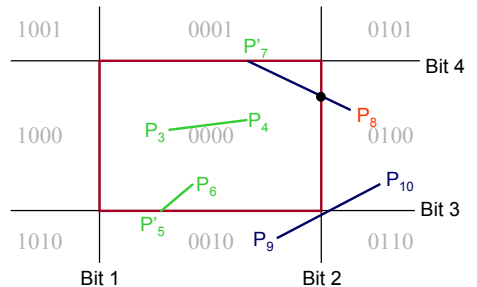

Cohen-Sutherland Line Clipping

- Compute interesections with window boundary for lines that can't be classified quickly
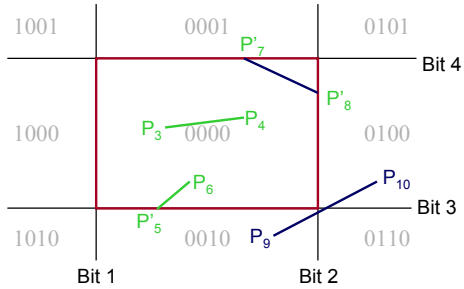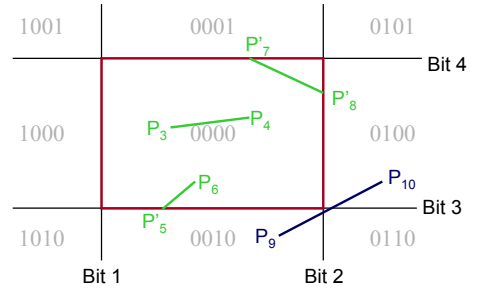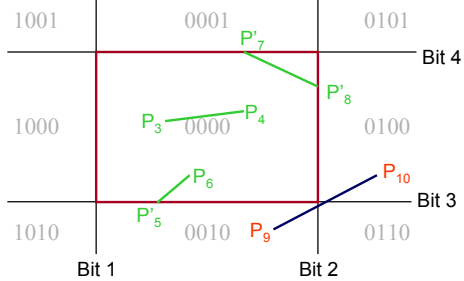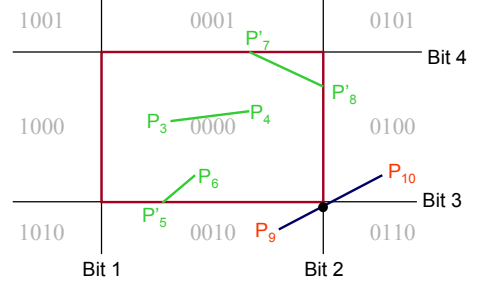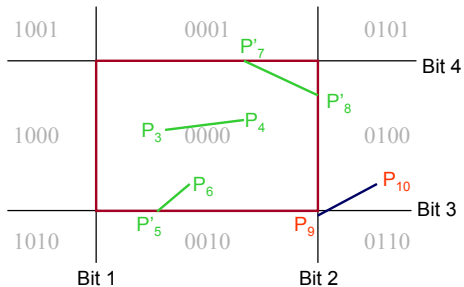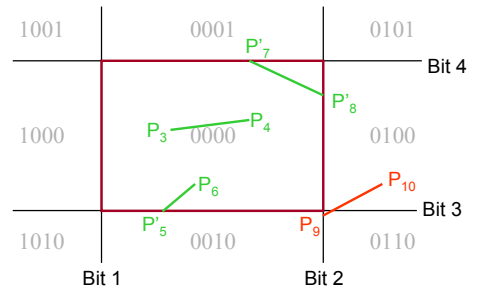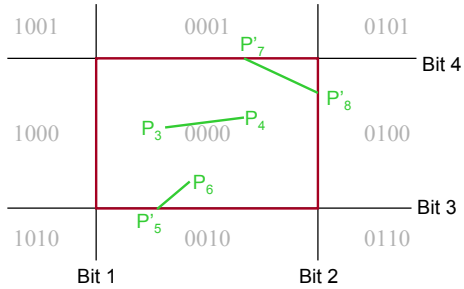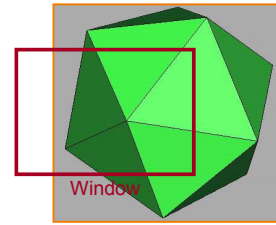
Cohen-Sutherland Line Clipping

- Compute interesections with window boundary for lines that can't be classified quickly

1001   0001   0101
Bit 4
P'_7
P'_8
1000   0000   0100
P_3 P_4
P_6 P_{10}
P'_5
Bit 3
1010   0010 P_9 0110
Bit 1   Bit 2

Cohen-Sutherland Line Clipping

- Compute interesections with window boundary for lines that can't be classified quickly

1001   0001   0101
Bit 4
P'_7
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Bit 4
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P'_5
Bit 3
1010   0010 P_9 0110
Bit 1   Bit 2

Cohen-Sutherland Line Clipping

- Compute interesections with window boundary for lines that can't be classified quickly

1001   0001   0101

P'_7

Bit 4

P'_8

1000 P_3 0000 P_4 0100

P_6

Bit 3

P'_5

1010   0010   0110

Bit 1   Bit 2

Clipping

- Avoid drawing parts of primitives outside window
  ○ Points
  ○ Lines
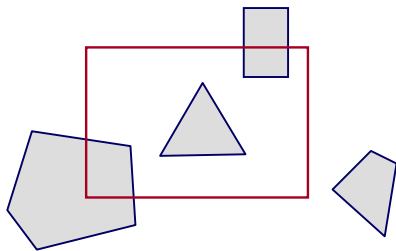 ○ Polygons
  ○ Circles
  ○ etc.

Window

2D Screen Coordinates

Polygon Clipping

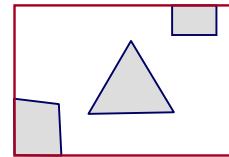- Find the part of a polygon inside the clip window?

Before Clipping

Polygon Clipping

- Find the part of a polygon inside the clip window?
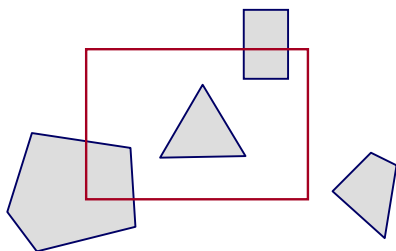
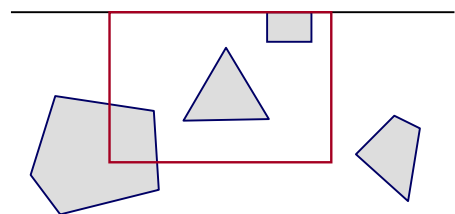After Clipping

Sutherland Hodgeman Clipping

- Clip to each window boundary one at a time
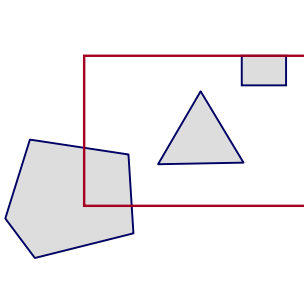
Sutherland Hodgeman Clipping

- Clip to each window boundary one at a time

Sutherland Hodgeman Clipping

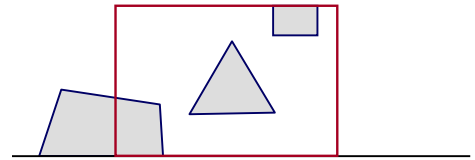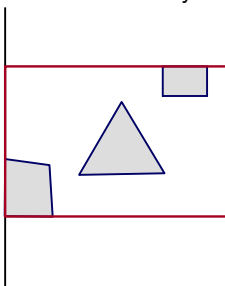- Clip to each window boundary one at a time

Sutherland Hodgeman Clipping

- Clip to each window boundary one at a time
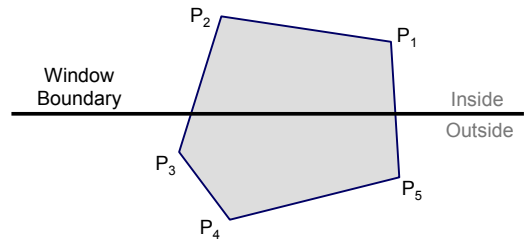
Sutherland Hodgeman Clipping

- Clip to each window boundary one at a time

Clipping to a Boundary

- Do inside test for each point in sequence,
  Insert new points when cross window boundary,
  Remove points outside window boundary

P_2 P_1

Window
Boundary   Inside
              Outside

P_3

P_5

P_4

Clipping to a Boundary

- Do inside test for each point in sequence,
  Insert new points when cross window boundary,
  Remove points outside window boundary

P_2 P_1

Window
Boundary   Inside
              Outside

P_3

P_5

P_4

Clipping to a Boundary

- Do inside test for each point in sequence,
  Insert new points when cross window boundary,
  Remove points outside window boundary

P_2 P_1

Window
Boundary   Inside
              Outside
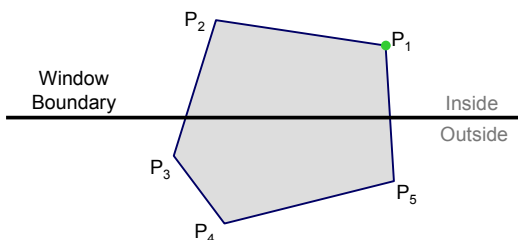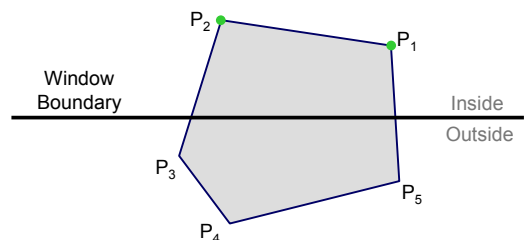
P_3

P_5

P_4

Clipping to a Boundary

- Do inside test for each point in sequence,
  Insert new points when cross window boundary,
  Remove points outside window boundary

Clipping to a Boundary

- Do inside test for each point in sequence,
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Clipping to a Boundary

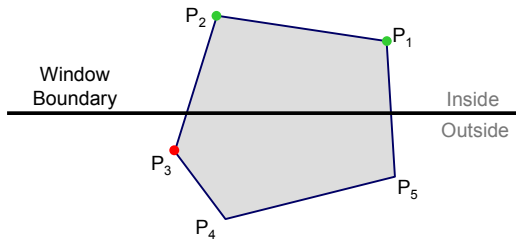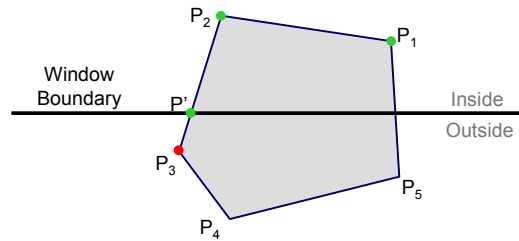- Do inside test for each point in sequence,
  Insert new points when cross window boundary,
  Remove points outside window boundary

Clipping to a Boundary

- Do inside test for each point in sequence,
  Insert new points when cross window boundary,
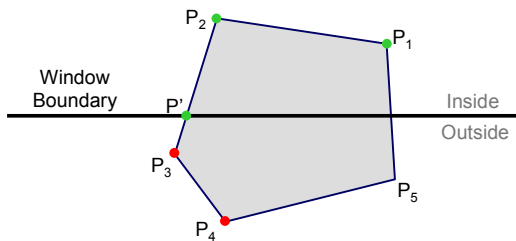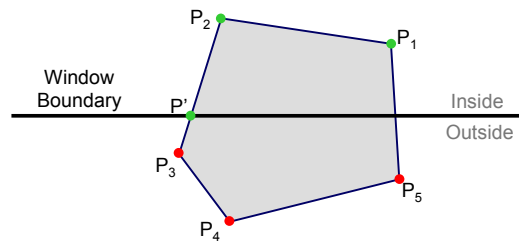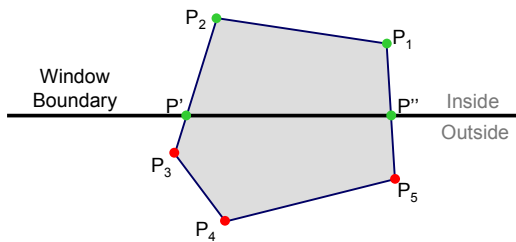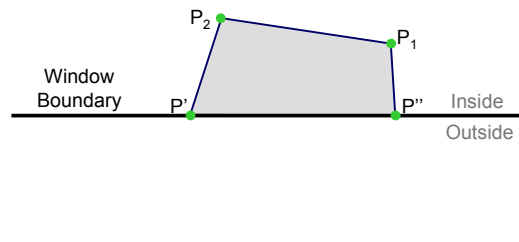 Remove points outside window boundary

Clipping to a Boundary

- Do inside test for each point in sequence,
  Insert new points when cross window boundary,
  Remove points outside window boundary

Clipping to a Boundary

- Do inside test for each point in sequence,
  Insert new points when cross window boundary,
  Remove points outside window boundary

2D Rendering Pipeline

3D Primitives
↓
2D Primitives
↓

| Clipping | Clip portions of geometric primitives residing outside the window |

↓

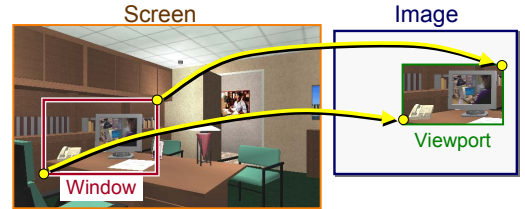| Viewport Transformation | Transform the clipped primitives from screen to image coordinates |

↓

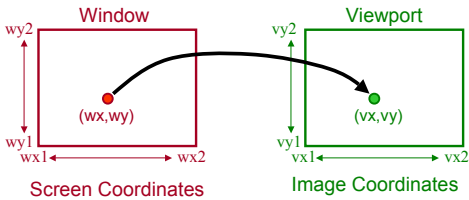| Scan Conversion | Fill pixels representing primitives in screen coordinates |

↓
Image

Viewport Transformation

- Transform 2D geometric primitives from screen coordinate system (normalized device coordinates) to image coordinate system (pixels)

Screen   Image

Window   Viewport

Viewport Transformation

- Window-to-viewport mapping

Window   Viewport

(wx,wy) (vx,vy)

Screen Coordinates   Image Coordinates

```
vx = vx1 + (wx - wx1) * (vx2 - vx1) / (wx2 - wx1);
vy = vy1 + (wy - wy1) * (vy2 - vy1) / (wy2 - wy1);
```
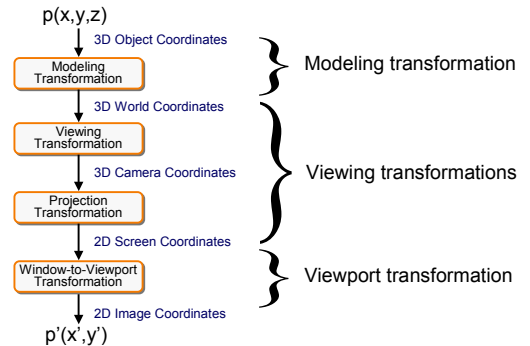

Summary of Transformations

$p(x,y,z)$

3D Object Coordinates

| Modeling Transformation | } Modeling transformation |

3D World Coordinates

| Viewing Transformation |

3D Camera Coordinates

| Projection Transformation |

} Viewing transformations

2D Screen Coordinates

| Window-to-Viewport Transformation | } Viewport transformation |

2D Image Coordinates

$p'(x',y')$

Summary

3D Primitives
↓
2D Primitives
↓

| Clipping | Clip portions of geometric primitives residing outside the window |

↓

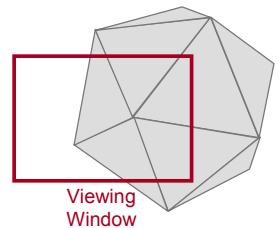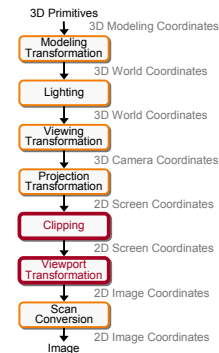| Viewport Transformation | Transform the clipped primitives from screen to image coordinates |

↓

| Scan Conversion | Fill pixels representing primitives in screen coordinates |

↓
Image

Summary

3D Primitives
↓ 3D Modeling Coordinates

| Modeling Transformation |

↓ 3D World Coordinates

| Lighting |

↓ 3D World Coordinates

| Viewing Transformation |

↓ 3D Camera Coordinates

| Projection Transformation |

↓ 2D Screen Coordinates

| Clipping |

↓ 2D Screen Coordinates

| Viewport Transformation |

↓ 2D Image Coordinates

| Scan Conversion |

↓ 2D Image Coordinates
Image

Viewing Window

Next Time

3D Primitives

3D Modeling Coordinates

Modeling
Transformation

3D World Coordinates

Lighting

3D World Coordinates

Viewing
Transformation

3D Camera Coordinates

Projection
Transformation

2D Screen Coordinates

Clipping

2D Screen Coordinates

Viewport
Transformation

2D Image Coordinates

Scan
Conversion

2D Image Coordinates

Image

Scan Conversion!