16-07-2018
11.00 Am.

Viewing and clipping.

** Short notes. (Book).

World Co-ordinate System:- object are placed into the scene by modeling transformation to a master Co-ordinate system. which is refferred as world co-ordinate system.

window: A rectangular area which is used to select a portion of ~~an image~~ a scene and whose edges ~~axes~~ are parallel to axes of wcs is called window.

viewing Co-ordinate system:- The additional co-ordinate system which is used to simulate the effect of moving and tilting camera is called viewing Co-ordinate system.

viewport:- A rectangular area which is used to specify a sub-region of the display and whose edges are parallel to axes of NDCS is called view port. (viewpoints).

normalized device co-ordinate system.

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window to viewport mapping :-

The process that converts object co-ordinates in wcs to normalize device co-ordinates is called window to viewport mapping or normalized transformati.

workstation transformation :-

The process that maps normalize device co-ordinates to discrete image co-ordinates is called workstation transformation.

collectively this two co-ordinate mapping operation are called viewing transformation.

(**) clipping.

Any procedure that identifies portions of a picture that are either inside or outside of a specified region is called clipping.

There are several types of clipping.

1. Point clipping.
2. line clipping.
3. polygon clipping

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point clipping :- point clipping is a technique which is used to determine either a point inside or outside of a clip window.

Let a point $p(x,y)$ and clipping window is defined by $(x_{min}, x_{max}, y_{min}, y_{max})$ then.

$$\boxed{x_{min} \le x \le x_{max}}, \quad \boxed{y_{min} \le y \le y_{max}}$$

The point $p(x,y)$ is considered inside the window when these inequalities ~~are~~ are evaluate true.

** Cohen - Sutherland Algorithm :

The clipping process is divide into two phases.

i) Identify those lines which intersects clipping window.

ii) perform clipping

All lines fall into one of following clipping categories

1. visible :- Both endpoint of the line lie within the window.

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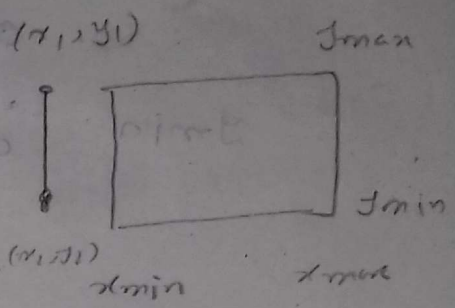
2. Not visible :- Bothe endpoint of the line lies outside window. If endpoints are (x_1, y_1) and (x_2, y_2) then inequalities are.

$x_1, x_2 > x_{max}$, $y_1, y_2 > y_{max}$.

$x_1, x_2 < x_{min}$, $y_1, y_2 < y_{min}$



3. Clipping candidate :- The line is neither category 1 or non category 2.

Algorithm :-

1. Assign a 4-bit region code for each endpoint of the line.

Region code =

1	2	3	4

Bit 1 = endpoint above the window = $(y - y_{max})$

Bit 2 = endpoint below the window = $(y_{min} - y)$.

Bit 3 = endpoint right of the window = $(x - x_{max})$.

Bit 4 = endpoint left of the wind = $(x_{min} - x)$.

If value is positive then bit will be 1 otherwise 0.

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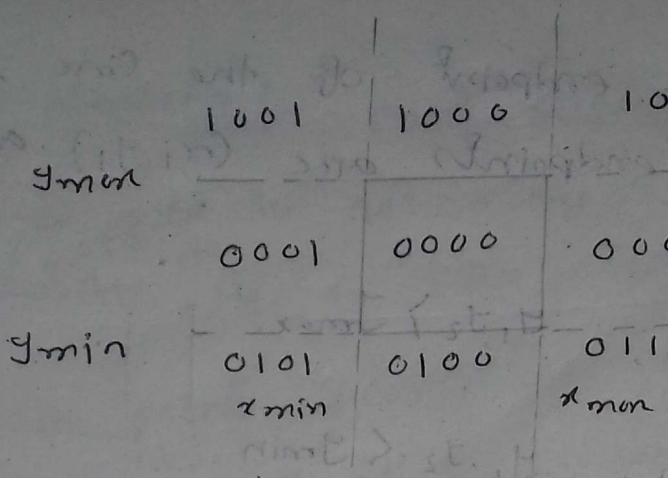

Fig:- Region code.

2. The line is visible if both region codes are 0000. Not visible if bitwise logical AND is not 0000. Clipping candidate if bitwise logical And is 0000.

The co-ordinates of intersection points are.

if boundary line is vertical.

$x_i = x_{min}$ or x_{max}.

$y_i = y_1 + m(x_i - x_1)$

if boundary line is horizontal.

$x_i = x_i + (y_i - y_1)/m$

$y_i = y_{min}$ or y_{max}.

$m = (y_2 - y_1)/(x_2 - x_1)$ Slope of the line.

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Midpoint subdivision :-

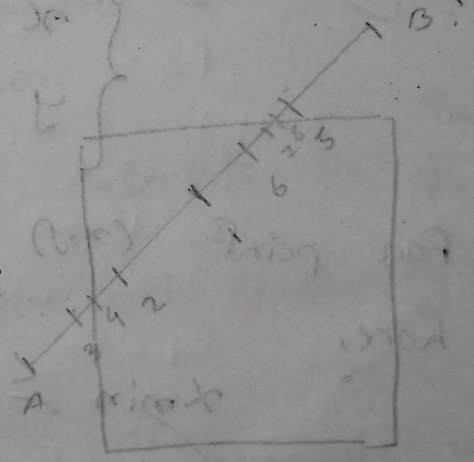
Midpoint subdivision is a technique to process clipping candidate lines using binary search.

1. The line divided into its midpoint into two shorter line segments.

2. The clipping categories of this two line segments are determined by region codes.

3. Each line which is a clipping candidate is divided again into shorter segments.

This process will continue until all lines become visible or not visible.



The midpoint co-ordinate (x_m, y_m) of line joining (x_1, y_1) and (x_2, y_2).

$$x_m = \frac{x_1 + x_2}{2}, \quad y_m = \frac{y_1 + y_2}{2}$$

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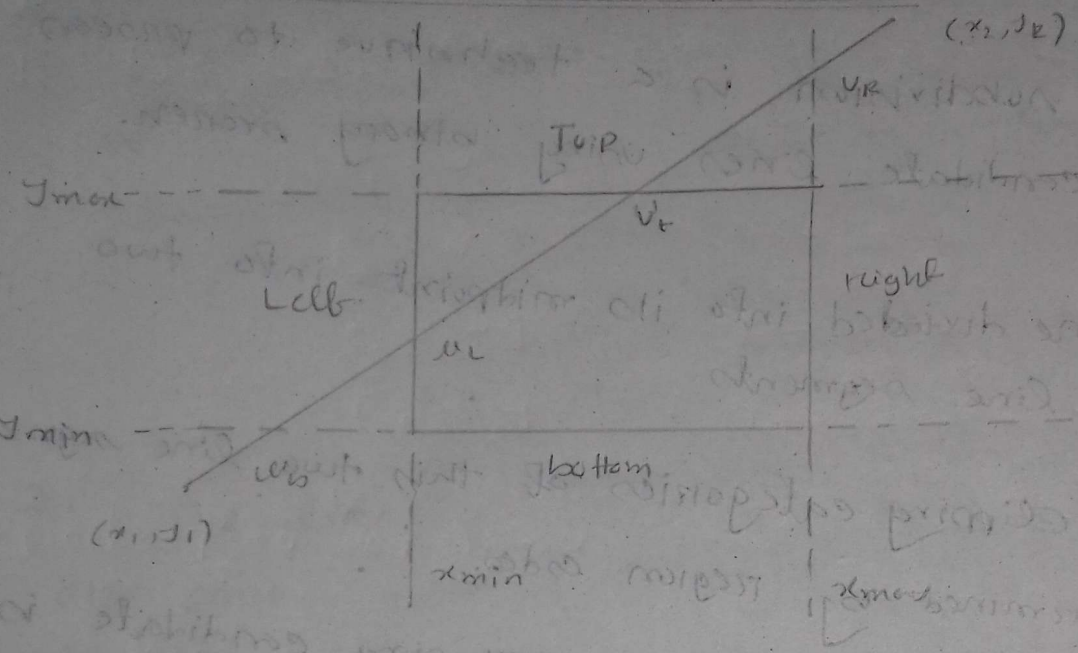
** Describe Liang-Barsky Algorithm.



The following parametric equation represents a line from (x_1, y_1) to (x_2, y_2) along with infinite extension

$$\begin{cases} x = x_1 + \Delta x \cdot u \\ y = y_1 + \Delta y \cdot u \end{cases}$$

For point (x, y) inside clipping window we have,

$$x_{min} \leq x_1 + \Delta x \cdot u \leq x_{max}.$$

$$y_{min} \leq y_1 + \Delta y \cdot u \leq y_{max}.$$

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Now these 4 inequalities can be written as, (Region Code 0000 2? (bit 1))

$$p_k \cdot v \le q_k \;, \quad k = 1, 2, 3, 4.$$

where,

$p_1 = -\Delta x$ $\qquad q_1 = x_1 - x_{min}$ (left)

$p_2 = \Delta x$ $\qquad q_2 = x_{max} - x_1$ (Right).

$p_3 = -\Delta y$ $\qquad q_3 = y_1 - y_{min}$ (bottom)

$p_4 = \Delta y$ $\qquad q_4 = y_{max} - y_1$ (Top).

Now we check whether the line is inside, outside or partially inside the window.

Steps:- i) If $p_k = 0$ and $q_k < 0$ for any k, eliminate the line and stop. otherwise go to next step.

ii) for all k such that $p_k < 0$, calculate $r_k = \frac{q_k}{p_k}$.

Let u_1 be the maximum of the set containing 0 and the calculated r ~~val~~ values.

iii) For all k such that $p_k > 0$ calculate $r_k = \frac{q_k}{p_k}$.

Let u_2 is the maximum of the set containing 0 and the calculated r values.

iv). If $u_1 > u_2$ eliminate the line. otherwise use u_1 and u_2 to calculate the endpoints of the clipped line.

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Math 5.12 (2015) 4(b)

1. For Line AB,

$p_1 = 0$ $\quad q_1 = 11 - 1 = 10$

$p_2 = 0$ $\quad q_2 = 9 - 11 = -2$

$p_3 = -4$ $\quad q_3 = 6 - 2 = 4$

$p_4 = 4$ $\quad q_4 = 8 - 6 = 2$

Since $p_2 = 0$ and $q_2 < 0$, so AB is outside right boundary.

2. For line CD,

$p_1 = 0$ $\quad p_1 = 3 - 1 = 2$

$p_2 = 0$ $\quad p_2 = 9 - 3 = 6$

$p_3 = -3$ $\quad p_3 = 7 - 2 = 5$ $\quad r_3 = -\frac{5}{3}$

$p_4 = 3$ $\quad p_4 = 8 - 7 = 1$, $r_4 = \frac{1}{3}$.

$u_1 = \max(0, -5/3) = 0$ $\quad u_2 = \min(1, 1/3) = 1/3$.

Since $u_1 < u_2$ the two endpoints of the clipped line are $(3, 7)$, and $(3, 7 + 3(\frac{1}{3}))$

$(3, 8)$.

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(3) for line EF,

$p_1 = -6$ $\quad q_1 = 2-1 = 1$ $\quad r_1 = -1/6$

$p_2 = 6$ $\quad q_2 = 9-2 = 7$ $\quad r_2 = \frac{7}{6}$

$p_3 = -7$ $\quad q_3 = 3-2 = 1$ $\quad r_3 = -1$

$p_4 = 7$ $\quad q_4 = 8-3 = 5$ $\quad r_4 = 5$

Now, $u_1 = (0, -1/6, -1)$ $\quad u_2 = \min(1, 7/6, 5)$

$= 0$ $\quad = 1$

since $u_1 = 0$ and $u_2 = 1$. EF is completely inside window.

(4) for line GH.

$p_1 = -2$ $\quad q_1 = 6-1 = 5$ $\quad r_1 = -2/5$

$p_2 = 2$ $\quad q_2 = 9-6 = 3$ $\quad r_2 = 3/2$

$p_3 = -3$ $\quad q_3 = 6-2 = 4$ $\quad r_3 = -4/3$

$p_4 = 3$ $\quad q_4 = 8-6 = 2$ $\quad r_4 = 2/3$.

$u_1 = \max(0, -2/5, -4/3)$, $\quad u_2 = \min(1, 3/2, 2/3)$

$= 0$ $\quad = 2/3$.

So endpoints are, $(6, 6)$ and $(6+2\cdot\frac{2}{3}, 6+3\cdot\frac{2}{3})$

$= \cancel{(6, 8)}$.

$= (7\frac{1}{3}, 8)$.

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⑤ Now for line IJ.

$p_1 = -12$ $\quad q_1 = -1-1 = -2$ $\quad r_1 = 1/6$

$p_2 = 12$ $\quad q_2 = 9+1 = 10$ $\quad r_2 = \frac{10}{12}$

$p_3 = 6$ $\quad q_3 = 7-2 = 5$ $\quad r_3 = \frac{6}{5}$

$p_4 = -6$ $\quad q_4 = 8-7 = 1$ $\quad r_4 = -1/6$.

$u_1 = \max(0, 1/6, -1/6)$ $\quad u_2 = \min(1, 10/12, \frac{5}{6})$

$= 1/6$ $\quad = 5/6$.

clipped points are,

$(-1 + 12 \cdot \frac{1}{6}, 7 + 6 \cdot \frac{1}{6}) = (1, 8)$

$(\cancel{-1 + 12 \cdot \frac{5}{6}},$

$(-1 + 12 \cdot \frac{5}{6}, 7 - 6 \cdot \frac{5}{6}) = (9, 2)$.

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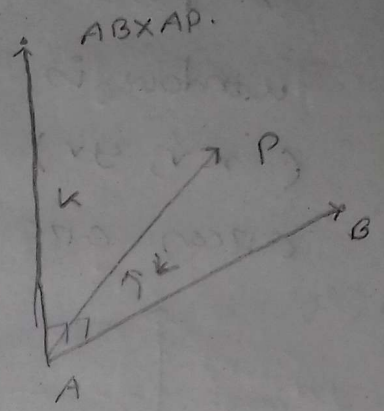
** How can we determine whether a point $P(x, y)$ lies to the left or right of a line joining the points $A(x_1, y_1)$ and $B(x_2, y_2)$.

→ From the vectors AB and AP. If point P is to the left of AB the cross product of AB X AP points to direction of vector k perpendicular to xy plane.



If it lies to the right the cross product point to direction $-k$.

$$AB = (x_2 - x_1)\, I + (y_2 - y_1)\, J.$$

$$AP = (x - x_1)\, I + (y - y_1)\, J.$$

$$\therefore AB \times AP = \left[(x_2 - x_1)(y - y_1) - (y_2 - y_1)(x - x_1) \right] k.$$

~~Pitch~~ direction of the cross product determined by the number,

$$\bar{c} = (x_2 - x_1)(y - y_1) - (y_2 - y_1)(x - x_1).$$

If $\bar{c}$ is positive P lies left of AB. If $\bar{c}$ is negative P lies right of AB.

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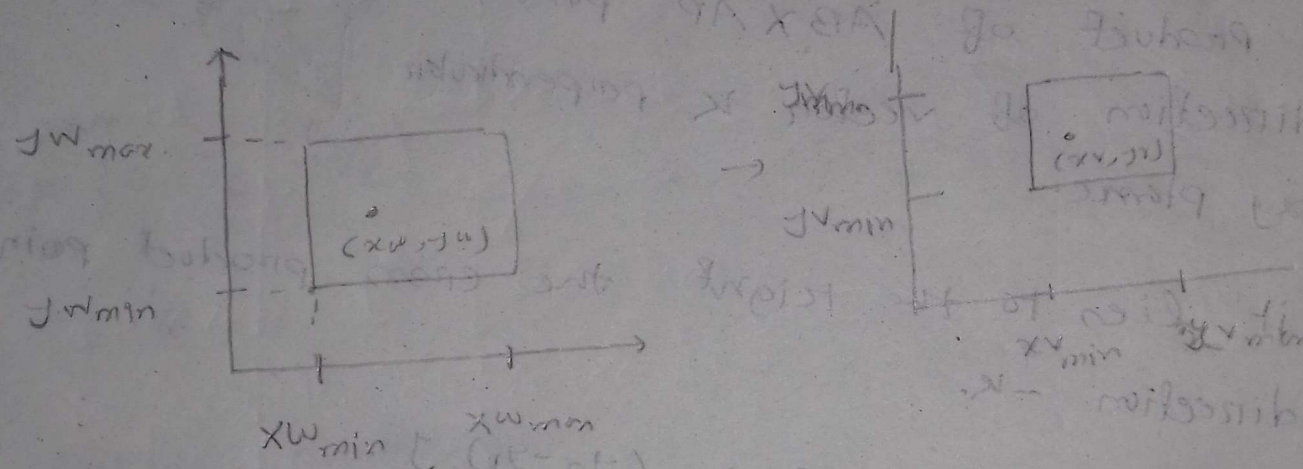
** Describe steps of window to viewport mapping.

A point at position (x_w, y_w) in a designated window is mapped to viewport co-ordinates (x_v, y_v) so that the relative position in two area are the same.



1. perform scalling transformation using a fixed point position of $(x_{w_{min}}, y_{w_{min}})$ that scales window area size of viewport.

2. Translate the scaled window area to the position of the viewpoint.

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Now,

$$\frac{x_v - x_{v_{min}}}{x_{v_{max}} - x_{v_{min}}} = \frac{x_w - x_{w_{min}}}{x_{w_{max}} - x_{w_{min}}}.$$

$$\frac{y_v - y_{v_{min}}}{y_{v_{max}} - y_{v_{min}}} = \frac{y_w - y_{w_{min}}}{y_{w_{max}} - y_{w_{min}}}.$$

Solving expression for viewpoint position (x_v, y_v).

$$x_v = x_{v_{min}} + (x_w - x_{w_{min}}) \cdot S_x.$$

$$y_v = y_{v_{min}} + (y_w - y_{w_{min}}) \cdot S_y.$$

Here,

$$S_x = \frac{x_{v_{max}} - x_{v_{min}}}{x_{w_{max}} - x_{w_{min}}}.$$

$$S_y = \frac{y_{v_{max}} - y_{v_{min}}}{y_{w_{max}} - y_{w_{min}}}.$$

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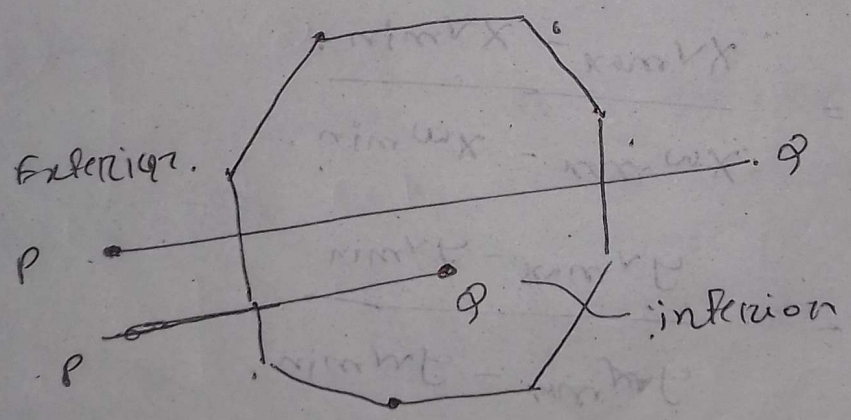
** How can we determine whether or not a given point is inside the polygon using even-odd method.

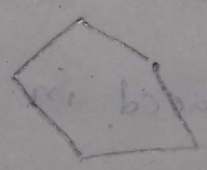
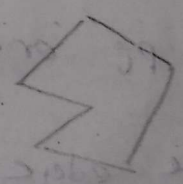
To apply this rule, we draw a line in any direction. starting from a particular point and any point outside the polygon.

Count the number of intersection of this line segment with each side of polygon. If the number of intersection is even then the point is outside.. otherwise it is inside.



Here first one is exterior point and second one is interior point.

** Differentiate between Convex and Concave polygon.

	Convex	Concave.
Defination.	A polygon is called convex if the line joining any two interior points lies completely inside polygon.	A polygon is called concave if the line joining any two interior points may not lie inside the polygon.
Self intersecting	No	Yes.
Angle	Every internal angle is less than 180°.	At least one internal angle is greater than 180°
Axis intersection	Any vertical or horizontal axis intersects at most ~~one~~ twice.	Any vertical or horizontal axis may intersect more than twice.
Recognizing Feature	All of its line curve outside	All of its line curve inward.
Example.		

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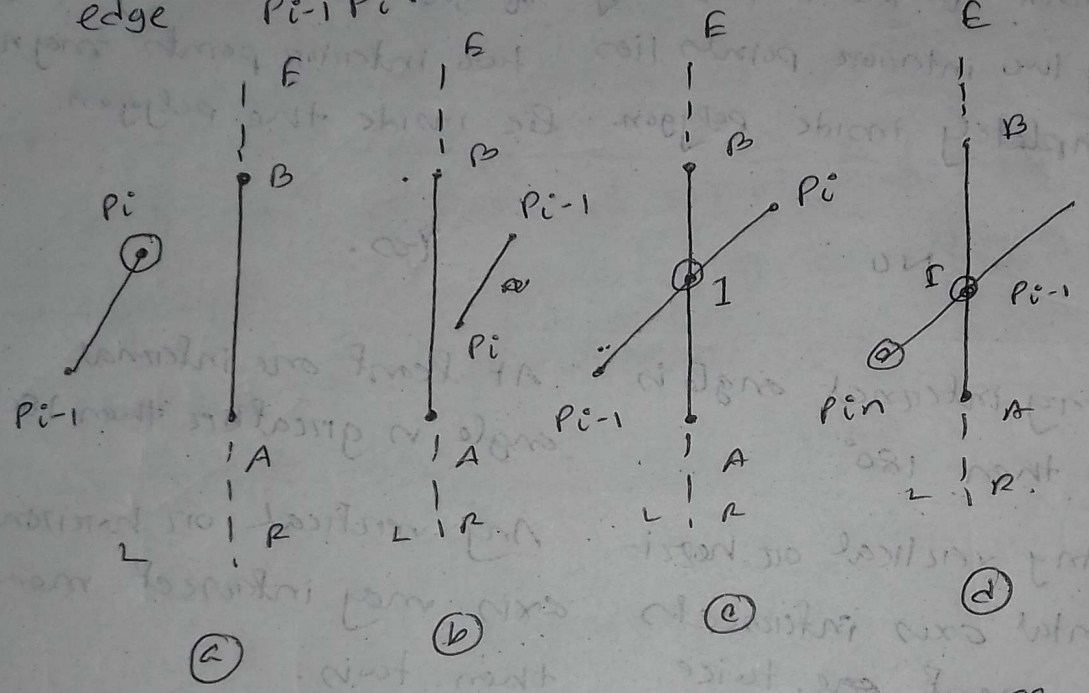
** Sutherland Hodgeman Algorithm.

In Sutherland Hodgeman algorithm we have to consider four case for each edge. Consider the edge $P_{i-1} P_i$.



1. If P_i and P_{i-1} are to the left of the edge, vertex P_i is placed in vertex output list.

2. If P_i and P_{i-1} both are to the right of the edge nothing is placed in vertex output list.

3. If P_{i-1} is to the left and P_i is to the right of the edge E, the intersection point I of edge and line is calculated and placed onto vertex output list.

4. If P_{i-1} is to the right and P_i is to the left of the edge E., the intersection point I of edge and line is calculated and both I and P_i is palaced in vertex output list.

v.vg

Drawbacks :-

1. clipping window must be a convex polygon.
2. may produce some dangling edges.
3. This algorithm produce list of vertices with extra edges.

To eliminate :-

i) we need to devise a post processing step.

ii) we can also use weilier artherton algorithm.

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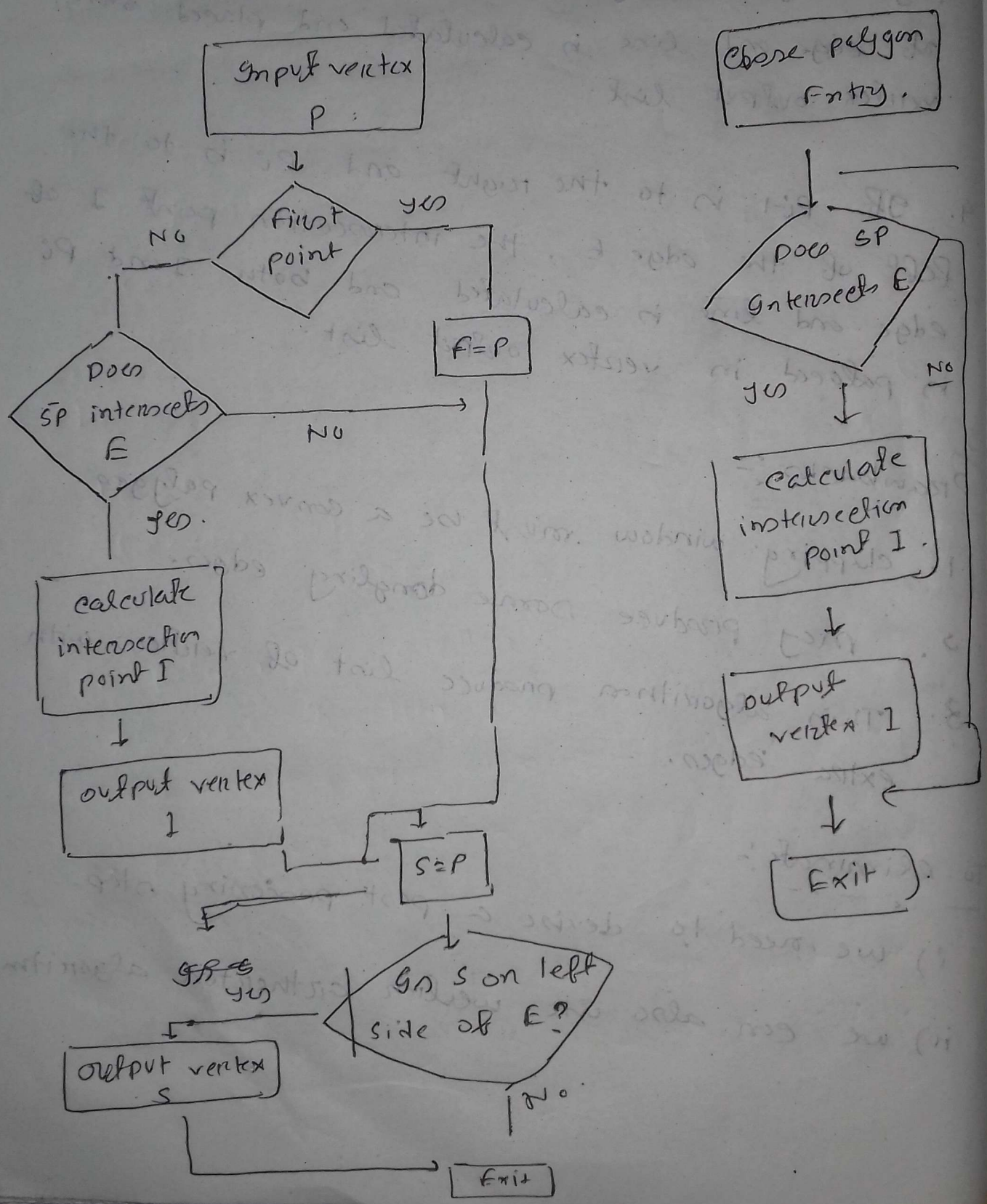
** Draw the flowchart illustrating logic of sutherland hodgeman algorithm.



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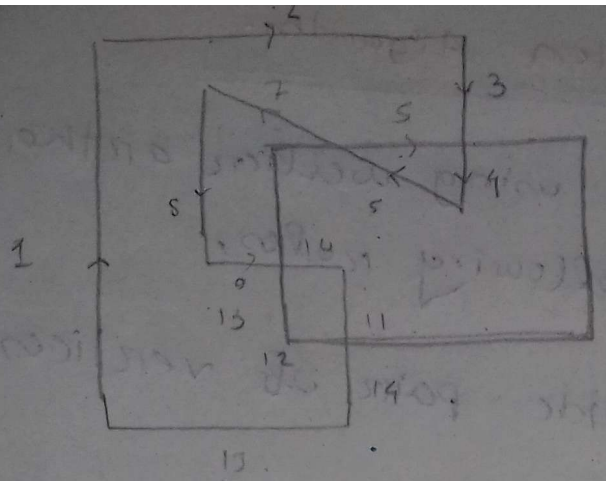
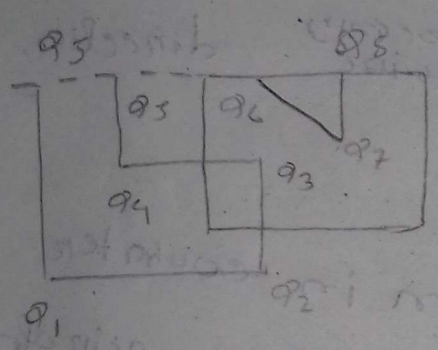
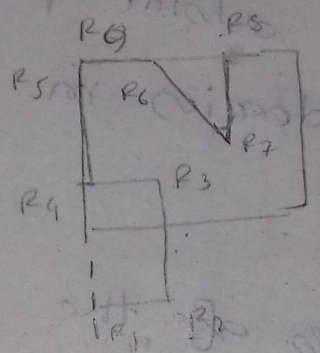
5.16

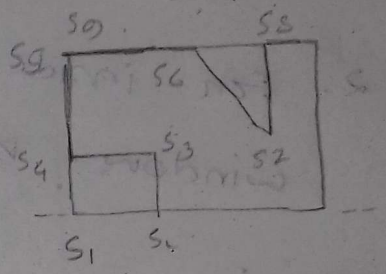




Clip Against Top boundary

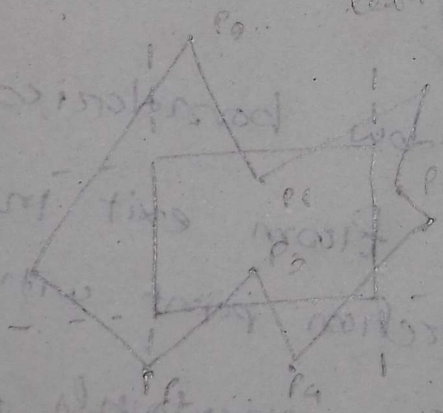


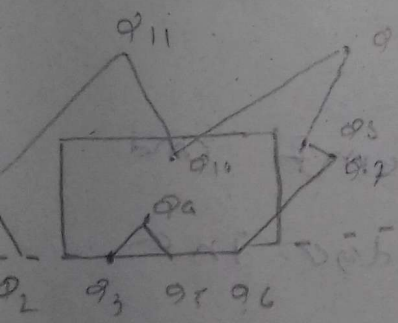
Clip against left boundary

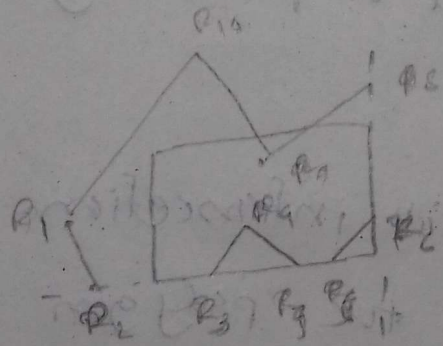


Clip against bottom boundary

5.95







(similarly

2nd

** State weiler atherton Algorithm-

For processing vertices using weiler atherton algorithm we use following rules,

1. For outside to inside pair of vertices follow polygon boundaries.
2. For inside to outside pair of vertices follow window boundaries in ~~clockwise~~ processing direction.

Steps :-

1. Process edges of the polygon in counter-clockwise order untill an inside-outside pair of vertices encountered.
2. Follow the window boundaries in a counter-clockwise direction from exit intersection point to another intersection point with polygon.
3. Repeat untill at a previously processed vertex,
4. Return to exit intersection point and continue processing the polygon edges in a counterclockwise order.

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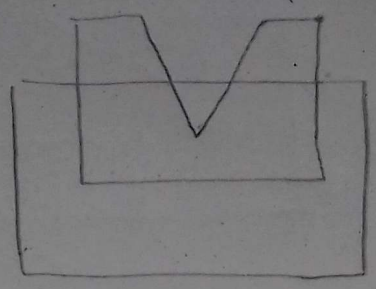
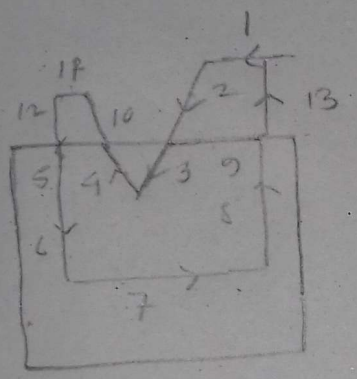
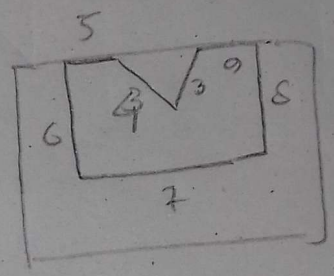
Example:-



By using Contour checking processing.





(গণনায় এক বিন্দু আসবে এই নিয়ম মেনে 270.

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