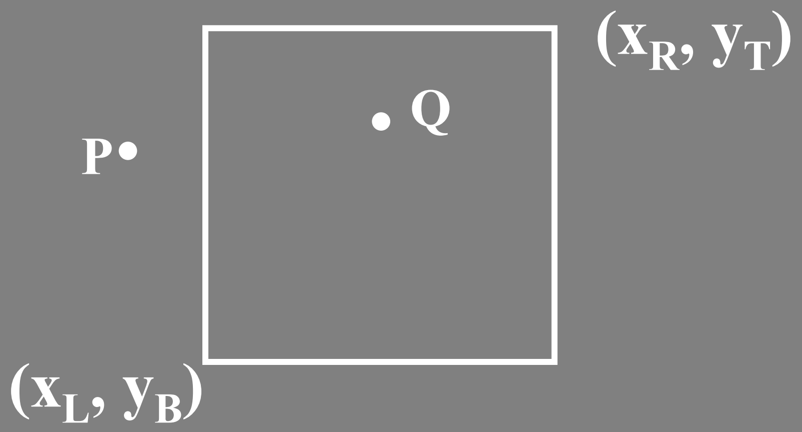
Clipping

Extraction of data/primitives inside a region of interest "window"
=> Discard (parts of) primitives outside window.

Point Clipping: Remove points outside window.
•A point is either entirely inside the window or not

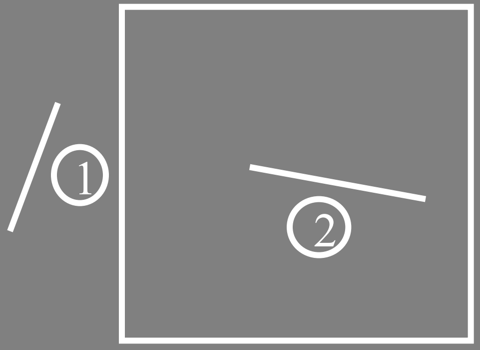


x_L <= x <= x_R
y_B <= y <= y_T
Q is *inside*
P is *outside*

Clipping

Line Clipping: Remove portion of line segment outside window

- Can we use point clipping for the end points?

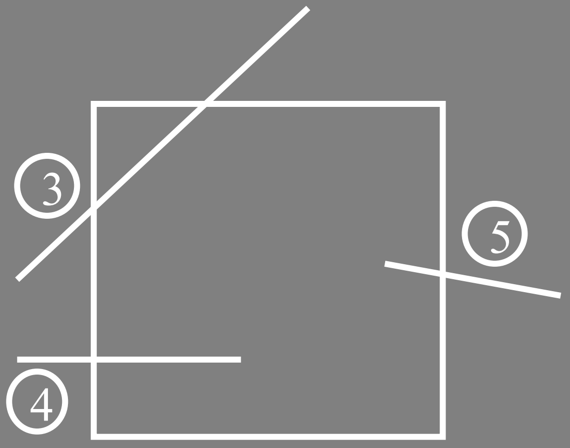


Point clipping works

Clipping

Line Clipping: Remove portion of line segment outside window

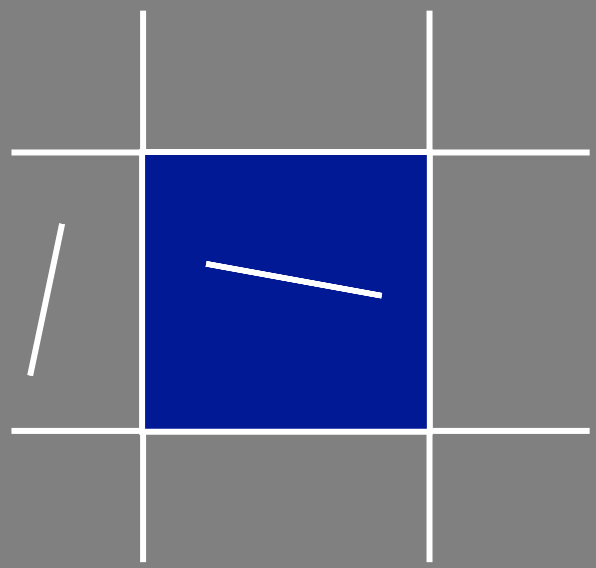
- How about these lines?



Point clipping does not work

Clipping

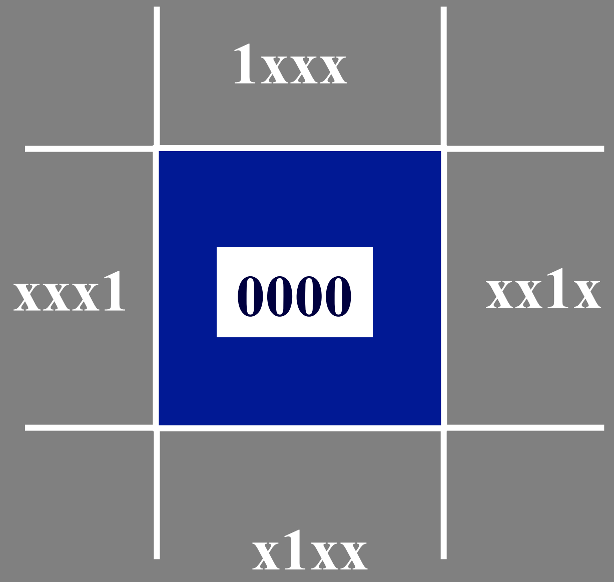
Cohen and Sutherland



Clipping

Cohen and Sutherland

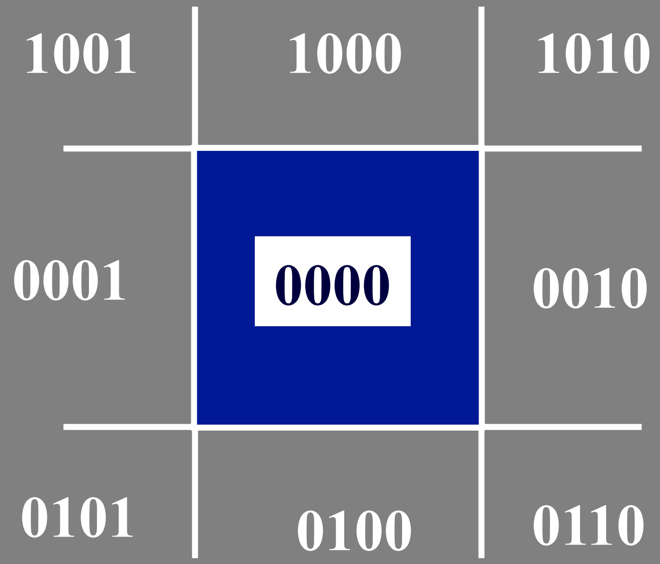
4 bit code to indicate the zone of end points of line with respect to window



Clipping

Cohen and Sutherland

4 bit code to indicate the zone of end points of line with respect to window

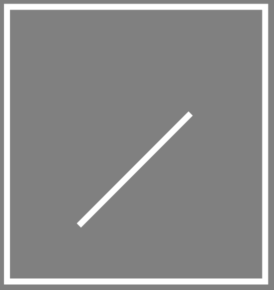


Clipping

Cohen and Sutherland

Trivially accept case

- line is totally visible
- if both ends of the line have outcode as 0000

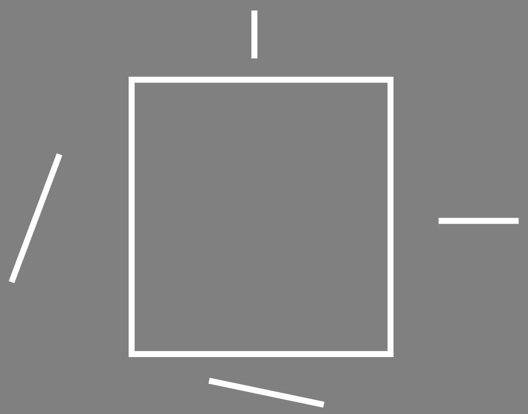


Trivially accept

Clipping

Cohen and Sutherland

Trivially reject case
- line is totally invisible
- logical AND of the two end points outcodes



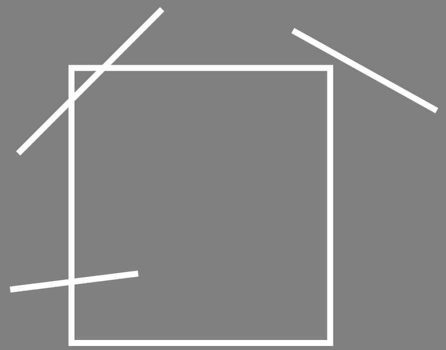
Trivially reject

Clipping

Cohen and Sutherland

If not trivially reject and accept case

- line is potentially visible



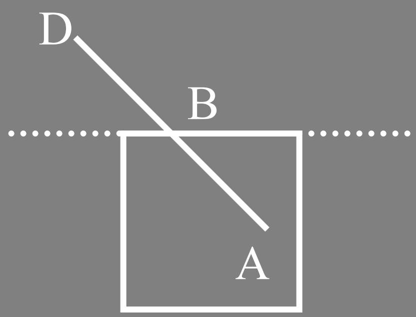
Potentially visible

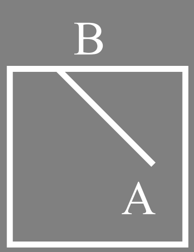
Clipping

Cohen and Sutherland

If potentially visible

- subdivide into segments and apply trivial acceptance and rejection test
- segments by intersection with window edges
- edges in any order but consistent (e.g., top-bottom, right-left)





Result

Clipping

Cohen and Sutherland

- simple, still popular
- limited to rectangular region
- extension to 3D clipping using 3D orthographic view volume is straightforward

Clipping

Cyrus Beck Line Clipping
(Liang and Barsky)

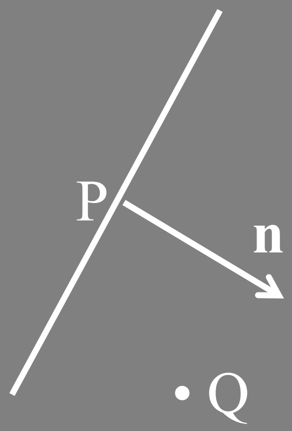
- any convex region

Parametric line (input line AB):

$$L(t) = A + (B - A)t; t \in (0,1)$$

Clipping

Cyrus Beck Line Clipping
(Liang and Barsky)



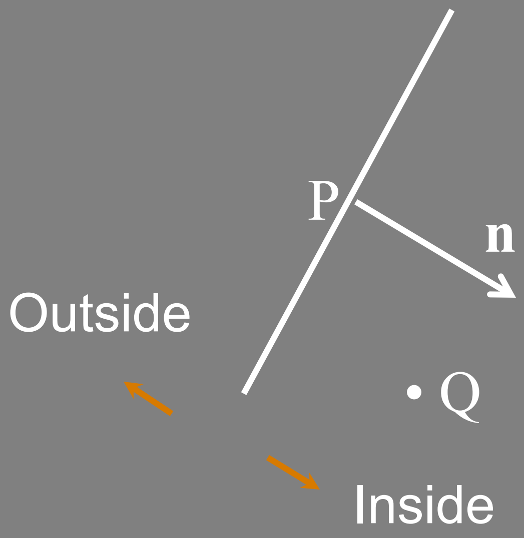
Implicit line (window edge):

$$I(Q) = (Q - P).n$$

Tells us on which side of the line the point Q is.

Clipping

Cyrus Beck Line Clipping
(Liang and Barsky)



Evaluate

$$I(Q) = (Q - P).n$$

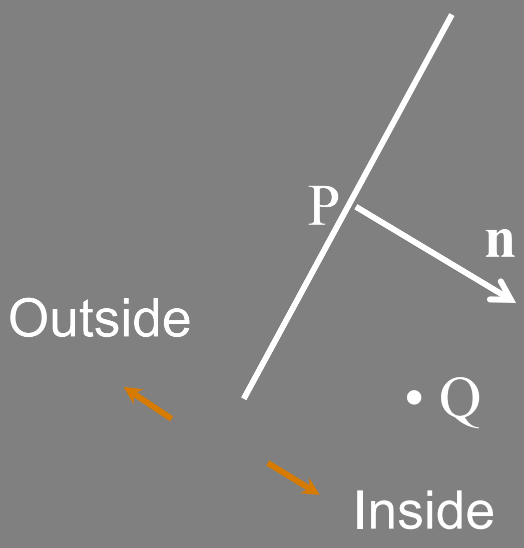
If > 0 inside halfspace of line (plane)
If < 0 outside halfspace of line (plane)
If = 0 on the line

Should give indications for trivial accept and reject cases.

Clipping

Cyrus Beck Line Clipping

(Liang and Barsky)



Window edge $I(Q) = (Q - P).n$

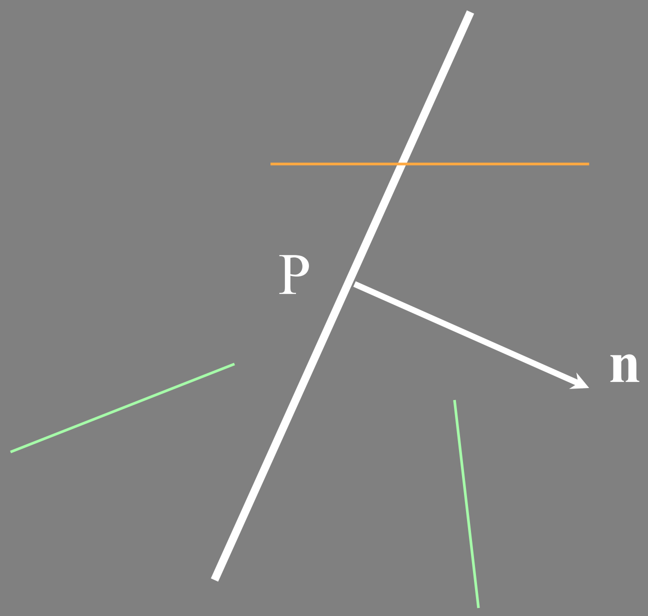
Line segment $L(t) = A + t(B - A)$

Trivial Reject $I(A) < 0 \text{ AND } I(B) < 0$

Trivial Accept $I(A) > 0 \text{ AND } I(B) > 0$

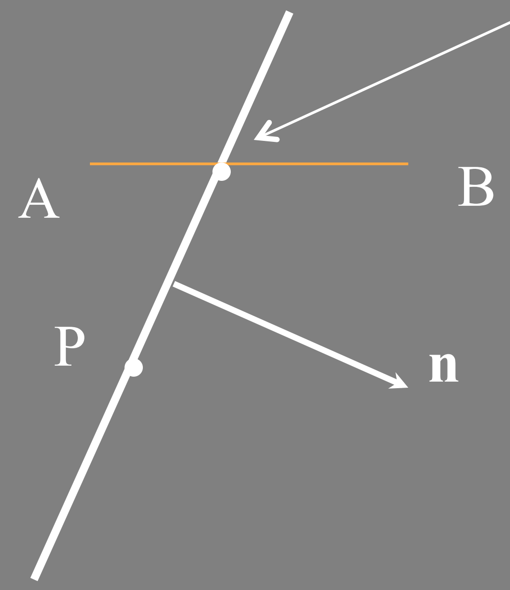
Clipping

Cyrus Beck Line Clipping
(Liang and Barsky)



Clipping

Cyrus Beck Line Clipping
(Liang and Barsky)



$$L(t) = A + (B - A)t$$

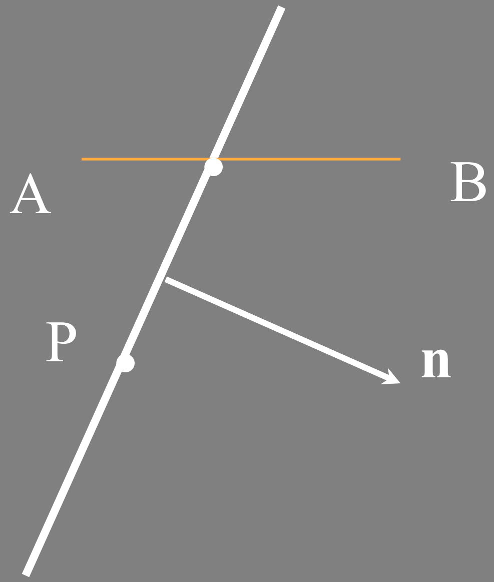
$$I(Q) = (Q - P).n$$

$$I(L(t)) = 0; \text{solve for t}$$

$$(L(t) - P).n = 0$$
$$(A + t(B - A) - P).n = 0$$
$$(A - P).n + t(B - A).n = 0$$

Clipping

Cyrus Beck Line Clipping
(Liang and Barsky)

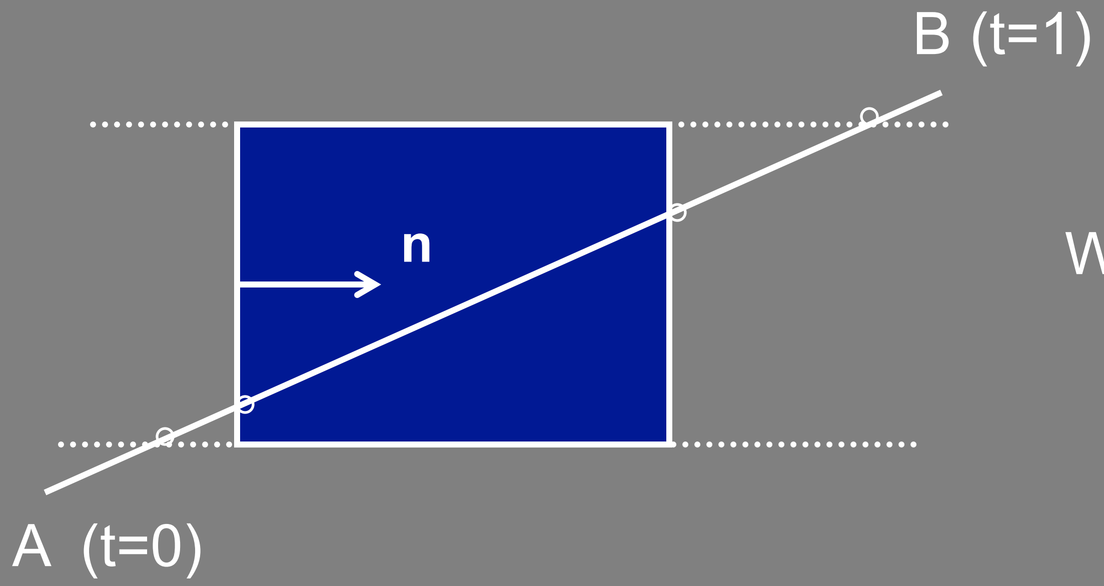


$$t = \frac{(A - P).n}{(B - A).n}$$

$$t = \frac{(A - P).n}{(A - P).n - (B - P).n}$$

Clipping

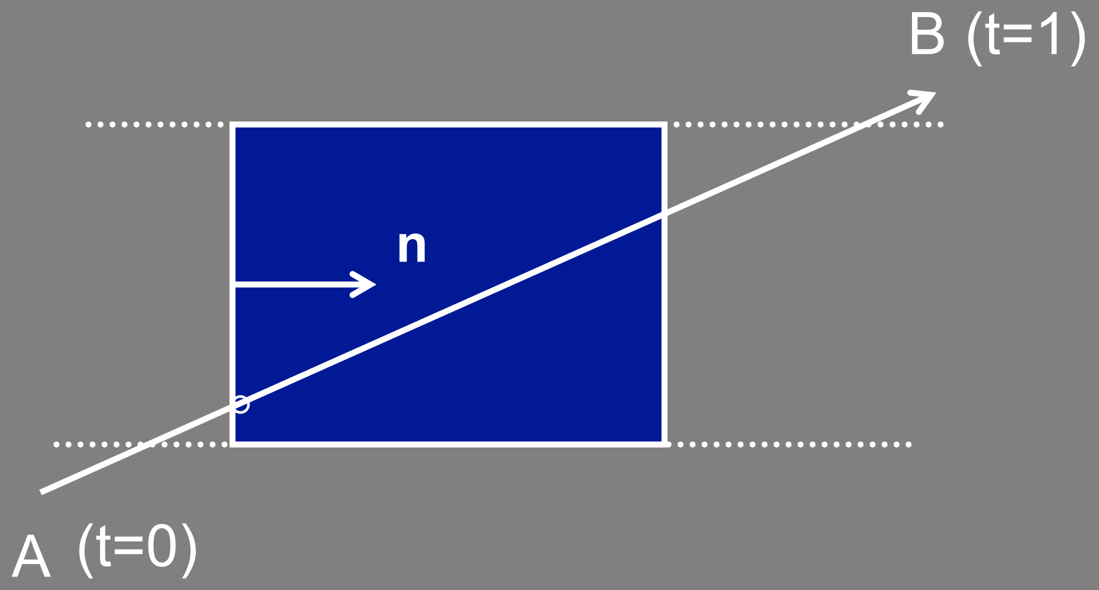
Cyrus Beck Line Clipping
(Liang and Barsky)



Which 't' to select ?

Clipping

Cyrus Beck Line Clipping
(Liang and Barsky)



$$t = \frac{(A - P).n}{(B - A).n}$$

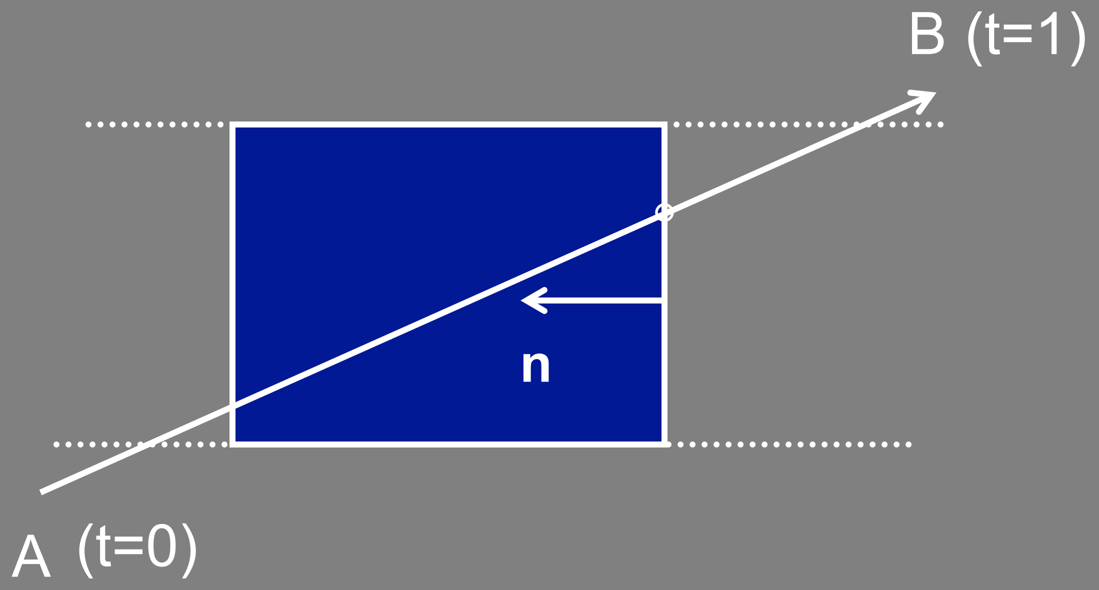
$$D = (B - A).n$$

D > 0 label t as t_E

Entering

Clipping

Cyrus Beck Line Clipping
(Liang and Barsky)



$$t = \frac{(A - P).n}{(B - A).n}$$

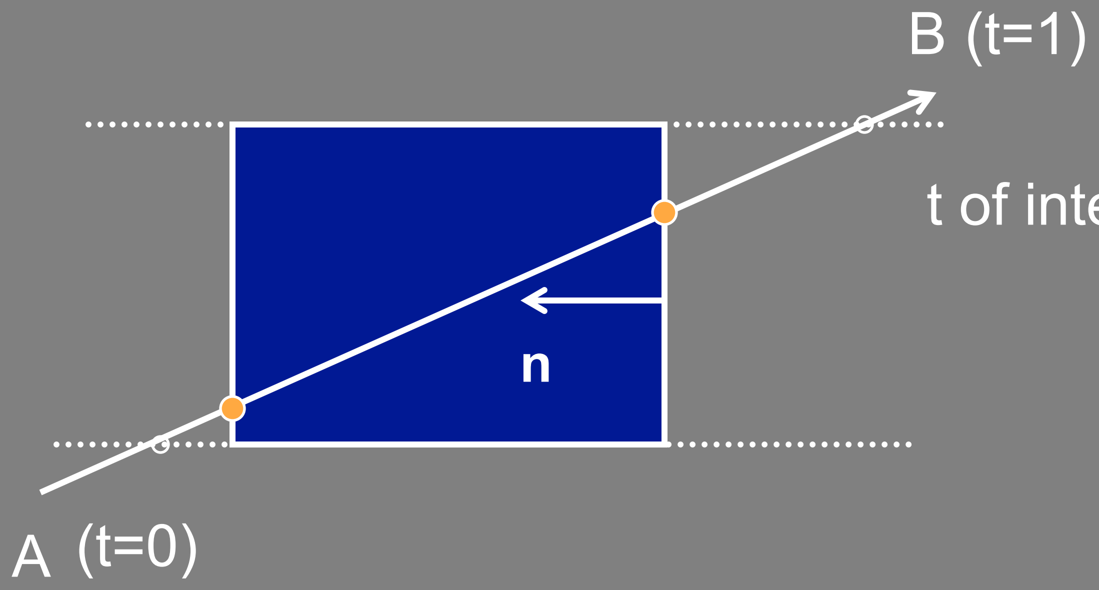
$$D = (B - A).n$$

D < 0 label t as t_L

Leaving

Clipping

Cyrus Beck Line Clipping
(Liang and Barsky)



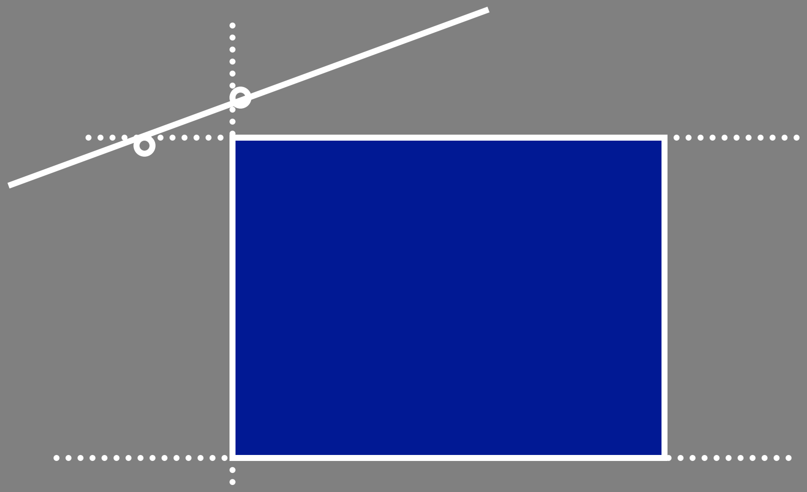
t of interest:

largest t_E $\boldsymbol{t_E^{max}}$

smallest t_L $\boldsymbol{t_L^{min}}$

Clipping

Cyrus Beck Line Clipping
(Liang and Barsky)



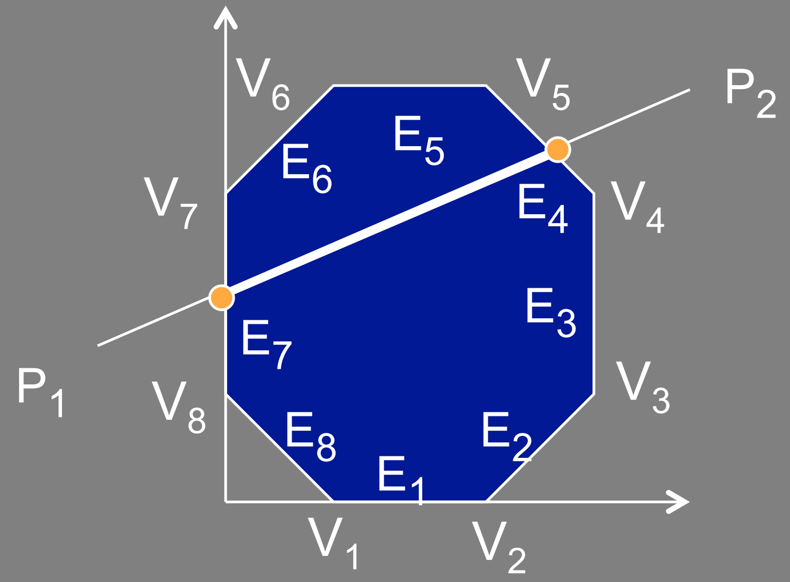
If $t_E^{max} > t_L^{min}$

Reject

Clipping

Cyrus Beck Line Clipping
(Liang and Barsky)

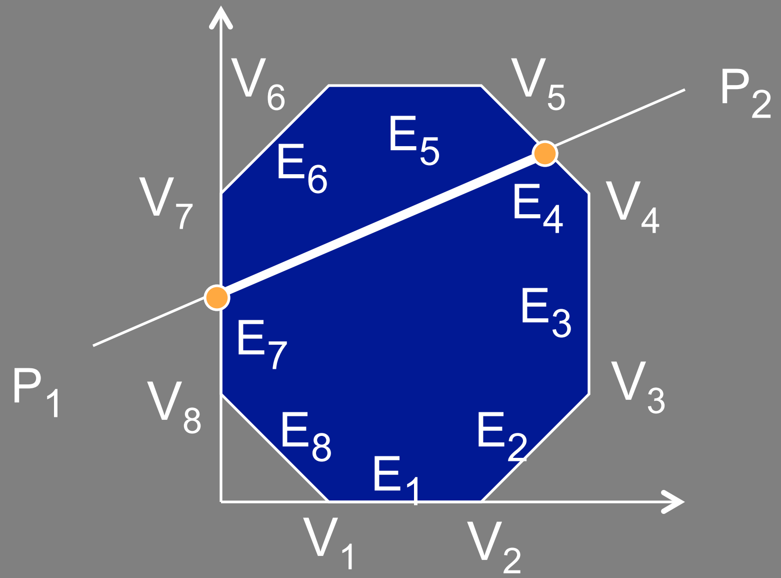
Arbitrary Convex Window



Clipping

Cyrus Beck Line Clipping
(Liang and Barsky)

Arbitrary Convex Window



$E_1 x E_2$: positive

$E_2 x E_3$: positive

.

.

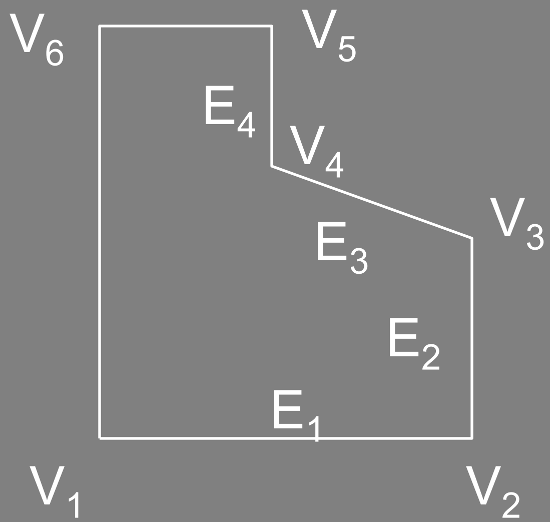
.

Polygon is convex if for all adjacent edges the sign of cross product is same.

Clipping

Cyrus Beck Line Clipping
(Liang and Barsky)

Arbitrary Window



$E_1 x E_2$: positive

$E_2 x E_3$: positive

$E_3 x E_4$: negative

.

.

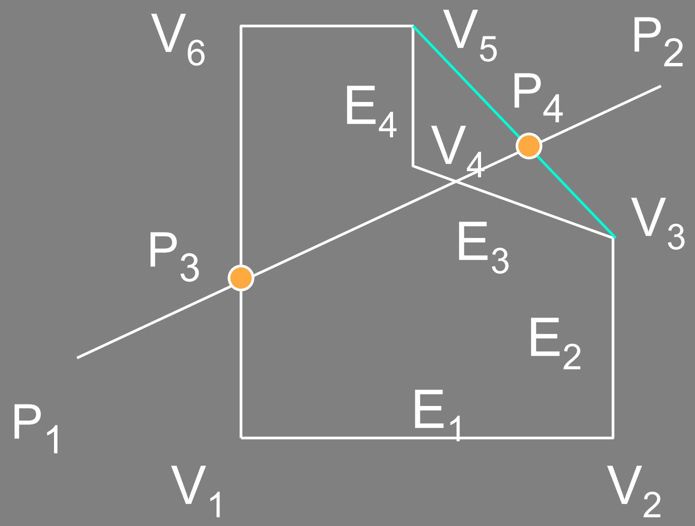
.

Polygon is non-convex

Clipping

Cyrus Beck Line Clipping
(Liang and Barsky)

Arbitrary Window



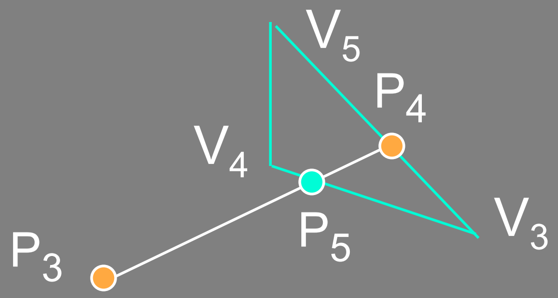
Make the polygon convex by adding the edge V_3V_5

Clip against the convex polygon => P_3P_4

Clipping

Cyrus Beck Line Clipping
(Liang and Barsky)

Arbitrary Window



Clip against the triangle
=> P_5P_4

Subtract P_5P_4 from P_3P_4
=> P_3P_5