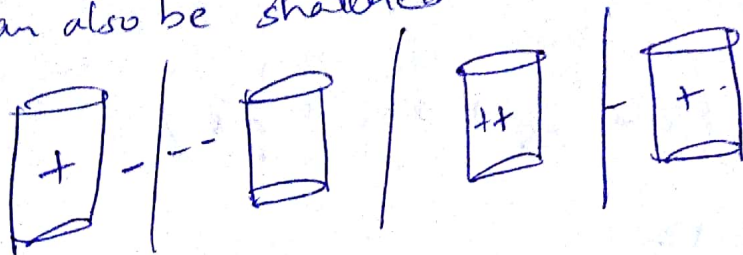


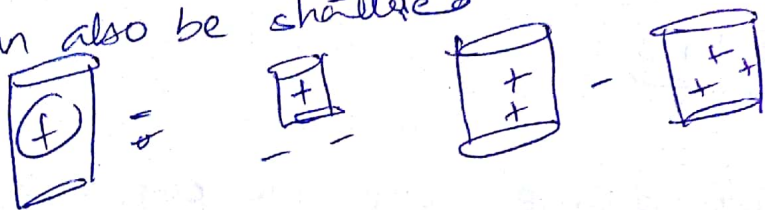
① \mathbb{R}^3 : Cylinder:

→ 1 point can always be classified ^{shattered}

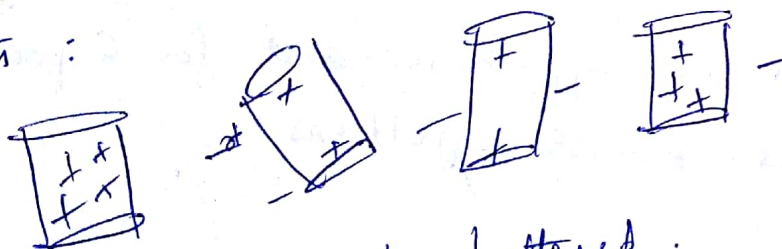
→ 2 points can also be shattered



→ 3 points can also be shattered

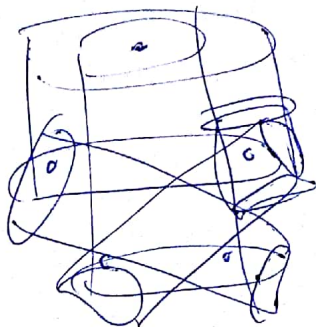


→ 4 points :



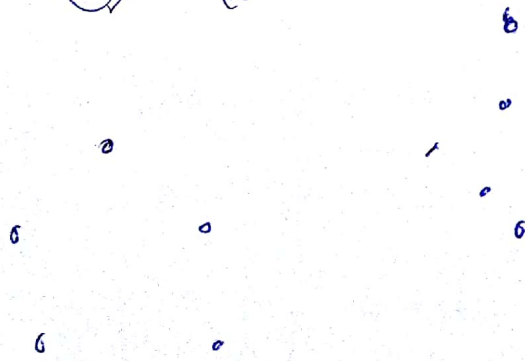
4 points can be shattered.

→ 5 points :



Any 5 points in the pentagon can be shattered.

6 points :



→ this set cannot be shattered

→ cannot be shattered

$$\Rightarrow |VC| = 5.$$

$$a) M \geq \frac{1}{\epsilon} \left(4 \ln \frac{2}{\delta} + 8 |VCH| \ln \frac{13}{\epsilon} \right)$$

$$\delta = 0.95$$

$$\epsilon = 0.8$$

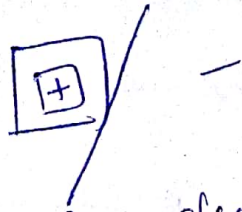
$$\Rightarrow M \geq \frac{1}{0.8} \left(4 \ln \frac{2}{0.95} + 8 \times 5 \ln \frac{13}{0.8} \right)$$

$$\Rightarrow M \geq 143.12$$

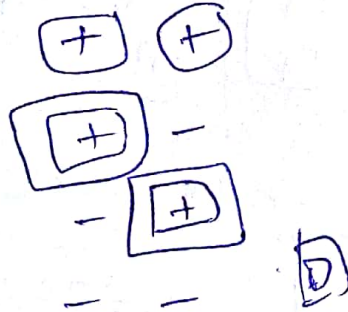
$$\Rightarrow \underline{M \geq 143}$$

⑥ $|VCH|$ doesn't change since we are choosing only one cylinder from the hypothesis and for 6 points it behaves the same as first hypothesis.

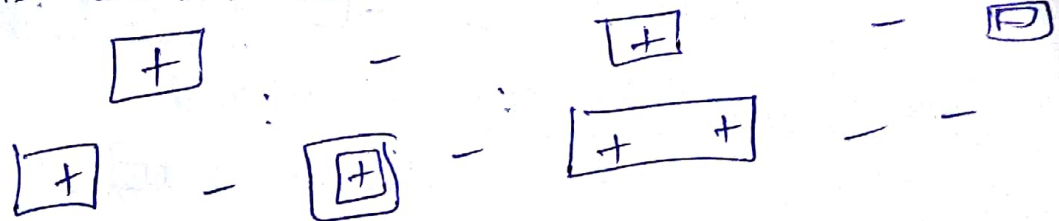
② \mathbb{R}^2 : ① single point can always be shattered



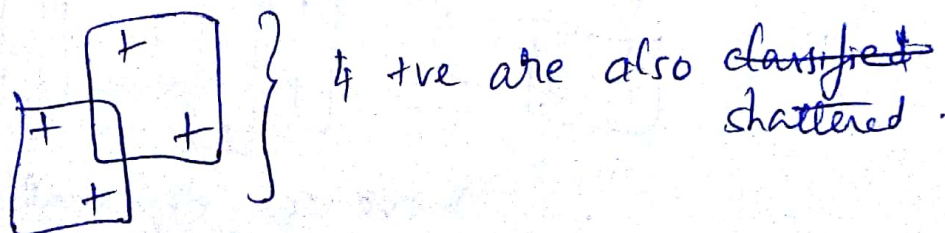
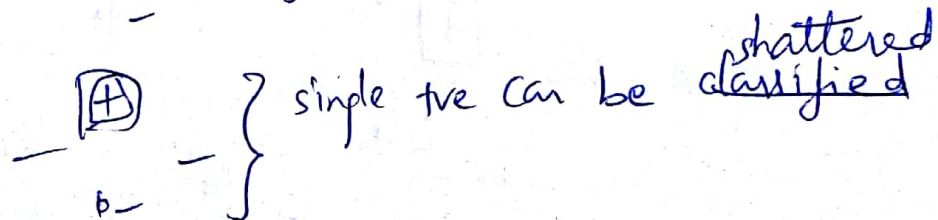
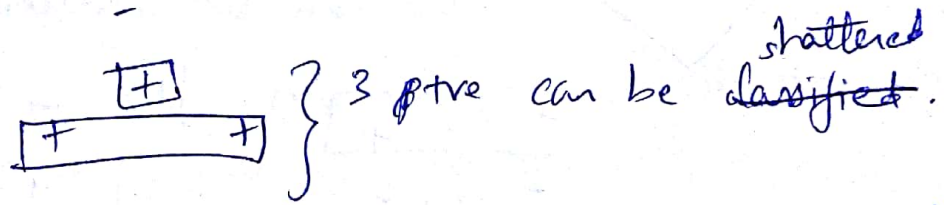
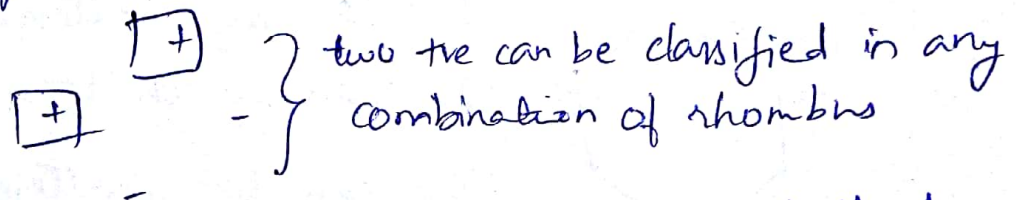
② two points can also be shattered



③ three points can also be shattered in a ~~triangle~~ triangle form



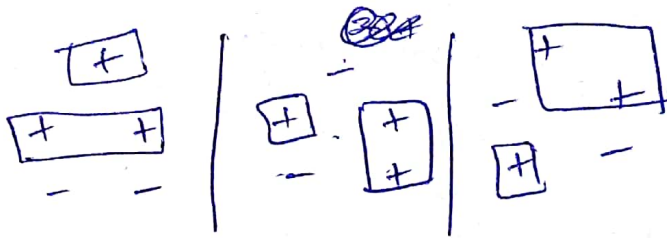
④ four points:



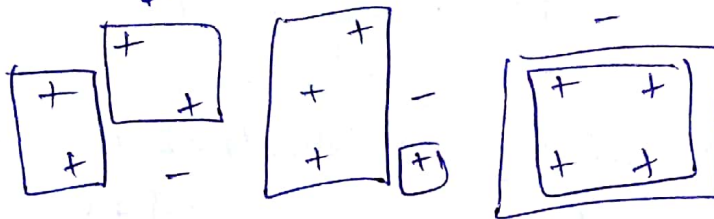
⑤ 5 points : pentagon formation

* ① + can be shattered

* ② + can be shattered



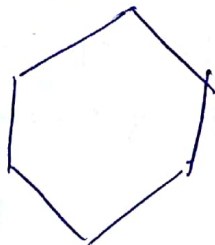
* ③ +ve can be shattered.



4+ve can be shattered

5+ve can also be shattered

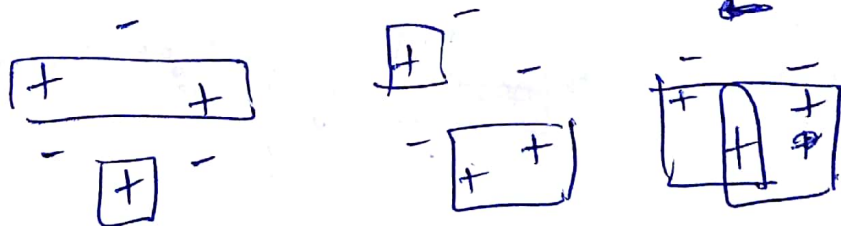
⑥ points : hexagon formation



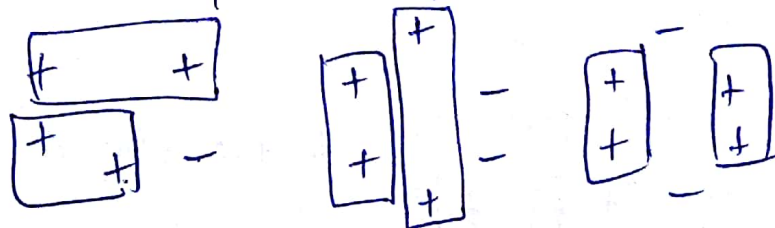
1 + can be shattered

2 + can be shattered

3 + can be shattered



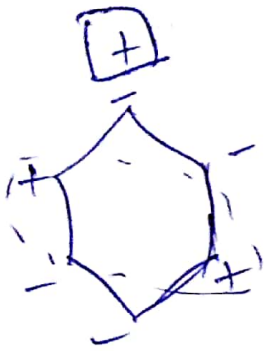
- 4+ve can be shattered



- 5+ve can be shattered

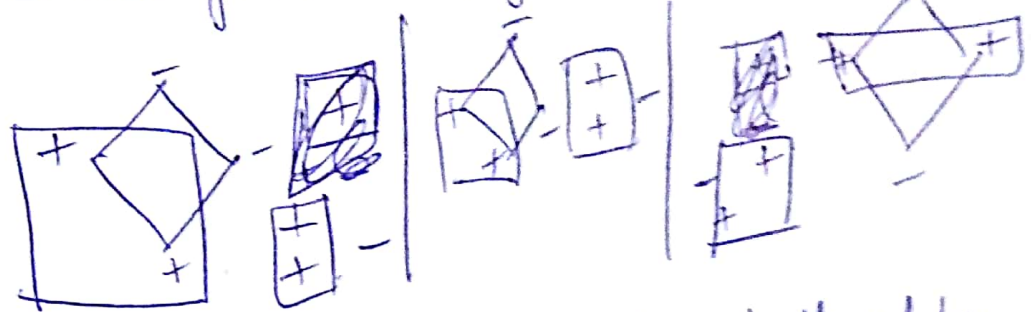
- 6+ve can be shattered.

7 points : ① we can have 6 points as hexagon and 1 point outside.



this configuration cannot be shattered.

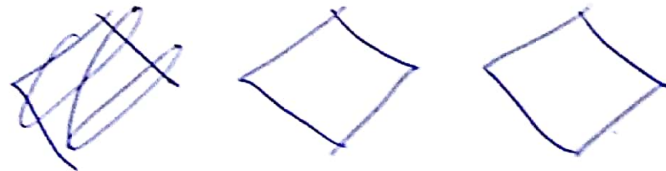
② ~~three~~ points + 4 points



any combination here can be shattered by two axis parallel rectangles (rhombus + triangle)

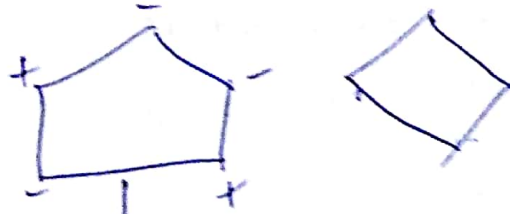
8 points : A single axis parallel rectangle can shatter 4 points in rhombus.

2 rectangles can shatter two rhombus configurations



9 points : \Rightarrow all 9 points in one polygon cannot be shattered by two rectangles

\rightarrow 5 points in ~~pentagon~~ pentagon and 4 points in rhombus



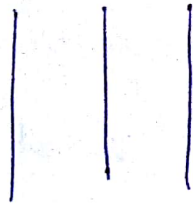
this cannot be shattered.

Any combination of 9 points in polygon form cannot be shattered

$$\Rightarrow \underline{\underline{|V| = 8}}$$

③ With three distinct linear separators:
we can have following configurations

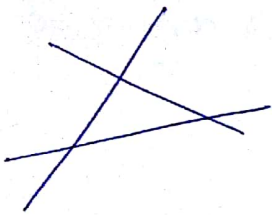
3 parallel:



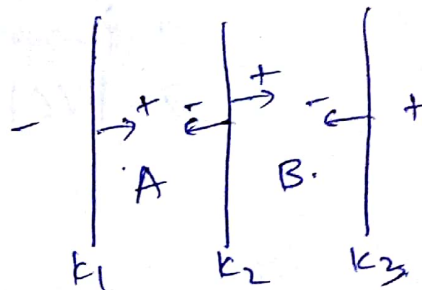
2 parallel:



All intersecting:

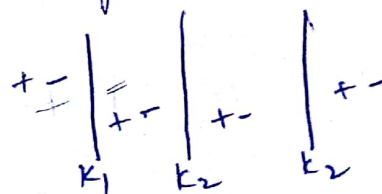


3 parallel lines:



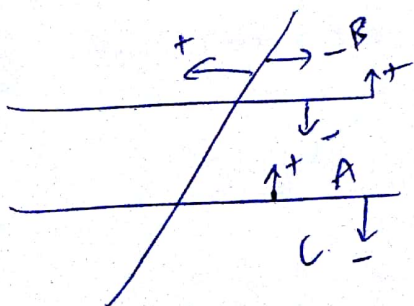
if a point is in region 'A' or 'B', it can be shattered by this space.

if two points are in any region here, ~~no~~ points cannot be shattered.



So, $|VC| = 1$ for this configuration of hypothesis space.

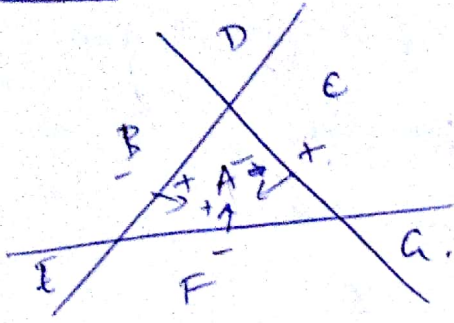
2 parallel lines:



if a point is in region 'A' or 'B' or 'C', it can be shattered by any one line.
if two points are in region 'A' or 'B' or 'C', it cannot be shattered.

$$\Rightarrow |VC| = 1$$

All intersecting :



Any one point can be shattered by this hypothesis space.

• If two points are in same region

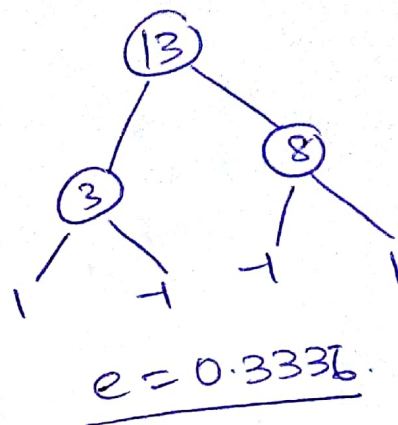
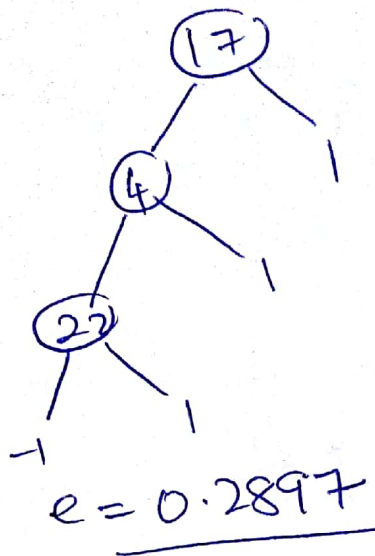
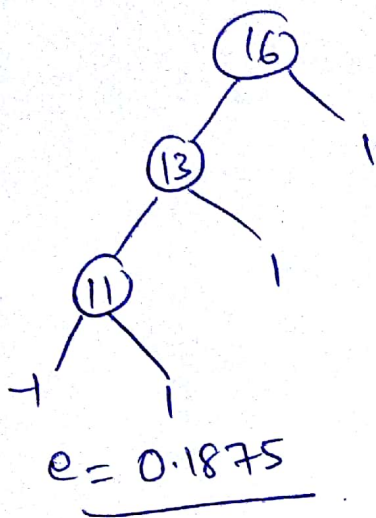
A \therefore cannot shatter

B
C
D
E
F
G
} cannot shatter.

Any combination of two point in two different regions also cannot be shattered
 $\Rightarrow |VC| = 1.$

2) Adaboost.

Ⓐ $M=3$:



Coordinate descent :

Ⓐ Ran 200 iterations of coordinate descent :
exponential loss before = 80
exponential loss after = 40.17

$\alpha = -1.5, 0.04, 0.6369, 0.045, -0.4624, 0.045, 0.47, 0.045$
 $-3.3 \dots (200 \text{ of them}).$

Ⓑ Coordinate descent Accuracy on test data = 0.695187

Ⓒ Adaboost 20 iterations : 0.66844

graphs attached.