

# Model Evaluation

# INTRODUCTION

- It is a table that is often used to describe the performance of a classification model on a set of test data for which the true values are known.
- It is a table of two dimensions; Actual Value and Predicted Value.
- Confusion matrix, also known as an error matrix.

## PREDICTED

A C T U A L	185	NO	YES	
	NO	55 [TN]	15 [FP]	70
	Yes	10 [FN]	105 [TP]	115
	65	120		

## Matrix Terms

- **True Positives (TP)** – It is the case when both actual class & predicted class of data point is 1.
- **True Negatives (TN)** – It is the case when both actual class & predicted class of data point is 0.
- **False Positives (FP)** – It is the case when actual class of data point is 0 & predicted class of data point is 1.
- **False Negatives (FN)** – It is the case when actual class of data point is 1 & predicted class of data point is 0.

## Measure Terms

- **Accuracy:**

- It is how close a measured value to the actual (True) value.

$$\text{Accuracy} = (\text{TP} + \text{TN}) / \text{Total}$$

$$= (55+105)/185$$

$$= 0.86$$

Cont...

- **Precision:**

- It is how close the measured values are to each other.

$$\text{Precision} = \text{TP} / \text{Predicted Yes}$$

$$= 105 / 120$$

$$= 0.87$$

# Recall



- **Recall:**

- It is the ratio of all correctly predicted positive predictions

$$\text{Recall} = \text{TP} / \text{Actual Yes}$$

$$= 105 / 115$$

$$= 0.91$$

Cont...

- **Error Rate:**

- It is calculated as the number of all incorrect predictions divided by the total number of the datasets.
- The best error rate is 0.0
- The worst error rate is 1.0.

$$\begin{aligned}\text{Error Rate} &= 1 - \text{Accuracy} = (\text{FN} + \text{FP}) / \text{Total} \\ &= 1 - 0.86 = (15 + 10) / 185 \\ &= 0.14\end{aligned}$$

# Specificity

Specificity means how many of the actual negative cases the model correctly identified as negative.

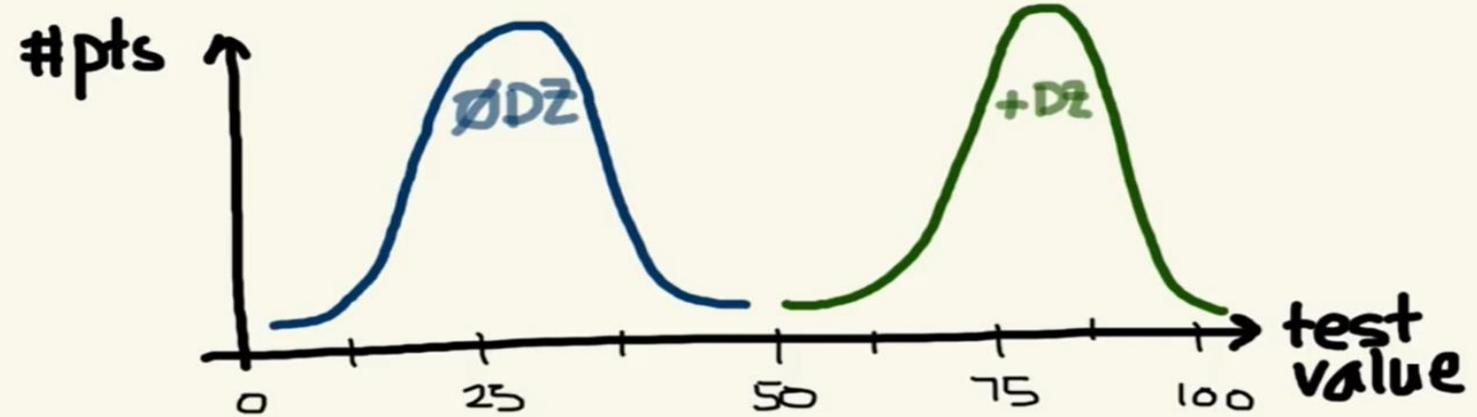
$$\text{Specificity} = \frac{TN}{TN + FP}$$

# Sensitivity

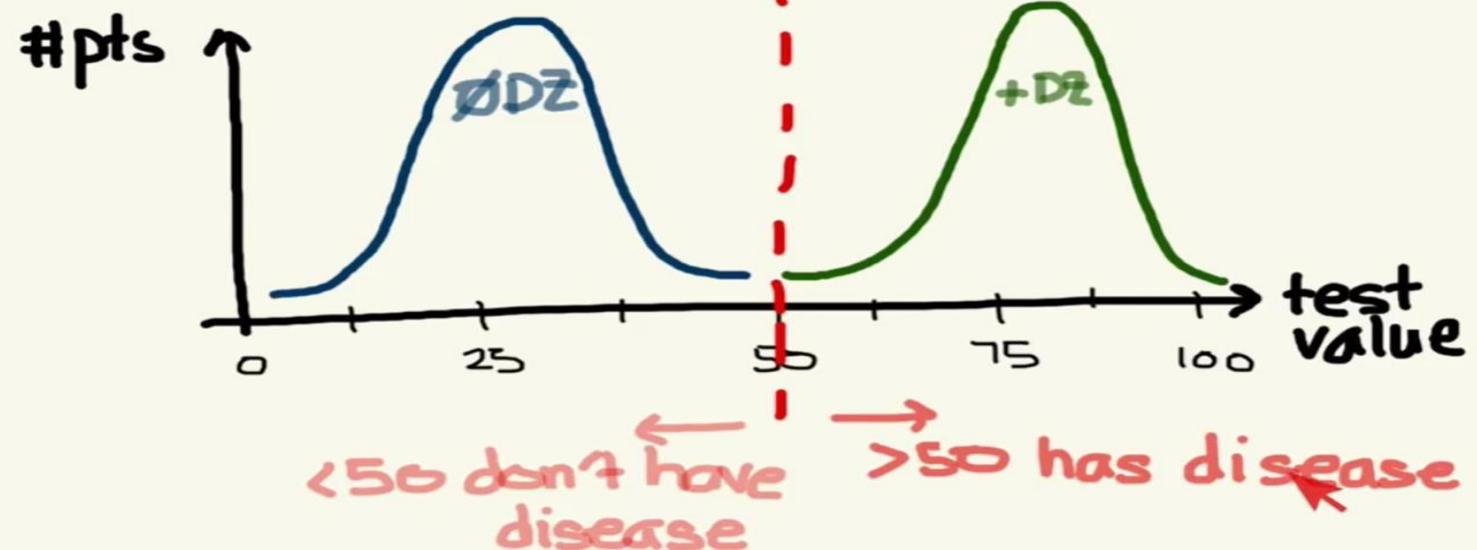
Sensitivity means how many of the actual positive cases the model correctly identified as positive. (Recall) (TPR)

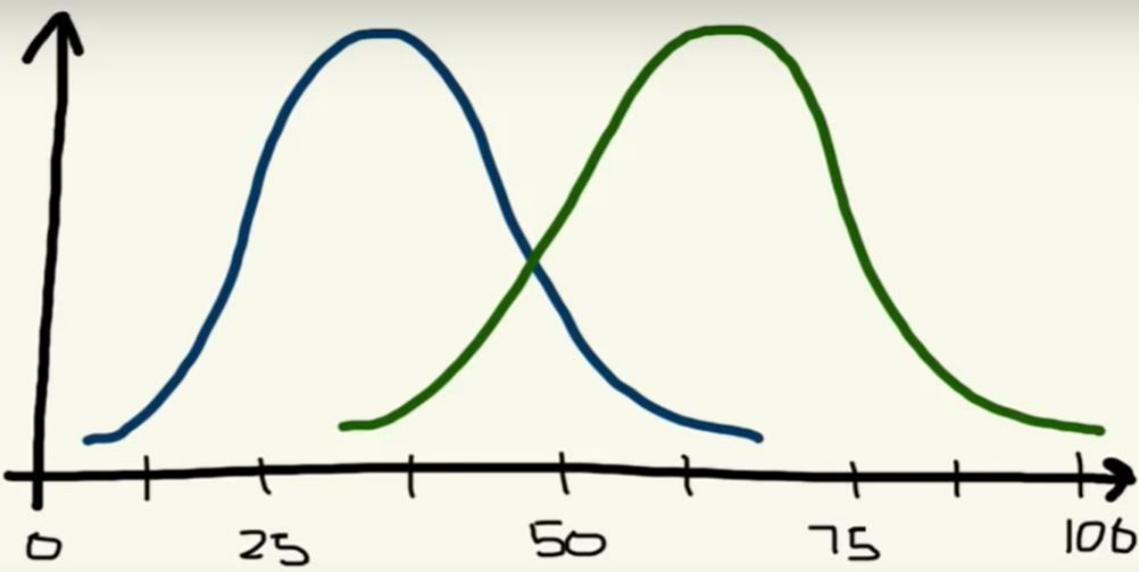
$$\text{Sensitivity} = \frac{TP}{TP + FN}$$

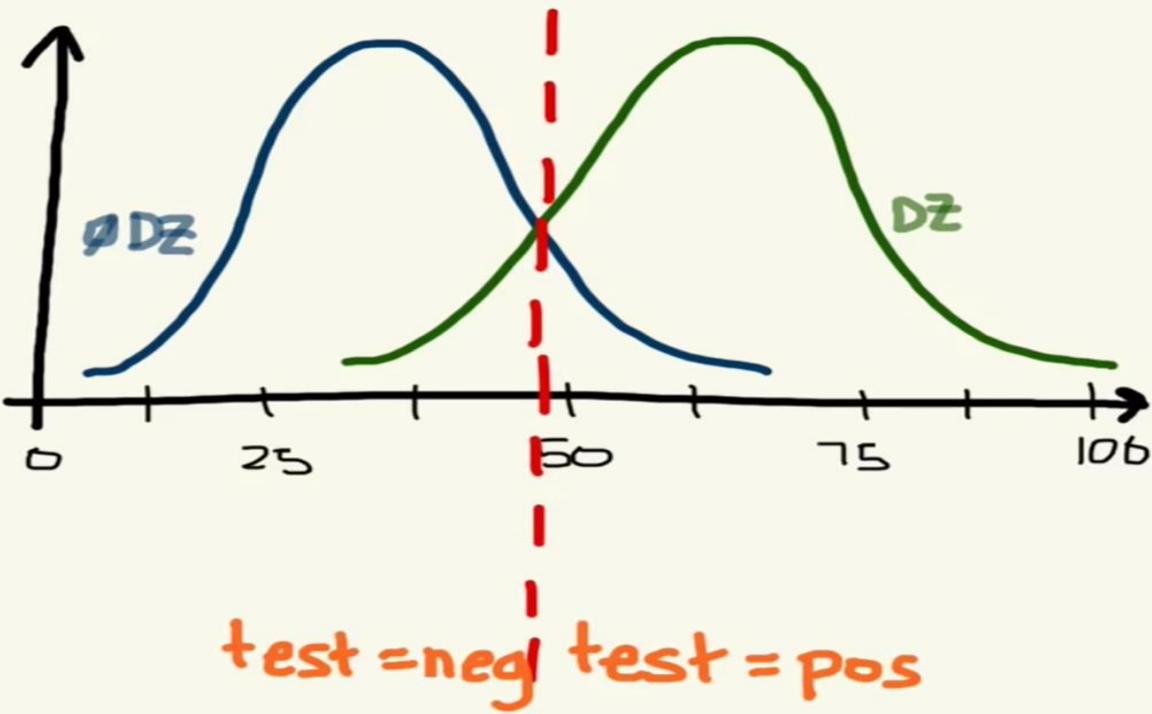
## the TRADEOFF between SENS & SPEC

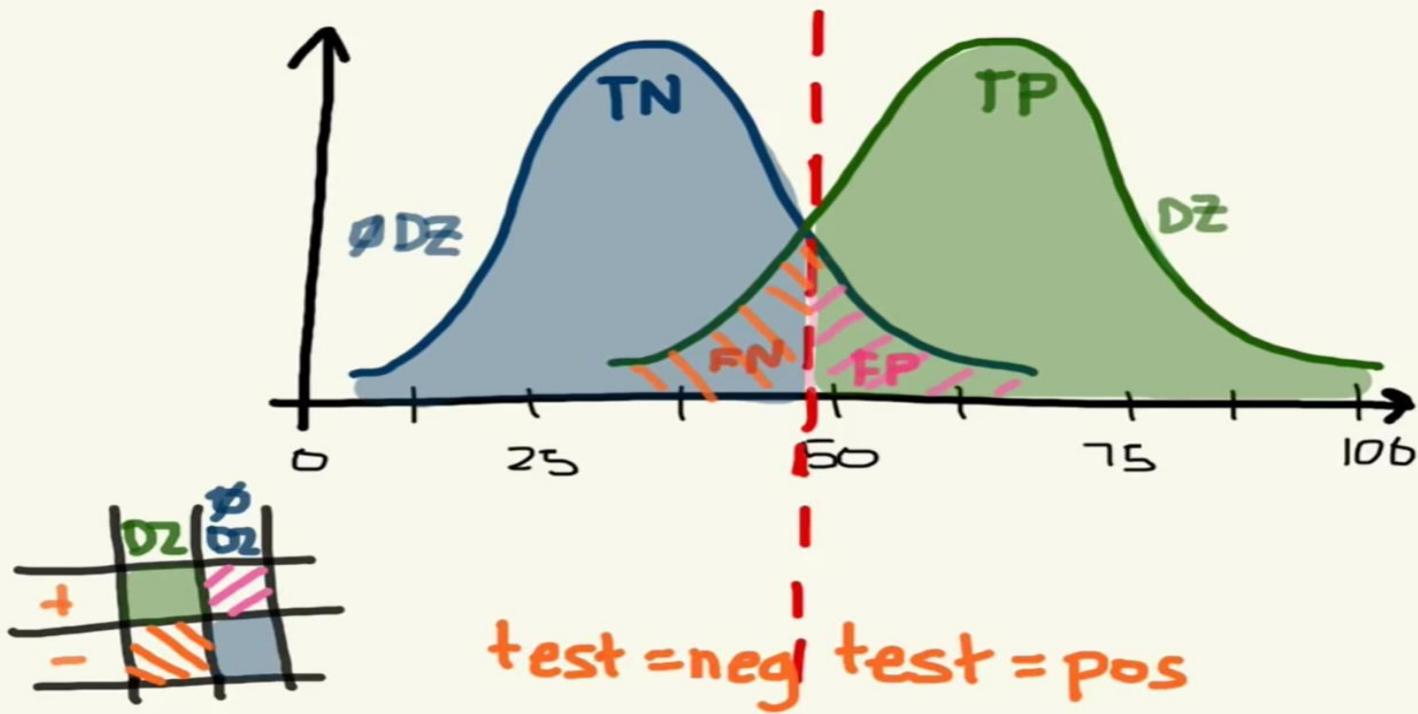


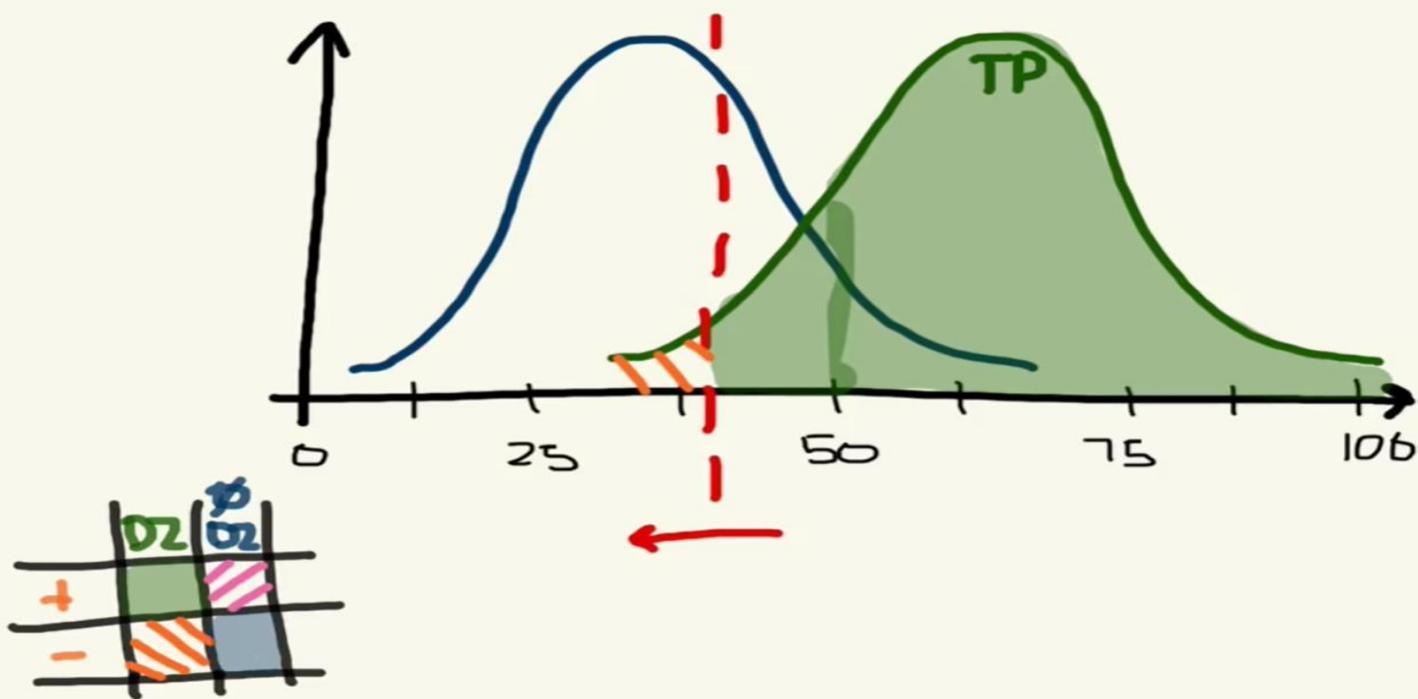
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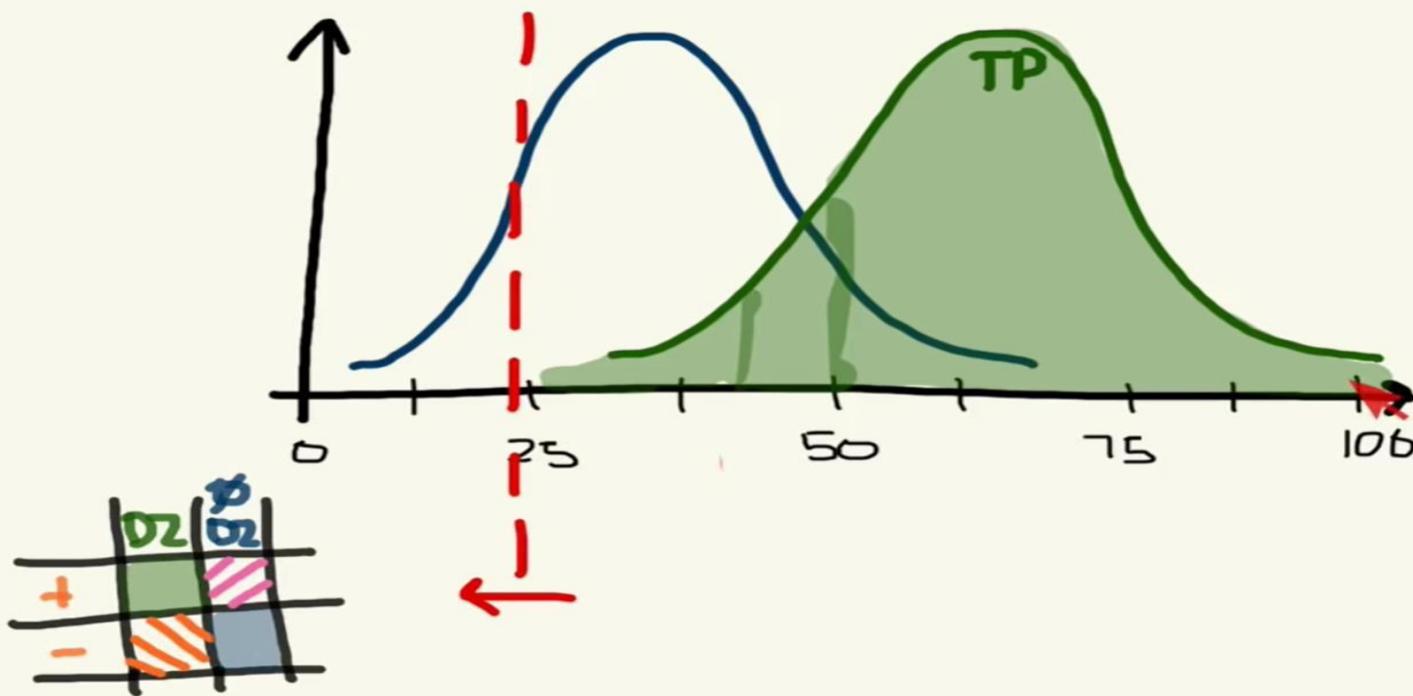


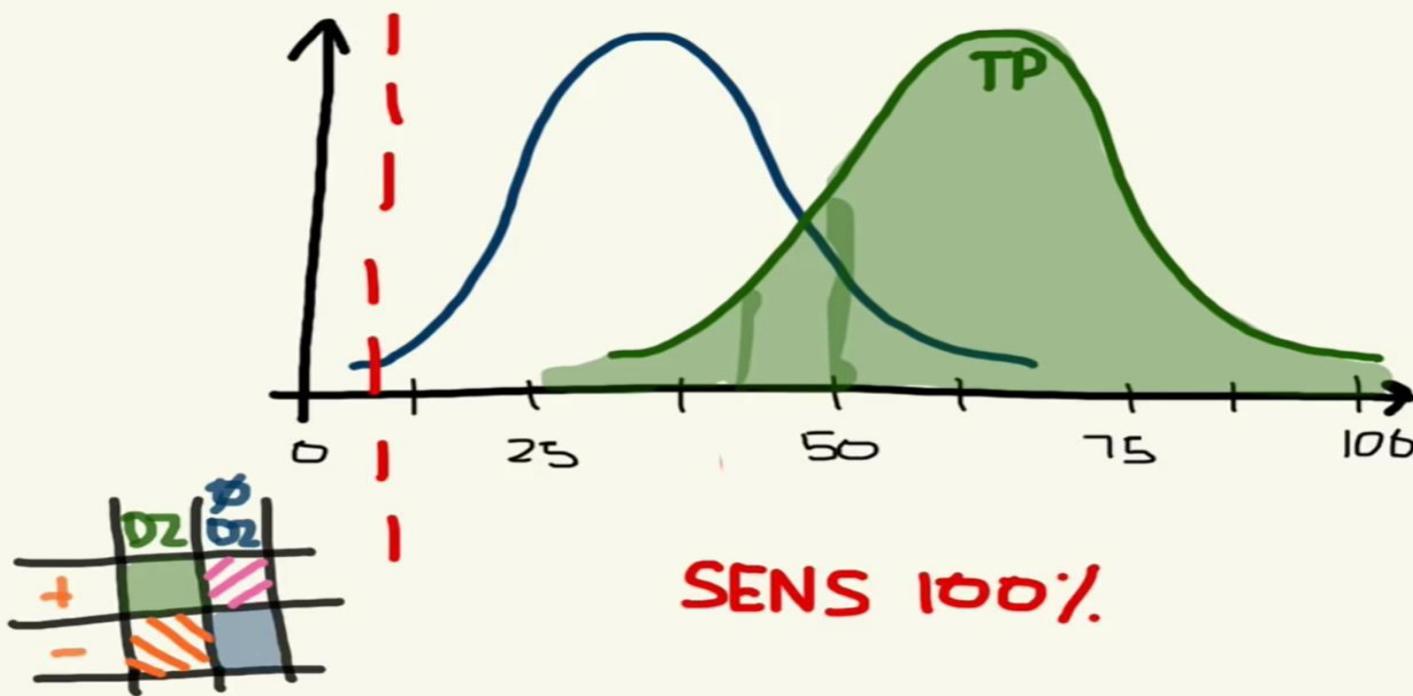


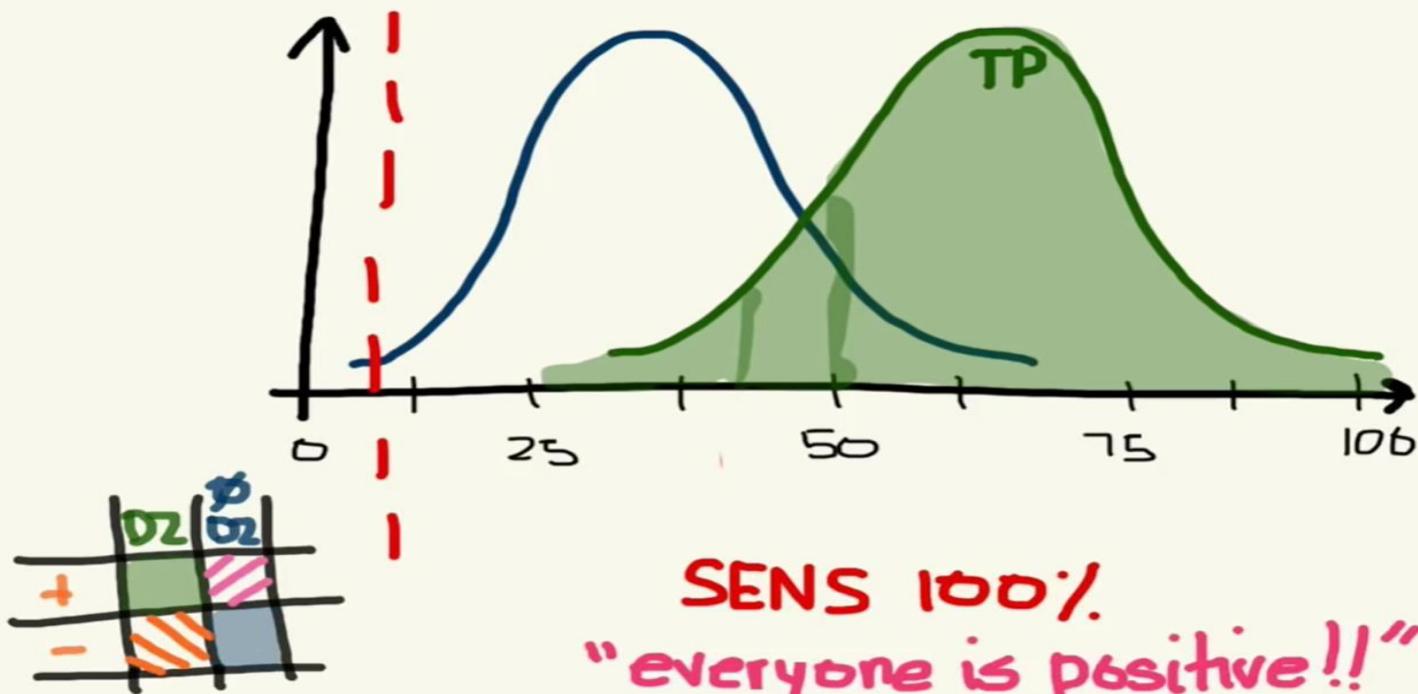


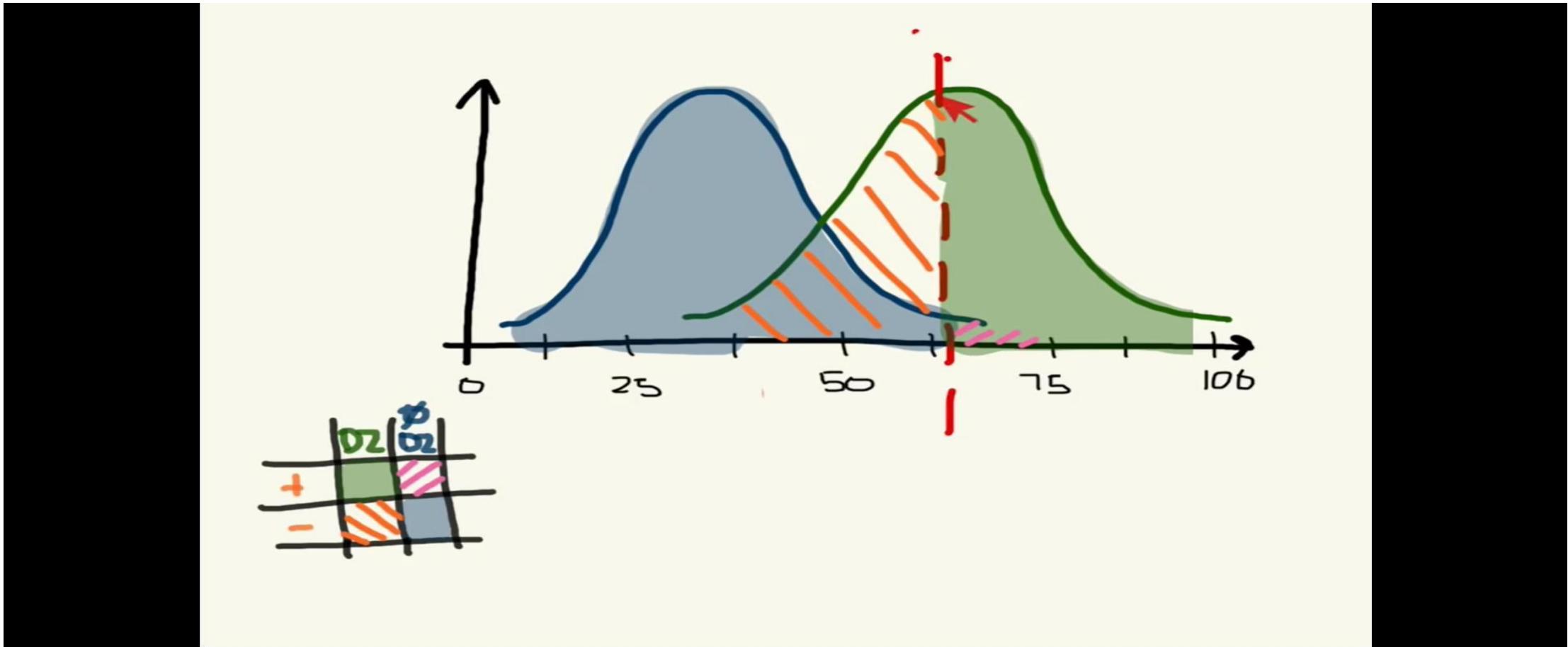


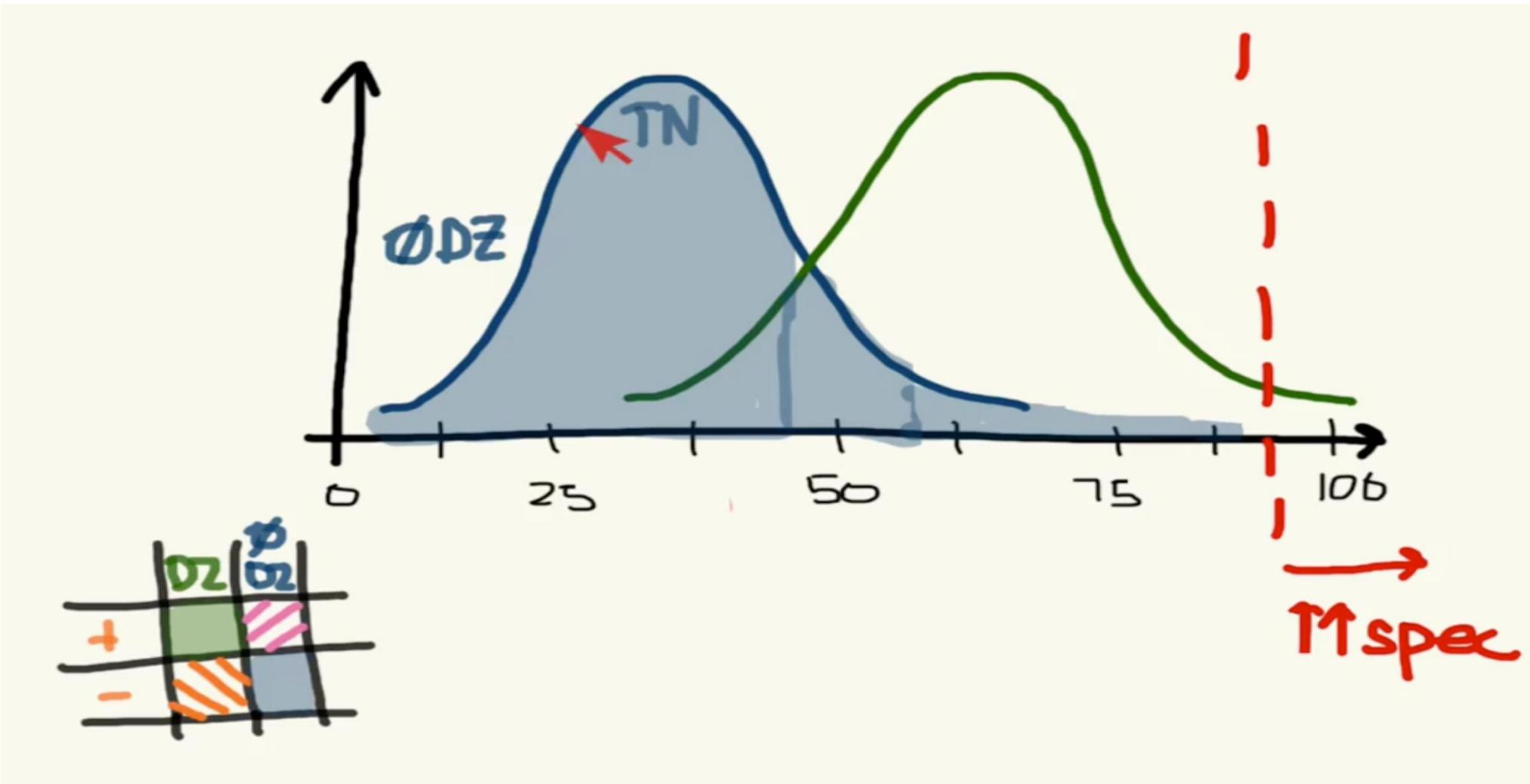


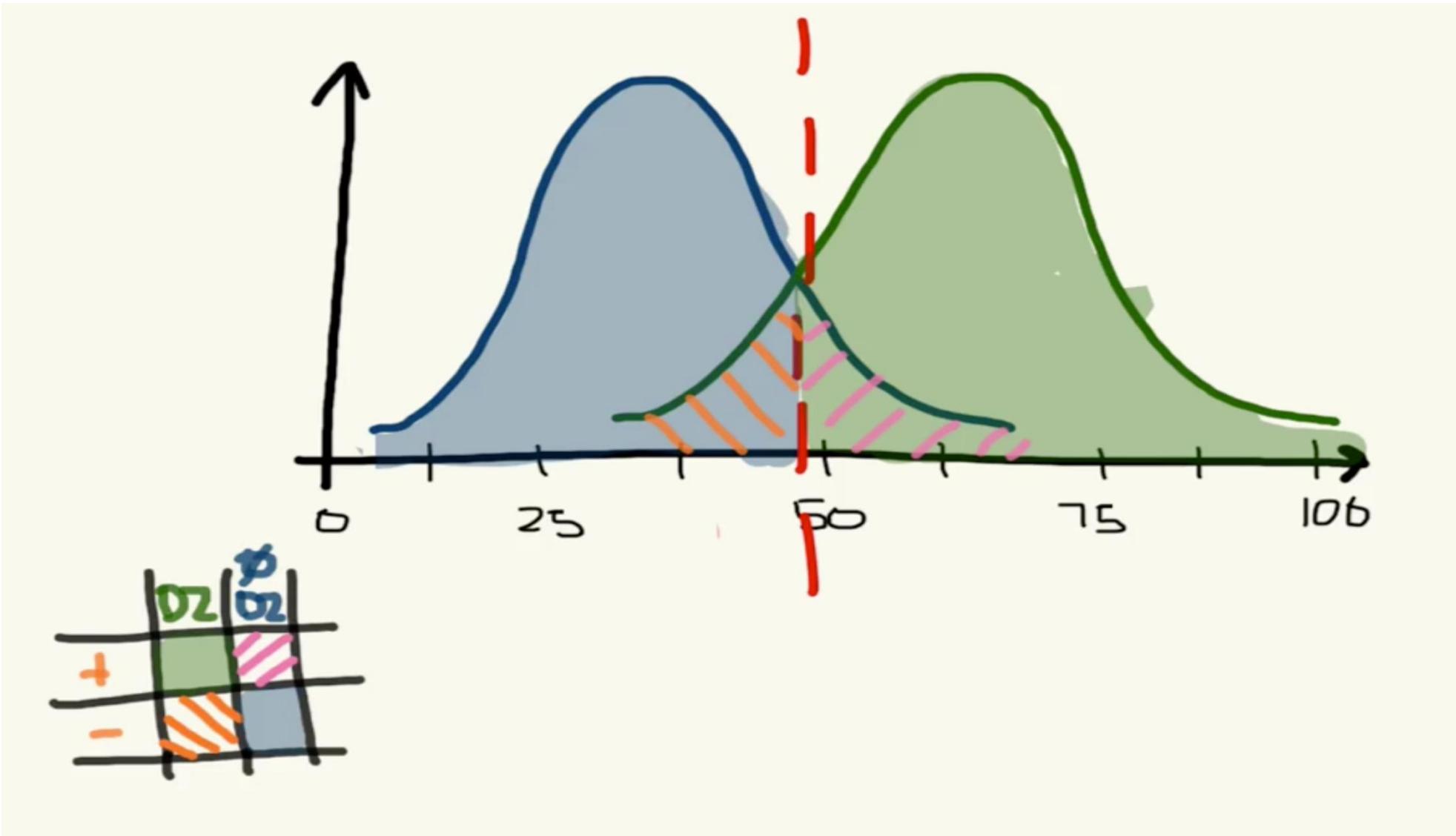


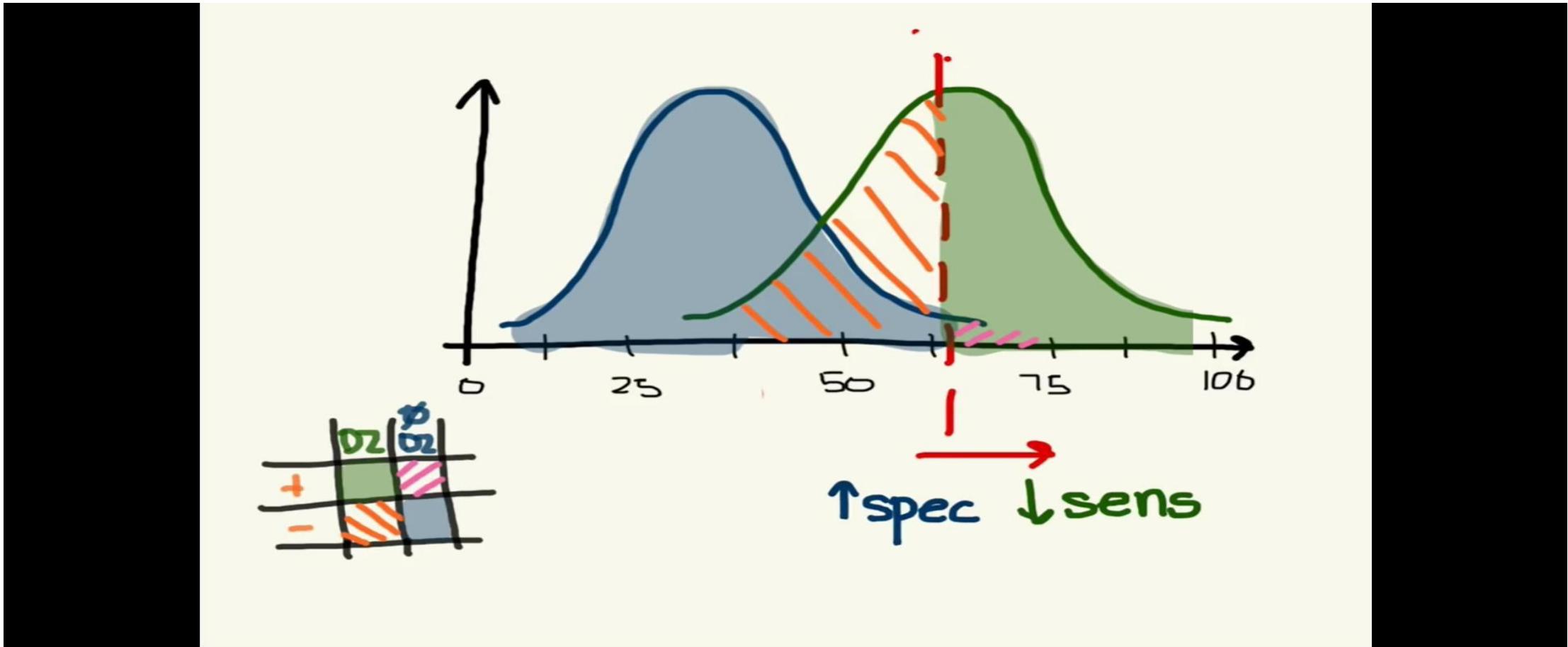


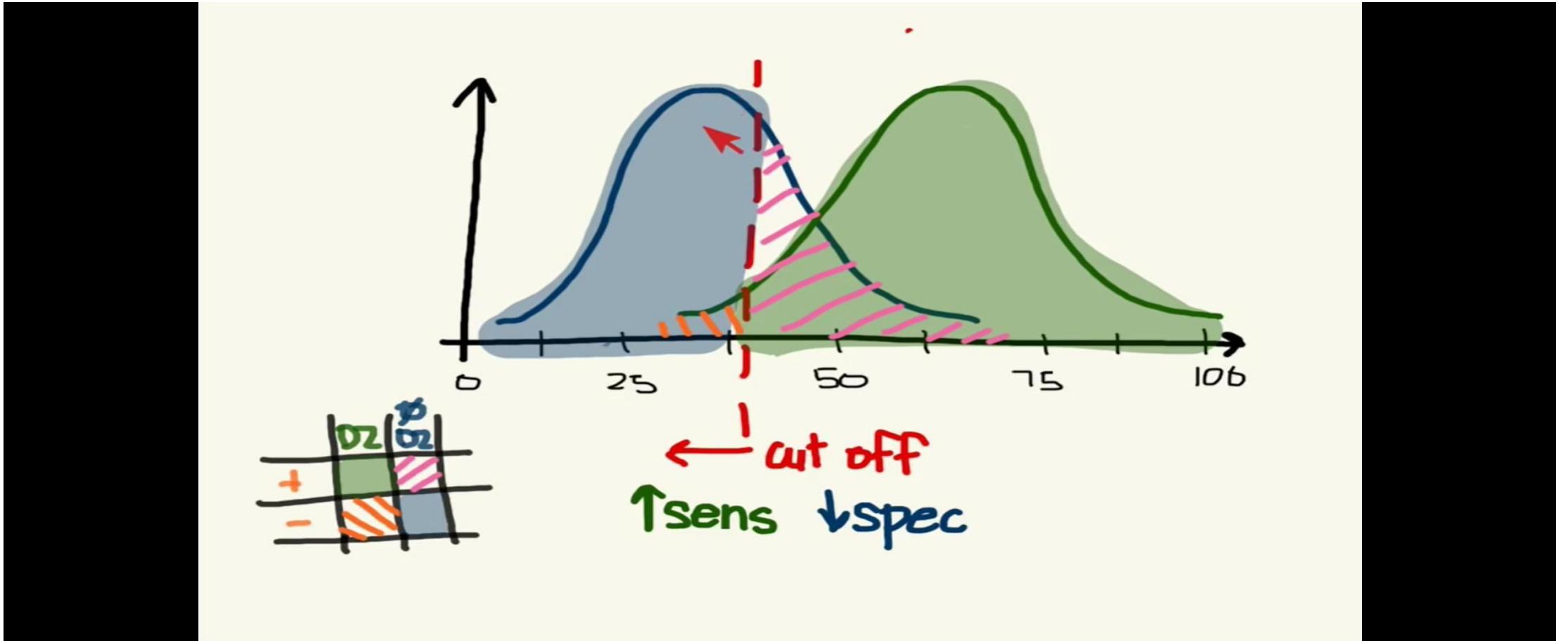


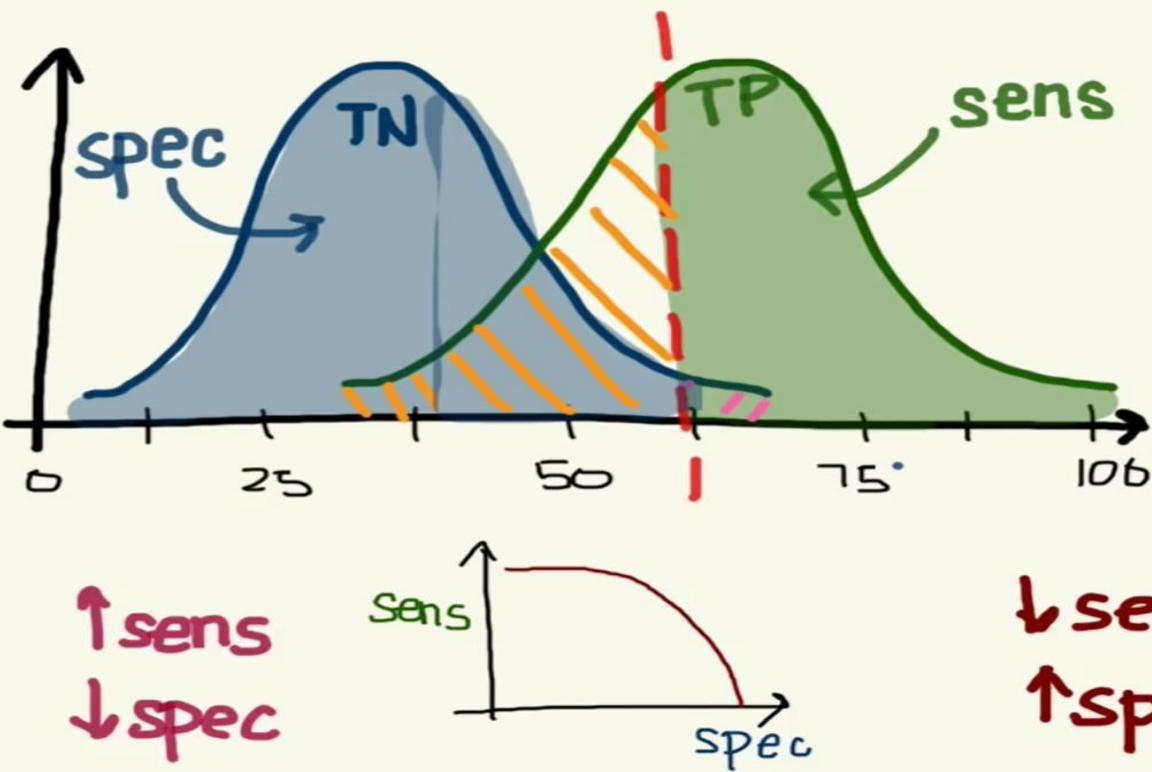


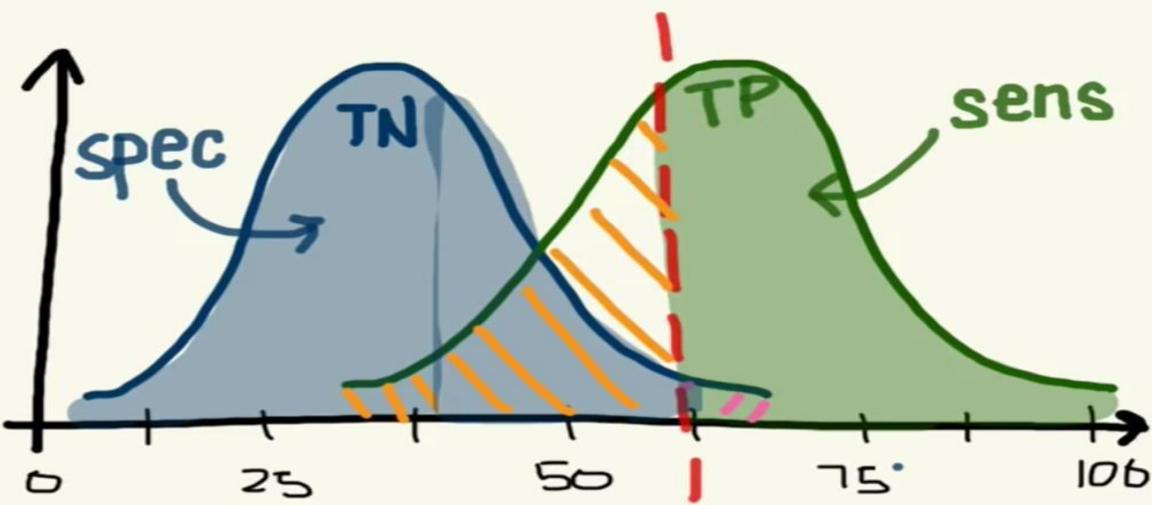




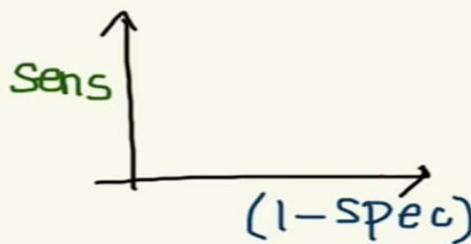




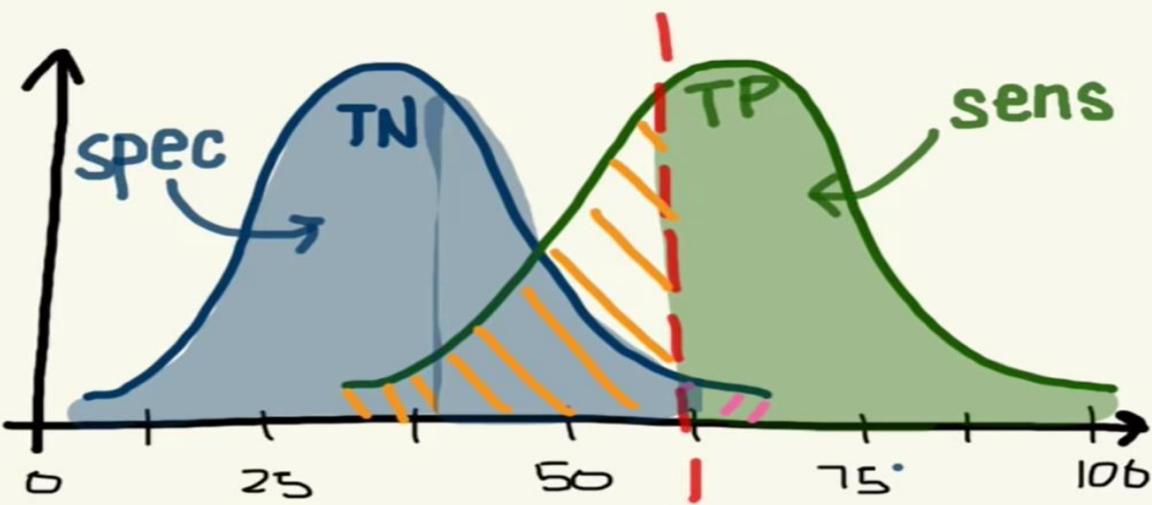




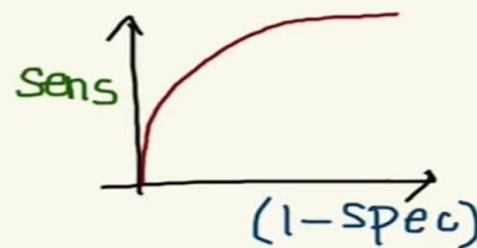
$\uparrow$ sens  
 $\downarrow$ spec



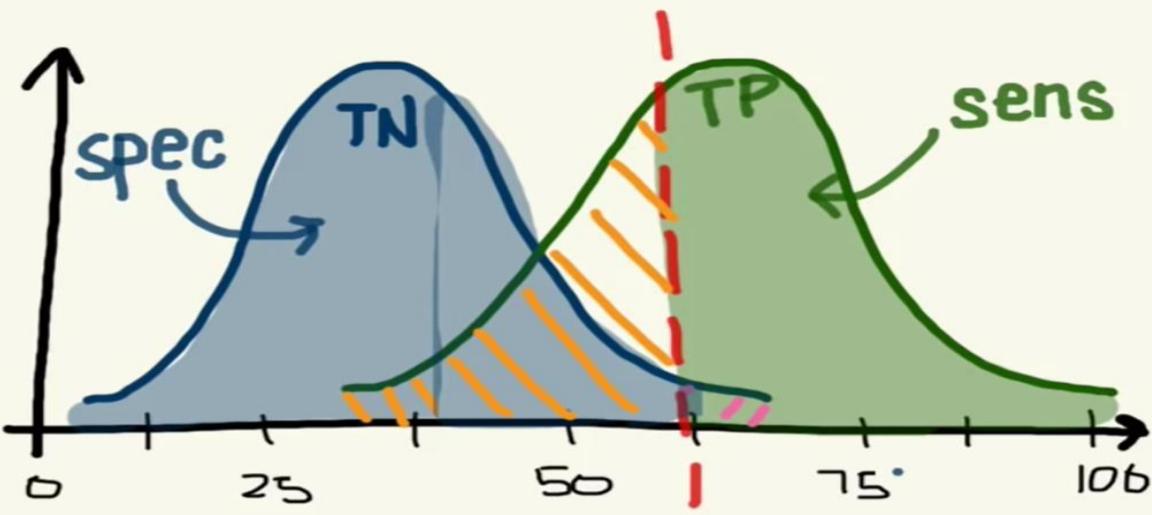
$\downarrow$ sens  
 $\uparrow$ spec



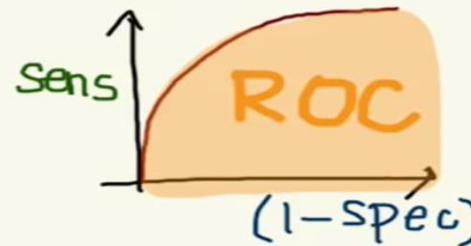
$\uparrow$ sens  
 $\downarrow$ spec



$\downarrow$ sens  
 $\uparrow$ spec



$\uparrow$ sens  
 $\downarrow$ spec



$\downarrow$ sens  
 $\uparrow$ spec

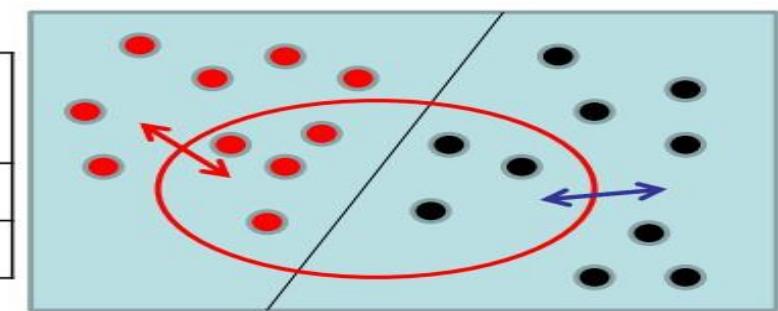
## **Receiver Operating Characteristic :**

- is a graph showing the performance of a classification model at all classification thresholds.
- This curve plots two parameters:
  - True Positive Rate
  - False Positive Rate

# True Positive Rate (Fraction) and False Positive Rate (Fraction)

		Predicted class		Total
		+		
Actual class	+	True positive	False negative	Positives
	-	False positive	True negative	Negatives

Confusion matrix



TPF= P correctly classified as P / P

FPF= N incorrectly classified as P / N

# ROC

The following table shows the actual class labels  $Y$  and the predicted probabilities  $\hat{Y}$  from a binary classification model:

Sample	Actual ( $Y$ )	Predicted Probability ( $\hat{Y}$ )
1	1	0.8
2	0	0.46
3	1	0.4
4	1	0.3
5	0	0.2
6	1	0.7

# ROC

Using the decision rule “**predict 1 if  $\hat{Y} > \text{threshold}$ , else 0**”,  
and thresholds **0.0, 0.2, 0.4, 0.6, and 1.0**,

- a) Construct the confusion matrix for each threshold.
- b) Calculate the **True Positive Rate (Sensitivity)** and **False Positive Rate (1 – Specificity)** for each threshold.
- c) Plot the **ROC (Receiver Operating Characteristic)** curve using FPR (x-axis) and TPR (y-axis).
- d) Estimate the **AUC (Area Under the Curve)** and comment on the model’s performance.

## Predictions (if $\hat{Y} > \text{threshold} \rightarrow 1$ , else 0)

Sample	$Y$	$\hat{Y}$	$\hat{Y}(0)$	$\hat{Y}(0.2)$	$\hat{Y}(0.4)$	$\hat{Y}(0.6)$	$\hat{Y}(1.0)$
1	1	0.8	1	1	1	1	0
2	0	0.46	1	1	1	0	0
3	1	0.4	1	1	0	0	0
4	1	0.3	1	1	0	0	0
5	0	0.2	1	0	0	0	0
6	1	0.7	1	1	1	1	0

## Final ROC Table with Confusion Matrix

Threshold	TP	FP	FN	TN	TPR (Sensitivity)	FPR (1-Specificity)
0.0	4	2	0	0	1.00	1.00
0.2	4	1	0	1	1.00	0.50
0.4	2	1	2	1	0.50	0.50
0.6	2	0	2	2	0.50	0.00
1.0	0	0	4	2	0.00	0.00

