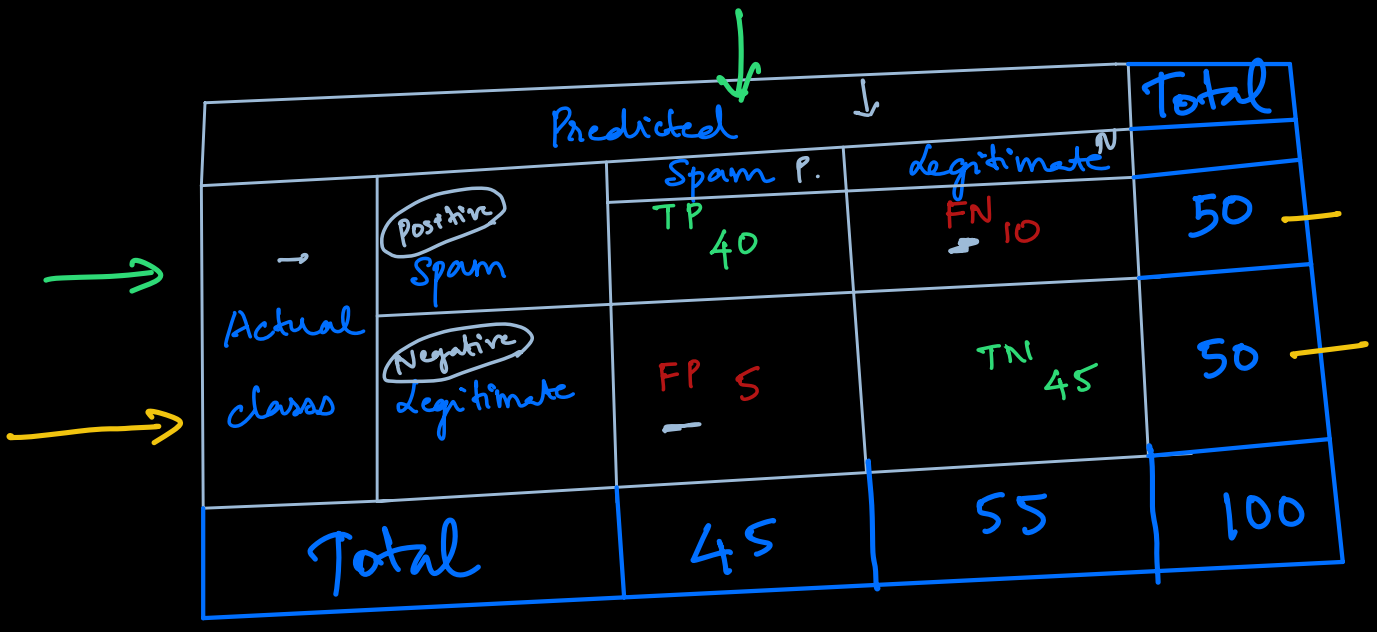


TP (True positive) = 40
Correctly Spam as spam

FN (False Negative) = 10
wrongly predicted as legitimate

FP (False positive) = 5
wrongly predicted legitimate as spam

TN (True Negative) = 45
Correctly legitimate as legitimate

1. Accuracy :

$$= \frac{TP + TN}{TP + TN + FP + FN}$$

$$= \frac{40 + 45}{40 + 45 + 5 + 10} = \frac{85}{100}$$

$$= 85\%$$

85% of all predictions were Correct

2. Recall : True Positive rate : Sensitivity

$$\frac{TP}{TP + FN}$$

$$= \frac{40}{40 + 10} = \frac{40}{50} = .8$$

$$= 80\%$$

Model catches 80% of actual Spam

3. Specificity

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

$$= \frac{45}{45 + 5} = \frac{45}{50} = 0.9$$

$$= 90\%$$

Model catches 90% of legitimate mails

4. Precision

$$= \frac{TP}{TP + FP}$$

$$= \frac{40}{40 + 5} = \frac{40}{50} = 0.88$$

89%

When model says 'SPAM' its right 89% of time

5. F1 score

$$F1 = \frac{2 \text{ Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$$

Geometric mean $\leftarrow \frac{x+y}{2} \Rightarrow$ Harmonic mean $\frac{2(x \times y)}{x+y}$ ✓

$\frac{x+y}{2} \Rightarrow$ (x) (y)

$\frac{2xy}{x+y}$

$x = 10 \quad y = 2$

$\frac{10+2}{2} = \frac{12}{2} = 6$

$\frac{2(10 \times 2)}{10+2}$

$\frac{2(20)}{12} = \frac{40}{12}$

$= 3.3$

$= \frac{2(PR)}{P+R} = \frac{2 \times 0.88 \times 0.8}{0.88 + 0.8}$

$= 84.2\%$

Harmonic mean balancing Precision and recall

Imbalanced Data

OverSampling

Yes	20
No	80
—	—
Yes	80
No	80

Synthetic Create more sample

UnderSampling

Yes	20
No	80
—	—
Yes	20
No	20

random selection

6. Roc Curve

Receiver Operating Characteristics

Curve which shows how the model performs at different threshold setting

email 1 : 0.95 probability of spam
↳ High Confidence spam

email 2 : 0.60 Medium Confidence Spam

email 3 : 0.20 probility of legitimate

Set a threshold < spam / legitimate

Email	Actual class	Spam (model) Probability
A	Spam	0.95
B	Spam	0.85
C	Legitimate	0.70
D	Spam	0.65
E	Legitimate	0.55
F	Spam	0.45
G	Legitimate	0.35
H	Spam	0.25
I	Legitimate	0.15
J	Legitimate	0.05

Threshold = 0.5

Predicted Spam = A B C D E

TP = 3 FP = 2 FN = 2 TN = 3

$$TPR = \text{Recall} = \frac{TP}{TP + FN}$$

$$= \frac{3}{3+2}$$

$$= \frac{3}{5}$$

$$= 0.60$$

$$\text{Specificity} = \frac{TN}{TN + FP} = \frac{3}{5}$$

$$= 0.6$$

$$FPR = 1 - \text{Specificity}$$

$= 1 - 0.6 \Rightarrow 0.4$

Threshold (0.7)

Predicted Spam = A, B, C

TP = 2 FP = 1 FN = 3 TN = 4

$\text{Recall} = \frac{2}{5} = 0.4$

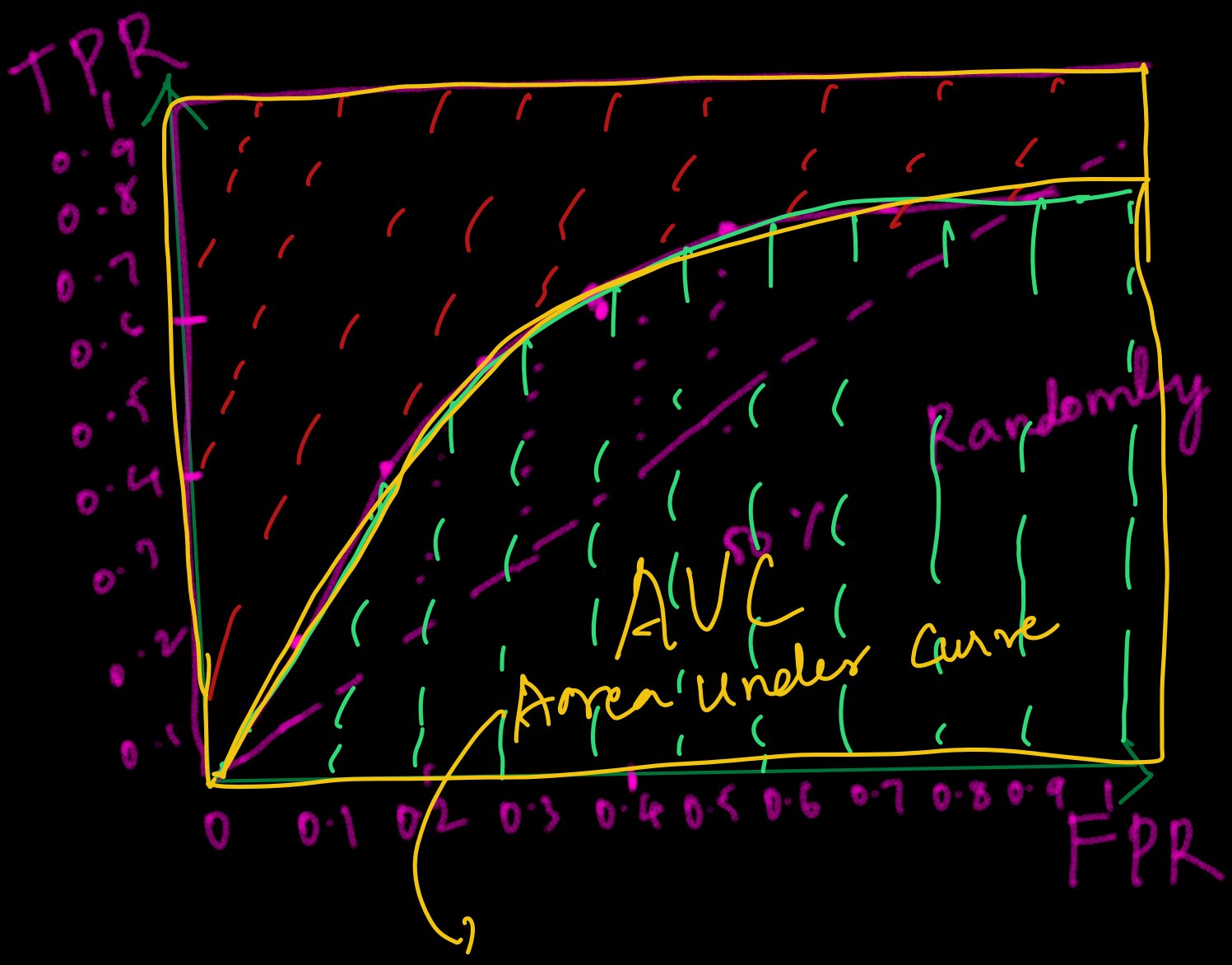
$\text{Specifity} = \frac{4}{4+1} = \frac{4}{5} = 0.8$

$\text{FPR} = 1 - \text{Specifity} \quad 1 - 0.8 = 0.2$

Threshold 0.3

Recall = 0.8

FPR = 0.6



AUC = 1 → Perfect model

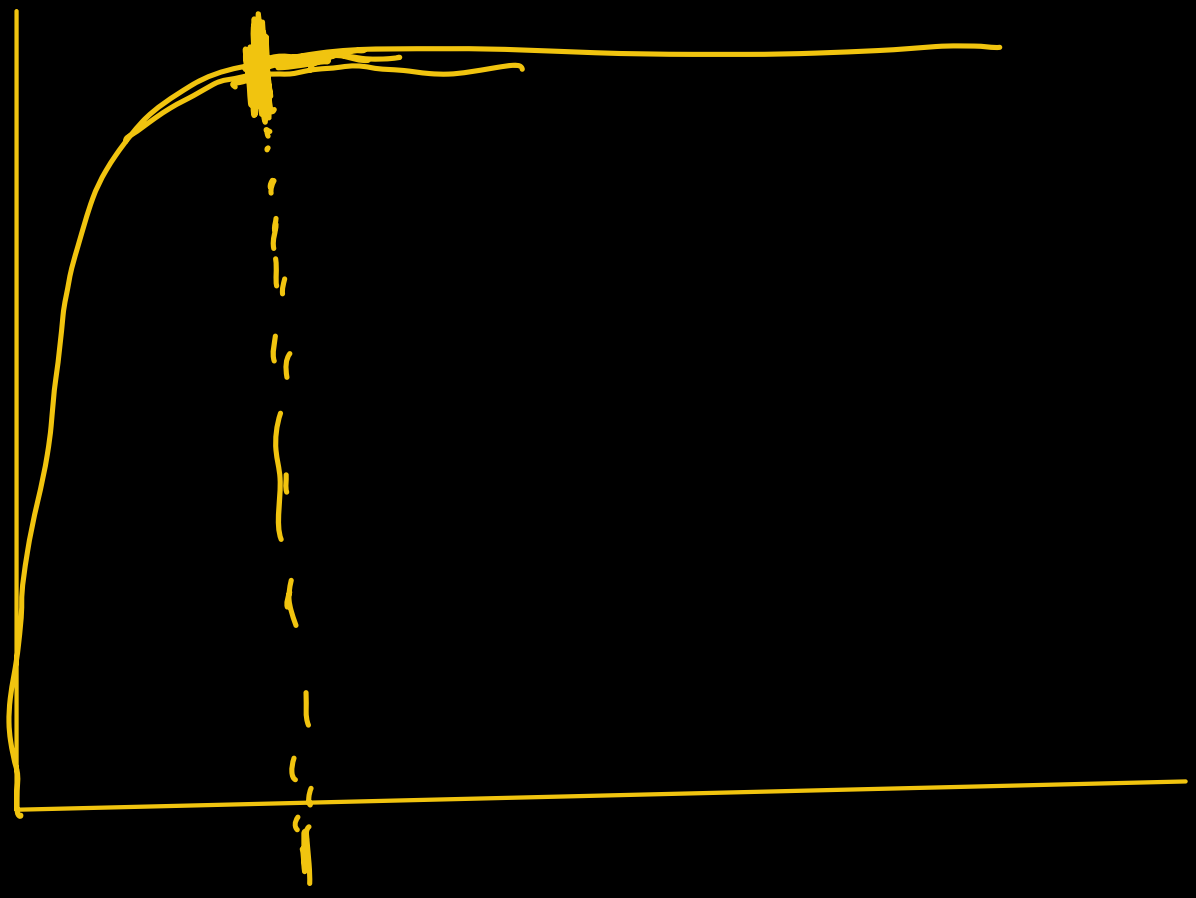
AUC = 0.9 - 1.0 = Excellent

AUC = 0.8 - 0.9 = Good

AUC = 0.7 - 0.8 = Fair model

AUC = 0.5 => No better than tossing a coin

AUC < 0.5 => Worse than random



Gradient descent

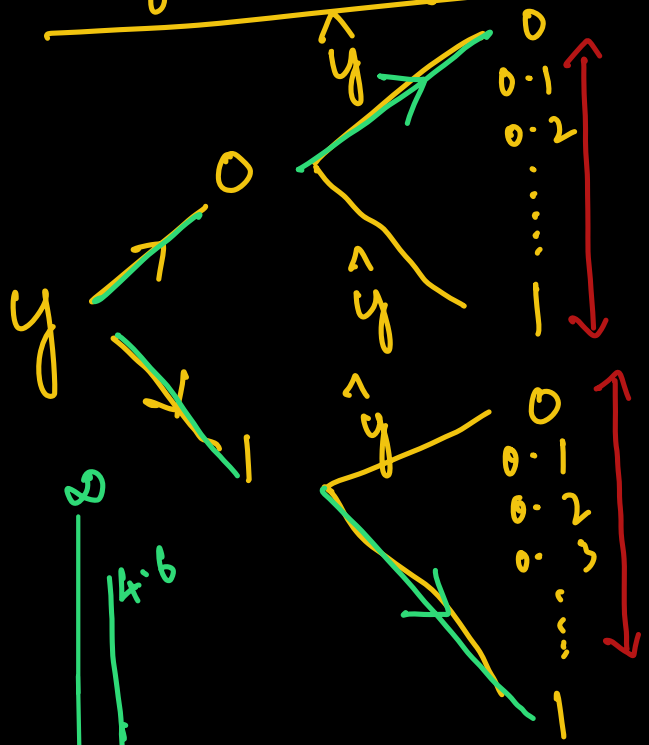
Cost function

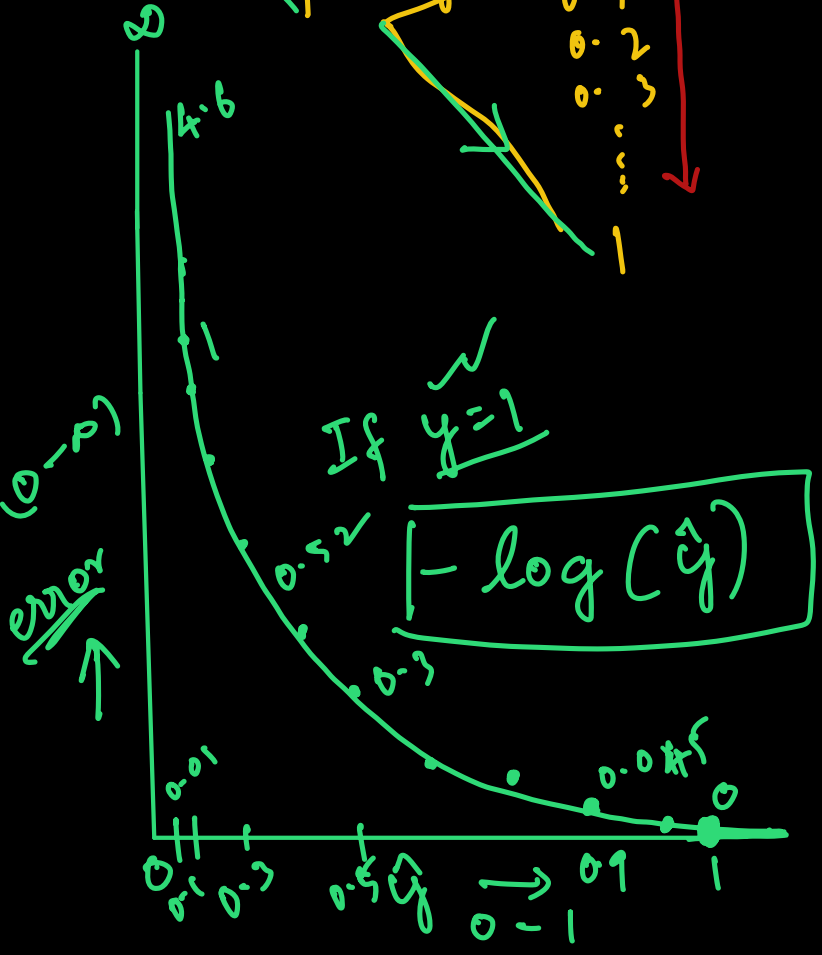
Logistic Regression (Classification)

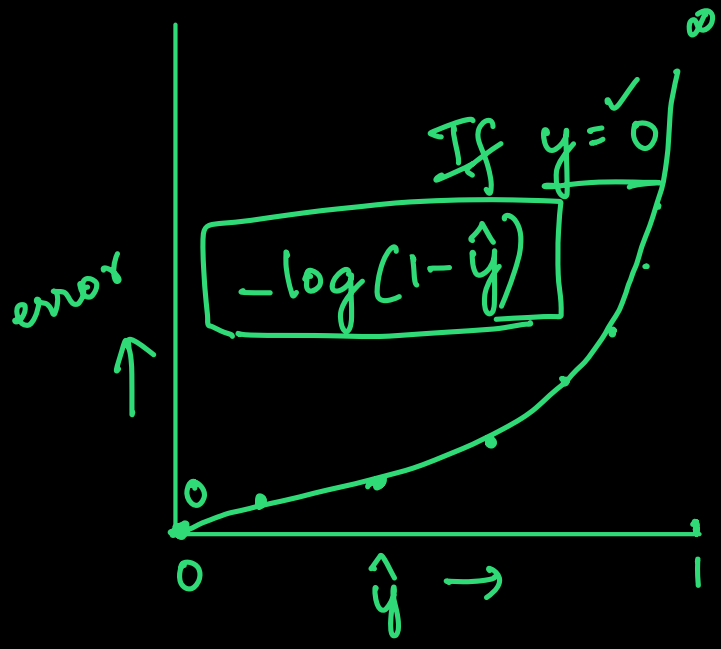
Linear Regression

MSE

$$\frac{\sum (y - \hat{y})^2}{n}$$







Cost function = $\begin{cases} -\log(\hat{y}) & \text{if } y=1 \\ -\log(1-\hat{y}) & \text{if } y=0 \end{cases}$

$$\frac{1}{m}\sum_{i=1}^{m} y_i\left[-\log(\hat{y})\right] + (1-y_i) - \left[\log(1-\hat{y})\right]$$

$$\frac{-1}{m}\sum_{i=1}^{m} y_i \log(\hat{y}) + (1-y_i)\log(1-\hat{y})$$

$y=0$ $y=1$

Log Loss