Question 1 table (given) $\Rightarrow$
(a)

Experience (year)	(\$1000) Salary
1.2	42
2.5	46
3.1	51
3.9	58
5.2	62

We know $h_{\omega}^{(x)} = \omega_0 + \omega_1 x$

Salary = $\beta_0 + \beta_1 \times$ experience

where = x is experience
$\beta_0 = \omega_0$ (the intercept of line)
$\beta_1 = \omega_1$ (the slope of line)

$h_{\omega}(x)$ = Salary

$$\bar{x} = \frac{1.2 + 2.5 + 3.1 + 3.9 + 5.2}{5} = 3.18$$

$$\bar{y} = \frac{42 + 46 + 51 + 58 + 62}{5} = 51.8$$

after that we will find

$x_i - \bar{x}$ & $y_i - \bar{y}$ (deviations)

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$\Rightarrow (x - \bar{x}) = (1.2 - 3.18), (2.5 - 3.18), (3.1 - 3.18), (3.9 - 3.18)$

$(5.2 - 3.18)$

$\Rightarrow \quad = -1.98, -0.68, -0.08, 0.72, 2.02$

$\Rightarrow (y - \bar{y}) = (42 - 51.8), (46 - 51.8), (51 - 51.8), (58 - 51.8), (62 - 51.8)$

$\Rightarrow \quad = -9.8, -5.8, -0.8, 6.2, 10.2$

Product of deviations $(x - \bar{x})(y - \bar{y})$

$\Rightarrow (-1.98)(-9.8), (-0.68)(-5.8), (-0.08)(-0.8), (0.72)(6.2),$

$(2.02)(10.2).$

$\Rightarrow (19.404) + (3.94) + (0.064) + (4.464) + (20.604).$

now adding all of them we get

$\Rightarrow 48.48$ //

now we find $(x - \bar{x})^2$

$\Rightarrow (-1.98)^2 + (-0.68)^2 + (-0.08)^2 + (0.72)^2 + (2.02)^2$

$\Rightarrow 3.92 + 0.462 + 0.0064 + 0.518 + 4.08$

$\Rightarrow 8.988$ //

Calculating β_1 i.e. $\beta_1 = \frac{\Sigma(x-\bar{x})(y-\bar{y})}{\Sigma(x_i-\bar{x})^2}$

$$\beta_1 = \frac{48.48}{8.988} = \underline{\underline{5.394}}$$

$$\beta_0 = \bar{y} - \beta_1 \bar{x}$$

$\therefore \beta_0 = 51.8 - 5.394 \times 3.18$

$$\beta_0 = 34.6470$$

$\therefore$ we know that

Salary = $\beta_0 + \beta_1 \times$ experience

[Salary = 34.6470 + 5.394 × experience.] //

(b) Salary of Person with 4.5 years of experience

Salary = 34.6470 + 5.394 × 4.5 //

Salary = 58.92 × ($1000) //

(c) Intercept the coefficient of my ~~hyp~~ $h_w(x)$

So evaluating β_0 & β_1

if employee have 0 experience

Salary = $34.6470 \times 5.394(0)$

Salary. = $34.670 \times (\$1000)$

will be basic salary //

& for β_1

each year the salary will be increased

$5.394 \times (\$1000)$ as the year increased.

Question 2 ⟹

House No.	Size	of bedrooms	Price
House 1	900	1	200
House 2	1600	3	330
House 3	1875	4	400

multiple linear Regression.

(a) Matrix X & vector Y //

hypathesis junction af Multiple linear regression

$h_\theta(x) = \theta_0 + \theta_1 \times \text{Size} + \theta_2 \times \text{bedrooms}.$

because we have to predict value on the basis of in 2 things (i) No. of bedrooms (ii) the Size (Sq.ft)

$\therefore$ θ_0 = intercept

θ_1 = Coefficient of Size.

θ_2 = Coeffecient of Number of bedroom.

(a) Setting the matrices with help of table.

Matrix X defines the No. of different house, No. of bedrooms and the size of the house.

$$X = \begin{bmatrix} 1 & 900 & 1 \\ 1 & 1600 & 3 \\ 1 & 1875 & 4 \end{bmatrix}_{(3\times3)} \qquad y = \begin{bmatrix} 200 \\ 330 \\ 400 \end{bmatrix}_{(3\times1)}$$

y = the vector defines the prices of house.

(b) Normal Equation & resulting equation of hypothesis

$$X = \begin{bmatrix} 1 & 900 & 1 \\ 1 & 1600 & 3 \\ 1 & 1875 & 4 \end{bmatrix}$$

$$X^T = \begin{bmatrix} 1 & 1 & 1 \\ 900 & 1600 & 1875 \\ 1 & 3 & 4 \end{bmatrix}$$

We have to find

$$X^T \cdot X = \begin{bmatrix} 1 & 1 & 1 \\ 900 & 1600 & 1875 \\ 1 & 3 & 4 \end{bmatrix} \cdot \begin{bmatrix} 1 & 900 & 1 \\ 1 & 1600 & 3 \\ 1 & 1875 & 4 \end{bmatrix}$$

$$= \begin{bmatrix} 3 & 4373 & 8 \\ 4373 & 6878129 & 13192 \\ 8 & 13192 & 26 \end{bmatrix} //$$

$$X^T \cdot Y = \begin{bmatrix} 1 & 1 & 1 \\ 900 & 1600 & 1875 \\ 1 & 3 & 4 \end{bmatrix} \times \begin{bmatrix} 200 \\ 330 \\ 400 \end{bmatrix}$$

$$3 \times 3 \times 3 \times 1$$

We get (3×1)

$$= \begin{bmatrix} 930 \\ 1630000 \\ 3250 \end{bmatrix} //$$

∴ Normal equation for Linear Regression

$$\theta = (X^T X)^{-1} X^T y$$

Where θ is the vector of coefficient

Now finding $(X^T X)^{-1}$

for that we have to find the determinant of the

$$X^T X = \begin{bmatrix} 3 & 4373 & 8 \\ 4373 & 6878129 & 13192 \\ 8 & 13192 & 26 \end{bmatrix}$$

∴ for $\det(X) = a(ei - fh) - b(di - fg) + c(dh - eg)$

when matrix $(X) = \begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix}$

∴ $\det(X) =$

$$3((6878129 \times 26) - (13192 \times 13192)) - 4373((4373 \times 26) - (13192 \times 8))$$
$$+ 8((4373 \times 13192) - (6878129 \times 8))$$

$= 14402480 - 35692426 + 21308672$

$= 23718.$

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~~$X^T X = \det(X^T X)$~~

$\therefore 3 \times (178831354 - 173830464) - 4373($
$113698 - 105536) + 8(57684916 - 55025032)$

$\Rightarrow 3 \times 5000890 - 4372 \times 8162 + 8 \times 2659884$

$\Rightarrow 15002670 - 35693026 + 21279072$

$\Rightarrow 588716$

Now we solve for adj.$(X^T X)$

for $C_{11} = (6878129 \times 26 - 13192^2)$
$= 5002090$

$C_{12} = -(4373 \times 26 - 8 \times 13192)$
$= -8126$

$C_{13} = (4373 \times 13192 - 6878129 \times 8)$
$= 2660484$

$C_{21} = -(4373 \times 26 - 8 \times 13192)$
$= -8162$

$C_{22} = (3 \times 26 - 8 \times 8) = 78 - 64$
$= 14$

$$C_{23} = -(3 \times 13192 - 4373 \times 8)$$
$$= -4592$$

$$C_{31} = (4373 \times 13192 - 6878129 \times 8)$$
$$= 2660484$$

$$C_{32} = -(3 \times 13192 - 4373 \times 8)$$
$$= -4592$$

$$C_{33} = (3 \times 6878129 - 4373^2)$$
$$= 1511258.$$

$\therefore$ the matric of Cofactor is

$$\begin{bmatrix} 5002090 & -8126 & 2660484 \\ -8162 & 14 & -4592 \\ 2660484 & -4592 & 1511258 \end{bmatrix}$$

now deviding $\det(X^T X)$ by $\mathrm{adj.}(X^T X)$

we get
$$\begin{bmatrix} 8.4 & -0.0137 & -2.56 \\ -0.0137 & 0.00002 & 0.0041 \\ -2.56 & 0.00419 & 0.78 \end{bmatrix} //$$

the $\dfrac{\mathrm{adj.}(X^T X)}{\det(X^T X)} = (X^T X)^{-1}$ //

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$$\theta = \begin{bmatrix} 930 \\ 1630000 \\ 3250 \end{bmatrix} \times \begin{bmatrix} 8.4 & -0.0137 & -2.56 \\ -0.0137 & 0.00002 & 0.0041 \\ -2.56 & 0.0041 & 0.78 \end{bmatrix}$$

$3 \times 1 \quad 3 \times 3$

$$\text{we get} = \begin{bmatrix} -22839 \\ 38.369 \\ 6983.9 \end{bmatrix}$$

$$\therefore \theta = \begin{bmatrix} \theta_0 \\ \theta_1 \\ \theta_2 \end{bmatrix} = \begin{bmatrix} 171.67 \\ -0.067 \\ 88.33 \end{bmatrix}$$

So now we put values of θ_0, θ_1 & θ_2 in the $h_\omega(\theta)$.

$\therefore$ when Size $= 0$ & Room $= 0$

Price $= 171.67$ (\$1000)

(c) 1500 Sq. ft. & 3 bedrooms

$$\text{price} = \theta_0 + \theta_1 X + \theta_2 Y$$

$$\text{Price} = 171.67 + 1500(-0.067) + 3 \times (88.33)$$

$$\text{Price} = 171.67 - 100.5 + 264.99$$

$$\text{Price} = 336.16 \ (\$1000)$$

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(d) Interpret coefficient of h/w

So. θ_0 is the base price of a room with 0 sq. ft of size

θ_1 is the change of price for each sq. ft.

θ_2 is the change of price on basis of each room

Question no. 3 $\Rightarrow$ Table given

Individual Number	Income ($ 1000's)	Age (Year)	Approved (0 or 1)
1	45	25	0
2	60	35	1
3	75	40	1
4	50	28	0
5	90	50	1
6	100	60	1

~~Multiple~~ Logistical ~~linear~~ regression (with binary classification)

(a) Cost function for the problem will be

this is a perfect example we can execute with logistical regression therefore. if I analise the question.

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the hypothesis of function of Logistical Regress

is

$$h_\theta(x) = \frac{1}{1 + e^{-(\theta_0 + \theta_1 \text{Income} + \theta_2 \text{age})}}$$

where : θ_0 is the Intecept

θ_1 is coeffecient of Income of person

θ_2 is coeffecient of age,

$h_\theta(x)$ is probablity that output is 1 (i.e.) Approved

$$\therefore \quad J(\theta) = -\frac{1}{m}\sum_{i=1}^{m}\left[y_i \log(h_\theta(x^i)) + (1-y_i)\log(1-h_\theta(x^i))\right]$$

Where

m is the number of data point

(we have 6 people that's why m=6)

y_i is actual value (0 or 1)

[Approved or not Approved]

$h_\theta(x^{(i)})$ is the hypothesis (Predicted value)

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(b) Coeffecient we need to optimize in this feature are basically 2 (i) Age (ii) Income

therefore we have to have 3 coeffecient

θ_0 intercept

θ_1 (Income Coeffecient)

θ_2 (Age coeffecient)

(c) expression for the derivative of the cost function with respect each Coeffecient

i.e. θ_0, θ_1, θ_2

So we move ahead with Gradient descent

$$\theta_j = \theta_j - \alpha \frac{\partial J(\theta)}{\partial \theta_j}$$

where α is learning rate.

we know derivative for logistic regression

$$\frac{\partial J(\theta)}{\partial \theta_j} = \frac{1}{m} \sum_{i=1}^{m} \left(h_\theta (x^{i}) - y^{(i)} \right) x_j^{(i)}$$

where $x_j^{(i)}$ is J^{th} feature for $x_0 = 1$ //

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$\therefore$

$$\theta_j = \theta_j - \alpha \cdot \frac{1}{m} \sum_{i=1}^{m} \left(h_\theta(x^{(i)}) - y_i \right) x_j^{(i)}$$

where,
α is learning rate
$h_\theta(x^{(i)})$ is predicted value for i-th.

y_i is active value (0 or 1)

x_j is feature value for x_j (for the intercept

$x_0 = 1$).

Update Rule for each coeffecient ($\theta_0, \theta_1, \theta_2$)

$$\text{for } \theta_0 = \theta_0 - \alpha \cdot \frac{1}{m} \sum_{i=1}^{m} \left(h_\theta(x^{(i)}) - y_i \right)$$

$$\text{for } \theta_1 = \theta_1 - \alpha \frac{1}{m} \sum_{i=1}^{m} \left(h_\theta(x^{(i)}) - y_i \right) \cdot \text{Income}_i$$

$$\text{for } \theta_2 = \theta_2 - \alpha \frac{1}{m} \sum_{i=1}^{m} \left(h_\theta(x^{(i)}) - y_i \right) \cdot \text{Age}_i$$

(d) initial value of 1 for 1^{st}, 2 for 2^{nd}, 3 for 3^{rd}
4 for 4^{th} & so on.

run one iteration of gradient descent using a learnin rate of 0.01.

hypothesis function for logistic regression

$$\theta_j := \theta_j - \alpha \cdot \frac{1}{m} \sum_{i=1}^{m} \left(h_\theta(x^{(i)}) - y_i \right) \cdot x_j^{(i)}$$

so we know $m = 6$

$h_\theta(x^{(i)})$ is prabablity for i^{th} example

y_i is actual outcome for i^{th} example as well.

$\theta_0 = 0$, $\theta_1 = 1$, $\theta_2 = 2$, θ_3 3, $\theta_4 = 4$ & so on

given in question.

$h_\theta(x)$ for each with thier initial value.

Individual 1
income = 45 age = 25 (from table)

$$h_\theta(x) = \frac{1}{1 + e^{(1 + 2\cdot 45 + 3\cdot 25)}}$$

$$h_\theta(x) = \frac{1}{1+e^{(1+90+75)}} = \frac{1}{1+e^{166}} \approx 1$$

$$h_\theta(x) = \frac{1}{1+e^{166}} \approx 1$$

for individual 2

income = 60 age = 35

$$h_\theta(x) = \frac{1}{1+e^{(1+2\cdot 60+3\cdot 35)}} = \frac{1}{1+e^{(1+120+105)}}$$

$$h_\theta(x) = \frac{1}{1+e^{(226)}} \approx 1$$

for individual 3

income = 75 age = 40

$$h_\theta(x) = \frac{1}{1+e^{(1+2\cdot 75+3\cdot 40)}} = \frac{1}{1+e^{(1+150+120)}}$$

$$h_\theta(x) = \frac{1}{1+e^{(271)}} \approx 1$$

for individual 4
income = 50 age = 28

$$h_\theta(x) = \frac{1}{1+e^{(1+2\cdot50+3\cdot28)}} = \frac{1}{1+e^{(1+100+84)}}$$

$$h_\theta(x) = \frac{1}{1+e^{185}} \approx 1$$

for individual 5

income = 90 age = 50

$$h_\theta(x) = \frac{1}{1+e^{(1+2\cdot90+3\cdot50)}} = \frac{1}{1+e^{(1+180+150)}}$$

$$h_\theta(x) = \frac{1}{1+e^{331}} \approx 1$$

for individual 6

income = 100 age = 60

$$h_\theta(x) = \frac{1}{1+e^{(1+2\cdot100+60\cdot3)}} = \frac{1}{1+e^{(1+200+180)}}$$

$$h_\theta(x) = \frac{1}{1+e^{381}} \approx 1$$

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Step 2 We will compute the gradients θ_0, θ_1 & θ_2

θ_0 (Gradient decent)

$$\frac{\partial J(\theta)}{\partial(\theta_0)} = \frac{1}{6}\sum_{i=1}^{6}(h_\theta(x^{(i)}) - y_{(i)})$$

So we used value of $h_\theta(x)$ & actual value y

For each individual :-

for 1 = $h_\theta(x^{(1)}) - y_1 = 1 - 0 = 1$

for 2 = $h_\theta(x^{(2)}) - y_2 = 1 - 1 = 0$

for 3 = $h_\theta(x^{(3)}) - y_3 = 1 - 1 = 0$

for 4 = $h_\theta(x^{(4)}) - y_4 = 1 - 0 = 1$

for 5 = $h_\theta(x^{(5)}) - y_5 = 1 - 1 = 0$

for 6 = $h_\theta(x^{(6)}) - y_6 = 1 - 1 = 0$

So the total $\theta_0 : \frac{1}{6} \times (1+0+0+1+0+0)$

$\Rightarrow \frac{1}{6} \times 2 \Rightarrow \frac{2}{6} = \frac{1}{3}$ //

now for θ_1 (income)

$$\frac{\partial J(\theta)}{\partial \theta_1} = \frac{1}{6}\sum_{i=1}^{6}(h_\theta(x^{(i)}) - y_i)\cdot \text{income.}$$

$$\frac{\partial J\theta}{\partial \theta_1} = \frac{1}{6} \times (1.45 + 0.60 + 0.75 + 0.90 + 1.50 + 0.100)$$

$$\Rightarrow \frac{1}{6} \times (45+50) \Rightarrow \frac{1}{6} \times 95 = \frac{95}{6} = 15.83$$

now for θ_2 (age)

$$\frac{\partial J(\theta)}{\partial \theta_2} = \frac{1}{6}\sum_{i=1}^{6}(h_\theta x^{(i)} - y_i)\cdot \text{age.}$$

$$\Rightarrow \frac{1}{6} \times [1.25 + 0.35 + 0.45 + 1.28 + 0.50 + 0.60]$$

$$\Rightarrow \frac{1}{6} \times [25 + 28] \Rightarrow \frac{1}{6} \times 53 \Rightarrow 8.83$$

Step 3 we update the coeffecient's.

as given initial value of θ_0, θ_1 & θ_2 = 1, 2, 3 resp.

$$\theta_0 = \theta_0 - \alpha \cdot \frac{\partial J(\theta_0)}{\partial \theta_0}$$

$$\theta_{0\,(\text{new})} = 1 - 0.01 \cdot \frac{1}{3} \Rightarrow 1 - \frac{0.01}{3} = 0.9967$$

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$$\theta_{1(new)} = \theta_1 - \alpha \cdot \frac{\partial J(\theta_1)}{\partial \theta_1}$$

$$= 2 - 0.01 \cdot 15.83$$

$$\theta_1 = \underline{\underline{1.8417}}$$

$$\theta_{2(new)} = \theta_2 - \alpha \cdot \frac{\partial J(\theta)}{\partial(\theta_2)}$$

$$= \theta_2 - 0.01 \times 8.83$$

$$\theta_2 = \underline{\underline{2.9117}}$$

(e) Now we calculate the accuracy using new updated coefficient.

for this we need accuracy formula

i.e ⇒ $\text{Accuracy} = \frac{\text{No. of correct prediction}}{\text{Tottal no. of prediction}} \times 100$

So from the table we have y for each one

$y_1 = 0$

$y_2 = 1$ and $\theta_0 = 0.997$

$y_3 = 1$ $\quad \theta_1 = 1.842$

$y_4 = 0$ $\quad \theta_2 = 2.912$

$y_5 = 1$

$y_6 = 1$

So we calculate predicted values for each one separately.

individual 1 = income = 45 K ; Age = 25

So we put in $h_\theta(x) = \dfrac{1}{1+e^{(\theta_0+\theta_1 \cdot income+\theta_2 Age)}}$

$$h_{\theta_1}(x_1) = \frac{1}{1+e^{(0.997+1.842\times 45+2.912(25))}} = \frac{1}{1+e^{156.68}}$$

$$= \frac{1}{1+0} \approx 1 //$$

individual 2 = income = 60K; age = 35

$$h_\theta(x_2) = \frac{1}{1+e^{0.997+1.842\times 60+2.912(35)}} = \frac{1}{1+e^{213.43}}$$

$$= \frac{1}{1+0} \approx 1 //$$

individual 3 = income = 75K ; age = 40

$$h_\theta(x_3) = \frac{1}{1+e^{(0.997+1.842\times 75+40.2.912)}} = \frac{1}{1+e^{255.627}}$$

$$\frac{1}{1+0} \approx 1 //$$

Similarly we calculate for individual 4, 5 & 6

we will have 1 for all of them
$\therefore$ everyone is having predicted outcome "approved" //

individual	Actual Outcome (y)	Predicted outcome (x)
1	0	1
2	1	1
3	1	1
4	0	1
5	1	1
6	1	1
	= 4 //	= 6 //

$\therefore$ Accuracy will be

$$= \frac{4}{6} \times 100 = \boxed{66.7\%} //$$

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Question No. 4 // => Predicted:

		No churn (0)	Churn (1)
Actual	No Churn (0)	180	20
	Churn (1)	70	30

(a) Calculate the accuracy, Precision, recall & F_1 score for the model.

So we write formulaes for each task at (a)

$$\text{ACCURACY} = \frac{\text{True Positive} + \text{True Negative}}{\text{Total Number of Prediction}}$$

$$\text{PRECISION} = \frac{\text{True Positive}}{\text{True Positive} + \text{False Positive}}$$

$$\text{Recall} = \frac{\text{True Positive}}{\text{True Positive} + \text{False Negative}}$$

$$F_1 \text{ Score} = 2 \times \frac{\text{Precision} \cdot \text{Recall}}{\text{Precision} + \text{Recall}}$$

we get values from given table	Predicted : No churn	Predicted churn
Actual : No Churn	180	20
Actual : ~~No~~ Churn	70	30

∴ we have

$TN = 180$ (True Negative)

$FP = 20$ (False Positive)

$FN = 70$ (False Negative)

$TP = 30$ (True Positive)

Calculating the Metrice.

$$\text{Accuracy} : \frac{TP + TN}{TP + TN + FP + FN}$$

$$= \frac{30 + 180}{30 + 20 + 70 + 180} = \frac{210}{300} = 0.70 = 70\%$$

$$\text{Precision} = \frac{TP}{TP + FP} = \frac{30}{30 + 20}$$

$$= \frac{30}{50} = \frac{3}{5} = 0.6 = 60\%$$

$$Recall = \frac{TP}{TP+FN} = \frac{30}{30+70} = \frac{30}{100} = 0.3$$

$= 30\%$

$$F_1 \text{ Score} = 2 \times \frac{Pricician \cdot Recall}{Pricisian + Recall}$$

$$\therefore 2 \times \frac{0.6 \times 0.3}{0.6 + 0.3} = \frac{2 \times 0.18}{0.9} = 0.2 \times 2$$

$= 0.4 = 40\%$

(b) we get the 40% F_1 Score.

So F_1 score is a measure between Product of Précisian & recall using thier harmonic value of mean.

it is useful when there is imbalance in data set & one class is comman than other one.

Only 10% of people is churned $\therefore$ we can say the data is very imbalanced and we can rely on F_1 Score.

as Accuracy can be deviated because of 90% of No churn data & the value will be

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in Accurate & F_1 Score used the Precision & recall in which the False Negative and False positive values is included in the product of the value.

(C.) -0.6 Salary = 30,000 / probablity of churning $= 0.63$

Recap logistic regression

$$h_\theta = \frac{1}{1 + e^{-(\theta_0 + \theta_1 \cdot x_1 + \dots + \theta_n x_n)}}$$

So we are told to have coeffecient for Salary = -0.6

$$\therefore \quad h_\theta(salary) = \frac{1}{1 + e^{-(\theta_0 - 0.6 \cdot Salary)}}$$

given info. we have

Salary = 30,000 & probablity = 0.63

$$\therefore \quad 0.63 = \frac{1}{1 + e^{-(\theta_0 - 0.6 \cdot 30000)}}$$

$$0.63 = \frac{1}{1 + e^{-(\theta_0 - 18000)}}$$

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$$0.63 = \frac{1}{1+\frac{1}{e^{18000-\theta_0}}} \Rightarrow 1+e^{-(\theta_0-18000)} = \frac{1}{0.63}$$

~~as~~

$\therefore$ we have

$$1+e^{-(\theta_0-18000)} = 1.587$$

$$e^{-(\theta_0-18000)} = 0.587$$

$$-(\theta_0-18000) = \ln(0.587)$$

$$18000-\theta_0 = -0.533$$

$$18000+0.533 = \theta_0$$

$$18000.533 = \theta_0 //$$

for 31,000 Salary. now

we know value $\theta_0 = 18000.533$.

$\therefore$ putting eq.

$$h_\theta(31000) = \frac{1}{1+e^{-(18000.533-0.6\cdot 31000)}}$$

$$= \frac{1}{1+e^{-(18000.533-18600)}}$$

now $h_\theta(31000) = \dfrac{1}{1 + e^{-599.468}}$

$\therefore$ Since $e^{-599.488}$ is large no.

making $P \approx 0$ //

$\therefore$ the probablity of churning will be decreases //

Question No. 5 $\Rightarrow$

Outlook	Temp.	Humidity	Play Tennis
Sunny	Hot	High	NO
Sunny	Hot	Normal	Yes
Overcast	Hot	High	Yes
Overcast	Mild	High	Yes
Sunny	Mild	Normal	NO

a) We have entropy formulae

$$H(P_i) = -\sum_{i=1}^{n} P_i \log_2 (P_i) //$$

So we know from the table for play tennis

So. (i) Calculate the initial entropy

⇒ for Playing Tennis we have

⇒ 2 NO & 3 Yes.

⇒ total cases = 5 ∴ N=5

⇒ Probablity (Yes) = $\frac{3}{5}$ Probablity (NO) = $\frac{2}{5}$

$$\therefore H(P_i) = -\frac{3}{5}\log_2\left(\frac{3}{5}\right) + \frac{2}{5}\log_2\left(\frac{2}{5}\right)$$

Solving via calculator.

$$= -(-0.4421) + (+0.5287)$$

$$H(P_i) = 0.971$$

(ii) Calculate entropy for each attribute

Out look, temprature, Humidity.

Outlook → Sunny = 1 yes, 2 NO
Outlook → overcast = 2 yes.

$H(\text{Sunny}) = -\left(\left(\frac{1}{3}\right)\log(1/3) + \left(\frac{2}{3}\right)\log(2/3)\right)$

$= 0.918$

$H(\text{overcast}) = 0$

$H(\text{outlook}) = 0 + 0.918$
$= 0.918$

Temprature → Hot (2 yes, 1 NO)
Temprature → Mild (1 yes, 1 No)

$H(\text{Hot}) = -\left(\frac{2}{3}\log_2(2/3) + \frac{1}{3}\log_2(1/3)\right)$

$= 0.918$

$H(\text{Mild}) = -\left(\frac{1}{2}\log_2(1/2) + \frac{1}{2}\log_2(1/2)\right)$

$= 1$

$H(\text{Temp.}) = 0.918 + 1$
$= 1.918$

Humidity → High (2 yes, 1 No)
→ Narmal (1 yes, 1 No)

$$H(\text{High}) = -\left(\frac{2}{3}\log_2(2/3) + \frac{1}{3}\log_2(1/3)\right)$$

$$= 0.918$$

$$H(\text{Normal}) = -\left(\frac{1}{2}\log_2(1/2) + \frac{1}{2}\log_2(1/2)\right)$$

$$= 1$$

$$H(\text{Humidity}) = 1 + 0.918$$

$$= 1.918$$

(iii) Calculating each Info. gain.

IG (outlook) = 0.917 − 0.918 = 0.053

IG (Temprature) = 0.971 − 1.918 = −0.947

IG (Humidity) = 0.971 − 1.918 = −0.947

(b) Outlook : Overcast

Temprature : Hot

Humidity : Normal.

after evaluating everything

we split the outlook we know

Outlook = Overcast & all records labelled as yes, therefore model predicted would be a good day to play Tennis //