Q2:

a) $P(HR=1, IO=1, IP=1 \mid \text{Class}=\text{Comet}) =$

$$\frac{P(HR=1 \mid \text{Class}=\text{Comet}) \cdot P(IO=1 \mid \text{Class}=\text{Comet}) \cdot P(IP=1 \mid \text{Class}=\text{Comet})}{P(\text{Class}=\text{Comet})}$$

↳ 1 mark

$$= \frac{3\cancel{0}}{12\cancel{0}} \cdot \frac{5\cancel{0}}{12\cancel{0}} \cdot \frac{4\cancel{0}}{12\cancel{0}} \cdot \frac{6\cancel{0}}{10\cancel{0}}$$

$$= \frac{360}{17280} = 0.02083$$

} 1 mark

$$\frac{3\cancel{0}}{6\cancel{0}} \cdot \frac{5\cancel{0}}{6\cancel{0}} \cdot \frac{4\cancel{0}}{6\cancel{0}} \cdot \frac{6\cancel{0}}{10\cancel{0}}.$$

$$= \frac{360}{2160} = 0.1667$$

Calculation :- -1/2
Missed $\frac{3}{10}$ or $\frac{4}{10}$: deduct for that part.

$P(HR=1, IO=1, IP=1 \mid \text{Class}=\text{Asteroid}) =$

$$\frac{P(HR=1 \mid \text{Class}=\text{Asteroid}) \cdot P(IO=1 \mid \text{Class}=\text{Asteroid}) \cdot P(IP=1 \mid \text{Class}=\text{Asteroid})}{P(\text{Class}=\text{Asteroid})}$$

$$= \frac{20}{35} \cdot \frac{10}{35} \cdot \frac{5}{35} \cdot \frac{40}{100} = \frac{40000}{4287500} = 0.00932$$

} 1 mark

$$\frac{2\cancel{0}}{4\cancel{0}} \cdot \frac{1\cancel{0}}{4\cancel{0}} \cdot \frac{5}{4\cancel{0}} \cdot \frac{4\cancel{0}}{100}$$

$$= \frac{40}{6400} = 0.00625$$

Classification: Comet } 1 mark

b). $0.4X_1 + 0.6X_2 - 120 = 0$

SV_1 High Risk $X_1 = 140$, $X_2 = 200$

$$0.4 \times 140 + 0.6 \times 200 - 120$$
$$= 56 + 120 - 120 = 56$$

} ½ mark

SV_2 Low Risk $X_1 = 130$ $X_2 = 220$

$$0.4 \times 130 + 0.6 \times 220 - 120$$
$$= 52 + 132 - 120 = 64$$

} 1/2 mark

New Patient $X_1 = 145$ $X_2 = 210$

$$0.4 \times 145 + 0.6 \times 210 - 120$$
$$= 58 + 126 - 120 = 64$$

} 1 mark

Belongs to Low Risk } 1 mark

Role of support vectors. } 1 mark

c). $w_0 = -4$ $w_1 = 0.6$ $w_2 = 0.8$

$Z = w_0 + w_1 x_1 + w_2 x_2$

$x_1 = 10$, $x_2 = 5$ $Z = -4 + 0.6 \times 10 + 0.8 \times 5 = -4 + 6 + 4 = 6$ } 1

wrong value used: subtract for that point.

$$g(z) = \frac{1}{1+e^{-6}} = \frac{1}{1+\frac{1}{e^6}} = \frac{1}{1+\frac{1}{403.4}} = \frac{1}{1+0.002} = 0.998$$ } 1

$0.998 > 0.5$ hence class = Pass ↗1

Threshold 0.7 still class is Pass ↗1

Q3

a)

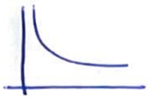
K	2	3	4	5	6
Inertia	3500	2500	1800	1200	1000

1000 700 600 200

Inertia : within cluster sum of squares } 1

why it decreases as K increases } 1

optimal K value using Elbow method : 5 ↳ 2



b). Meaning of PC1 captures 65% variation in dataset
↳ Project on PC1, variance is .65 } 2

should it be reduced to two principal components
↳ Yes, together (65+25=90) they capture more than 80% } 2

c).

		Predicted		
		HS=0	HS=1	
Actual	HS=0	TN 360	FP 40	
	HS=1	FN 20	TP 80	= 100
			120	

} 2 marks

Precision = $\frac{TP}{TP+FP} = \frac{80}{80+40} = 0.67$

Recall = $\frac{TP}{TP+FN} = \frac{80}{80+20} = 0.8$

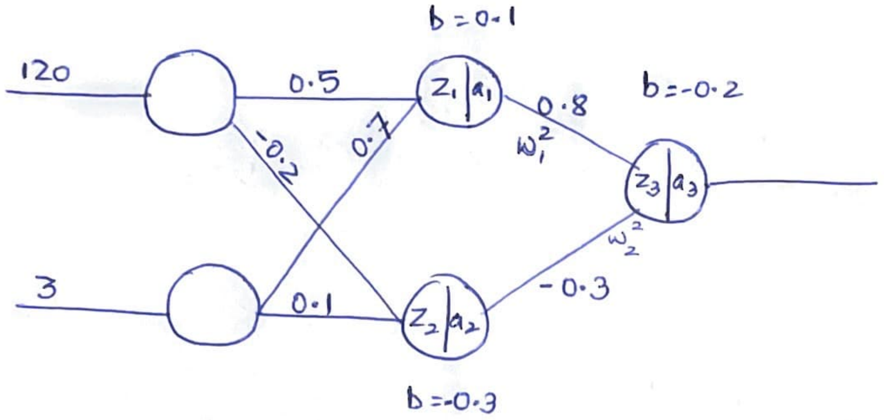
Specificity = $\frac{TN}{TN+FP} = \frac{360}{360+40} = 0.9$

F1 Score = $\frac{2.P.R}{P+R} = \frac{2\times0.67\times0.8}{0.67+0.8} = \frac{1.072}{1.47} = 0.729$

} 4 × ½ = 2 marks

Q4:

a)



Basic formula wrong for Z_1, Z_2 : ½

method correct all calculations wrong : 3

Some calculations wrong : 3½

wrong activation Relu+Sigmoid : 2

wrong in multiple places : 2

done half z_1, a_1, z_2, a_2 : 1

$Z_1 = 120 * 0.5 + 3 * 0.7 + 0.1 = 62.2$ ½

$a_1 = \text{Relu}(Z_1) = 62.2$ ½

$Z_1 = 120 * 0.5 + 3 * -0.2 + 0.1$
$= 60 - 0.6 + 0.1 = 59.5$ 1
$a_1 = 59.5$

$Z_2 = 120 * (-0.2) + 3 * 0.1 - 0.3 = -24$ ½

$a_2 = \text{Relu}(Z_2) = \text{Relu}(-24) = 0$ ½

$Z_2 = 120 * 0.7 + 3 * 0.1 - 0.3$
$= 84 + 0.3 - 0.3 = 84$ 1
$a_2 = 84$

$Z_3 = 62.2 * 0.8 + 0 * (-0.3) - 0.2 = 49.56$ ½

$z_3 = 0.8 * 59.5 + (-0.3) * 84 - 0.2$
$= 47.6 - 25.2 - 0.2$
$= 22.2$ 1
$a = \frac{1}{1+e^{-22.2}} = \sim 1$

$a_3 = \frac{1}{1+e^{-49.56}} = \sim 1$ ½

Customer belongs to Churn, Class 1 1

b). $\text{Error} = -(y \log \hat{y} + (1-y)\log(1-\hat{y}))$

$= -(1 \log 1 + (1-1)\log(1-1)) = -(1 \log 1 + 0 \cdot \log 0) = 0$ } 2

$\frac{\partial J}{\partial a_3}$?

$J = -(y \log a_3 + (1-y)\log(1-a_3))$

$\frac{\partial J}{\partial a_3} = -\left(\frac{y}{a_3} - \frac{(1-y)}{1-a_3}\right) = \frac{a_3 - y}{a_3(1-a_3)}$ } 2 → - sign forgot : -½

$\frac{\partial J}{\partial a_3} = 0$

④

c)
$$\frac{\partial J}{\partial w_1^2} = \frac{\partial J}{\partial a_3} \cdot \frac{\partial a_3}{\partial z_3} \cdot \frac{\partial z_3}{\partial w_1^2}$$

$$\frac{a_3 - y}{a_3(1-a_3)} \qquad (a_3)(1-a_3) \qquad z_3 = a_1 w_1^2 + a_2 w_2^2$$

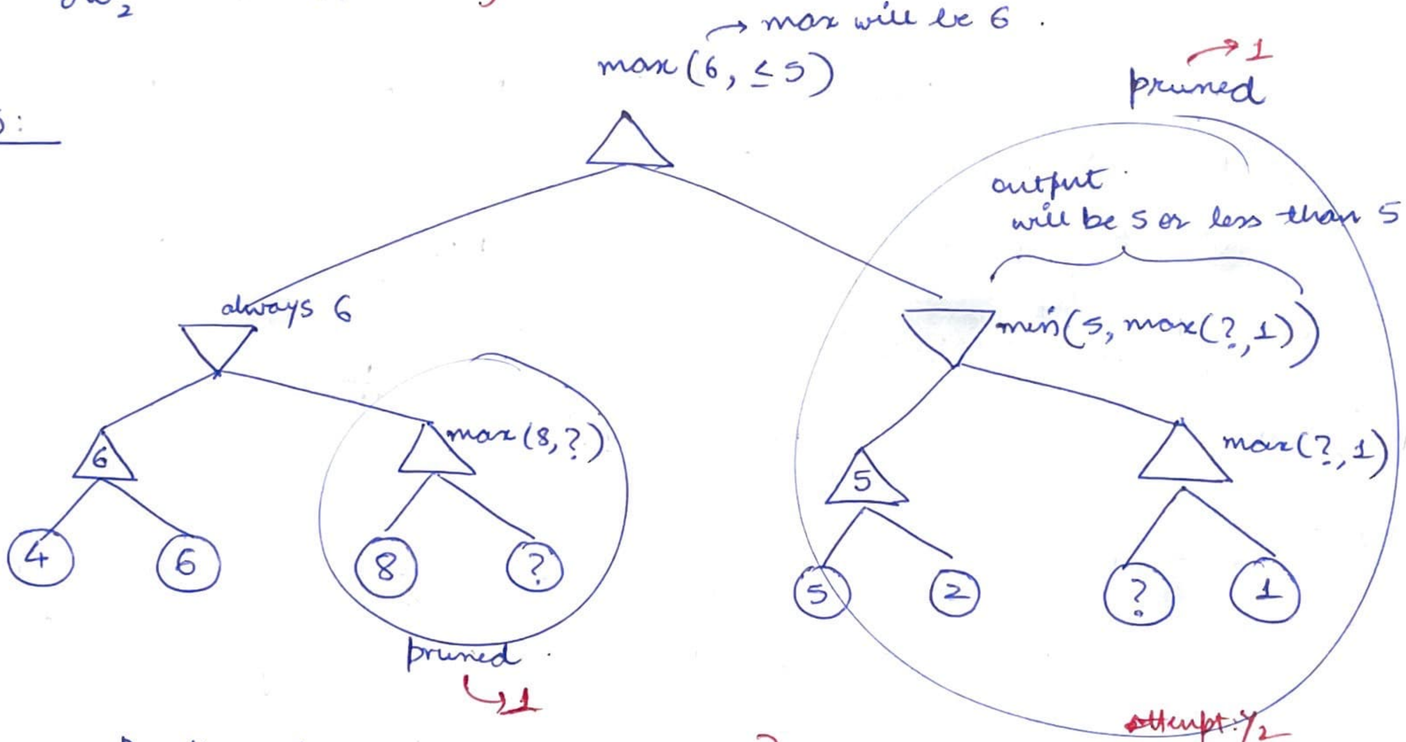
$$\frac{\partial z_3}{\partial w_1^2} = a_1$$

$$= (a_3 - y)\, a_1 \;\}2$$

$$\frac{\partial J}{\partial w_2^2} = (a_3 - y)\, a_2 \;\}2$$

Q5:

a)



Root node optimal value: 6 }2

b)

γ=0.8

-0.2 instead of 0.2 : ½

	1	2	3	4
1	4.0	4.8		
2	5.2	5.6		
3			8.0	
4				20.0 *

1½

~~Q(11, →) = R(11) + 0.8 * 4.8 = 4 + 0.8 * 4.8 = 7.84~~

~~Q(11, ↓) = R(11) + 0.8 * 5.2 = 4 + 0.8 * 5.2 = 8.16~~

1½

Impact of γ on decision }1

γ close to 1 : more emphasis on future.

→ = -2 + 0.8 * 4.8 = 1.84

↓ = -2 + 0.8 * 5.2 = 2.16

↑ ← = -2 + 0.8 * 4 = 1.2

} only this shown: ½