Q) Given

i/p image size $i \times i = 224 \times 224$
No. of i/p channels $C = 3$
o/p size : $o \times o = 55 \times 55$
No. of o/p feature maps (filters) : $N = 96$.
Kernel size : $k \times k = 11 \times 11$.

Multiplications in a Conv. Layer = $o \times o \times N \times C \times k \times k$.

per o/p feature map

For each of the $N = 96$ o/p feat. maps, the conv. op. involves sliding the kernel over the i/p volume (which has $C = 3$ channels).
For each of pos^n in the o/p (55×55), the kernel (11×11) is applied to each of 3 i/p channels, resulting in $11 \times 11 \times 3$ multiplications per o/p pixel.
Total Multiplications.
Multiply the no. of o/p pixels (55×55) by the no. of feat maps (96) and the multiplications per pixel ($11 \times 11 \times 3$):

$$\underline{55 \times 55} \times \underline{96} \times \underline{3 \times 11 \times 11}$$

Result:
No. of multiplications = 105,019,200.
105415200.

Q2

Step 1: Compute Mean (μ) of the Mini batch

$$\mu = (2.1 + 4.1 + 0.2 + 0.5 + 3.4)/5 = 10.3/5 = \underline{2.06}$$

Step 2: Compute the Variance (σ^2) (using the mean μ)

$$\sigma^2 = \frac{(2.1-2.06)^2 + (4.1-2.06)^2 + (0.2-2.06)^2 + (0.5-2.06)^2 + (3.4-2.06)^2}{5}$$

$$= (0.0016 + 4.1616 + 3.4596 + 2.4336 + 1.7956)/5$$

$$= (11.852)/5$$

$$= 2.3704$$

Step 3: Normalize each value

Batch Norm formula: $\hat{x}_i = \dfrac{x_i - \mu}{\sqrt{\sigma^2 + \epsilon}}$

(Assuming $\epsilon = 10^{-5}$ for numerical stability, but here $\sqrt{2.3704} \approx 1.54$

$$x_i = \frac{x_i - 2.06}{1.54}$$

$\hat{x}_1 \approx 0.03$

$\hat{x}_2 \approx 1.32$

$\hat{x}_3 \approx -1.21$

$\hat{x}_4 \approx -1.01$

$\hat{x}_5 \approx 0.87$

Apply Scale (γ) and Shift (β) $\quad y_i = \gamma x_i + \beta$

given $\gamma = 1.0$ and $\beta = 0.9$ $\;+1.0$

$y_1 = \cancel{1.0}\ 0.9 \times 0.03 + \cancel{0.9}\ 1.0 = \cancel{0.93}\ 1.0$

$y_2 = \cancel{1.0}\ 0.9 \times 1.32 + \cancel{0.9}\ 1.0 = 2.\cancel{22}\ 2.2$

$y_3 = \cancel{1.0}\ 0.9 \times (-1.21) + \cancel{0.9}\ 1.0 = -\cancel{0.31}\ -0.1$

$y_4 = \cancel{1.0}\ 0.9 \times (-1.01) + \cancel{0.9}\ 1.0 = -\cancel{0.11}\ 0.1$

$y_5 = \cancel{1.0}\ 0.9 \times 0.87 + \cancel{0.9}\ 1.0 = 1.\cancel{77}\ 1.8$

Final O/p (to 1 Dec. place)

~~$y = [0.9, 2.2, -0.3, -0.1, 1.3]$~~

~~$y = [1.0, 2.2, -0.1, 0.1, 1.3]$~~

$y = [1.0, 2.2, -0.1, 0.1, 1.8]$

Q3

Confusion Matrix : $\begin{bmatrix} 21 & 10 & 3 \\ 2 & 31 & 5 \\ 4 & 3 & 28 \end{bmatrix}$

Step 1 (Totals)

Total Samples : $21 + 10 + 3 + 2 + 31 + 5 + 4 + 3 + 28 = 107$

Step 2 (Per class metric)

Class A.

$TP = 21$ (correctly predicted A)

$FP = 2 + 4 = 6$. (others predicted as A)

$FN = 10 + 3 = 13$ (A predicted as others)

$TN = \text{Total} - TP - FP - FN = 107 - 21 - 6 - 13 = 67$

Accuracy: $\dfrac{TP + TN}{\text{Total}} = \dfrac{21 + 67}{107} = \dfrac{88}{107} \approx 0.82$.

Precision: $\dfrac{TP}{TP + FP} = \dfrac{21}{21 + 6} = \dfrac{21}{27} \approx 0.78$.

Recall : $\dfrac{TP}{TP + FN} = \dfrac{21}{21 + 13} = \dfrac{21}{34} \approx 0.62$.

Class B.

$TP = 31$

$FP = 10 + 3 = 13$.

$FN = 2 + 5 = 7$

$TN = 107 - 31 - 13 - 7 = 56$.

Accuracy:

$\dfrac{31 + 56}{107} = \dfrac{87}{107} \approx 0.81$

Precision:

$\dfrac{31}{31 + 13} = \dfrac{31}{44} \approx 0.70$.

Recall : $\dfrac{31}{31 + 7} = \dfrac{31}{38} \approx 0.82$

Class C

$TP = 28$

$FP = 3+5 = 8$

$FN = 4+3 = 7$

$TN = 107 - 28 - 8 - 7 = 64$

Accuracy:

$$\frac{28+64}{107} = \frac{92}{107} \approx 0.86.$$

Precision:

$$\frac{28}{28+8} = \frac{28}{36} \approx 0.78$$

Recall:

$$\frac{28}{28+7} = \frac{28}{35} \approx 0.80.$$

Final 3 x 3 matrix (rounded to 2 decimal places).

$$\begin{bmatrix} 0.82 & 0.78 & 0.62 \\ 0.81 & 0.70 & 0.82 \\ 0.86 & 0.78 & 0.80 \end{bmatrix}$$

Each row:

[Accuracy, Precision, Recall] for A, B, C respectively

Q.4

Given.

o/p probabilities (softmax o/p's):

$P_c = [0.19, 0.24, 0.23, 0.17, 0.17]$

Ground truth class labels

$Y_c = 3$ [classes are indexed from 0 to 4].

Step 1 One-hot encoding of Ground truth.

For $Y_c = 3$, the one-hot encoded vector $y = [0, 0, 0, 1, 0]$

Step 2 Cross Entropy loss (L)

$$L = -\sum_{c=0}^{4} Y_c \log(P_c)$$

Since only $y_3 = 1$, this simplifies to:

$$L = -\log(P_3)$$

Step 3 Plug in the probability

From P_c, the probability of the true class ($c=3$) is $P_3 = 0.17$.

$$L = -\log(0.17)$$

Step 4 Compute the logarithm

Using natural logarithm (base e):

$$L = -\log(0.17) \approx -(-1.77196) = \underline{1.772}$$