

Convolution by Hand

Name		Date	
Class / Sec		Roll no.	

1 · AIM

To perform the **convolution** operation by hand on a small grayscale image, observe how different kernels produce different outputs, and calculate the size of the resulting feature map.

2 · SOFTWARE AND TOOLS USED

TOOL	WHAT IT IS FOR
A pencil	The arithmetic is done by hand — that is the point of the entry
The worksheet grids	5×5 image, 3×3 kernels, and blank output grids
A browser (Part 4 only)	To compare your hand result with a live convolution demo

3 · THEORY

Convolution slides a small grid of numbers, called a **kernel**, across an image. At each position every overlapping pair is multiplied and the products are added, giving one number in the **feature map**. Different kernels detect different features.

TERM	WHAT IT MEANS
Kernel	A small grid of numbers, usually 3×3, slid across the image
Feature map	The grid of results produced by the convolution
Stride	How far the kernel moves each step — 1 unless stated otherwise
Padding	Extra border values added so the output stays the same size

The output size formula: Output = **image - kernel + 1** in each direction, when there is no padding. A 5×5 image with a 3×3 kernel gives $5 - 3 + 1 = 3$, so a 3×3 feature map. **Forgetting the +1 is the commonest error in this unit.**

4 · METHOD

This entry is a **worked activity** rather than a program. Follow the attached worksheet, and staple it behind this cover page.

STAGE	WHAT YOU DO	WHAT IT PRODUCES
1	One window worked in full	Nine products, one sum, one output value
2	The complete feature map	All nine positions, giving a 3×3 output
3	A second kernel	A different feature map from the same image
4	Comparing the two	Which kernel detected which feature, and why

Attached worksheet: Activity_Convolution_by_Hand — the full worksheet with the image grid, both kernels and blank output grids. Complete it in pencil and staple it behind this page.

5 · RESULTS

Record your key figures here, then attach the completed worksheet and screenshots behind this page.

WHAT TO RECORD	YOUR RESULT
Image size	
Kernel size	
Output (feature map) size	
Value of the first window	
What kernel 1 detected	
What kernel 2 detected	

[ATTACH WORKSHEET AND SCREENSHOTS HERE]

The completed Convolution by Hand worksheet, showing every product and every sum

6 • OBSERVATION AND RESULT

Two or three sentences in your own words. Say what each kernel detected and how you calculated the output size.

Example observation: Convoluting the 5×5 image with a 3×3 kernel and no padding gave a 3×3 feature map, since $5 - 3 + 1 = 3$. The first kernel produced large values along the boundary between the dark and light halves and near zero elsewhere, so it detected a vertical edge. The second kernel responded most strongly to the flat regions, showing that the same image gives completely different feature maps depending on the kernel used.

7 • VIVA QUESTIONS FOR THIS ENTRY

LIKELY QUESTION	SHAPE OF A STRONG ANSWER
What size feature map did you get, and why?	3×3 , because $5 - 3 + 1 = 3$ in each direction with no padding
Why does the output shrink?	The kernel cannot be centred on the outermost rows and columns, so those positions are lost
How would padding change your answer?	With padding the output stays 5×5 , because the border values give the kernel somewhere to sit
What did your first kernel detect?	Name the feature — an edge, say — and point to the large values in your own feature map
Show me one window's arithmetic.	Have one worked window ready: nine products, then the sum

8 • HOW THIS ENTRY IS MARKED

FULL MARKS

Every product shown, not just the totals · the output size calculated with the formula written out · both kernels completed · a comparison saying what each one detected · working in pencil with corrections visible

LOSES MARKS

Only the final feature map given, with no products shown · output size stated as 5×5 or 6×6 — the +1 forgotten or double-counted · no comparison between the two kernels

Before you submit: Check your output grid is **3×3**, not 5×5. And check one window by re-adding the nine products — the marks here are for the **working**, so a wrong total with clear steps still scores.