CNN Fundamentals.

1. Explain the basic components of a digital image and how it is represented in a computer. State the differences between grayscale and color images.
   Ans:
   Basic Components of a Digital Image
   A digital image is composed of:

- **Pixels (Picture Elements)**: The smallest unit of an image, each representing a single color or intensity value.
- **Channels**:
  - **Grayscale**: Single channel (intensity values, typically 0-255).
  - **Color (RGB)**: Three channels (Red, Green, Blue), each with intensity values (0-255).
- **Resolution**: Determined by width × height (e.g., 1920×1080 pixels).
- **Bit Depth**: Number of bits per pixel (e.g., 8-bit = 256 intensity levels).

Grayscale vs. Color Images

Feature	Grayscale Images	Colour (RGB) Image
Channels	1(intensity)	3(R,G,B)
File size	Smaller	Larger(3*grayscale)
Applications	Medical imaging, edge detection.	Photography, object detection.

2. Define Convolutional Neural Networks (CNNs) and discuss their role in image processing.Describe the key advantages of using CNNs over traditional neural networks for image-related tasks
   Ans:
   Convolutional Layers & Purpose

- **Purpose**: Detect local patterns (edges, textures) via **filters/kernels**.
- **Operation**: Slides a filter over the input, computing dot products to produce a **feature map**.

Filters (Kernels)

- Small matrices (e.g., 3×3, 5×5) that extract features.
- Eg. Vertical edge detector.

3. Define convolutional layers and their purpose in a CNN.Discuss the concept of filters and how they are applied during the convolution operation.Explain the use of padding and strides in convolutional layers and their impact on the output size

concept	Purpose	Impact on Output Size
Padding(Adding zeros around edges)	Preserves spatial dimensions	Output size = Input size(with “same” padding.)
Stride(step size of filter)	Controls downsamplingL	Larger stride→ smaller output(eg, strid=2 halves dimension)

Output size Formula.
Output size = [(Input size-Filter size+2*padding)/stride]+1

4. Describe the purpose of pooling layers in CNNs.Compare max pooling and average pooling operation

   Ans: **Purpose of Pooling Layers**

- **Dimensionality Reduction**: Reduces spatial size (controls overfitting).
- **Translation Invariance**: Makes network robust to small shifts.
- **Computational Efficiency**: Reduces parameters for subsequent layers.

Max Pooling vs. Average Pooling

Pooling type	Operations	Advantages	Disadvantages
Max Pooling	Select maximum value in windows	Preserves sharps feature(edges)	Loses some special details
Average pooling	Computes mean of window	Smooth outfput (reduces noise)	Blurs edges.

Example (2×2 Pooling):

- Input: [[1, 3], [2, 4]]
- **Max Pooling**: 4
- **Average Pooling**: (1+3+2+4)/4 = 2.5