Date: / / Page No.

# Computer Vision Assignment

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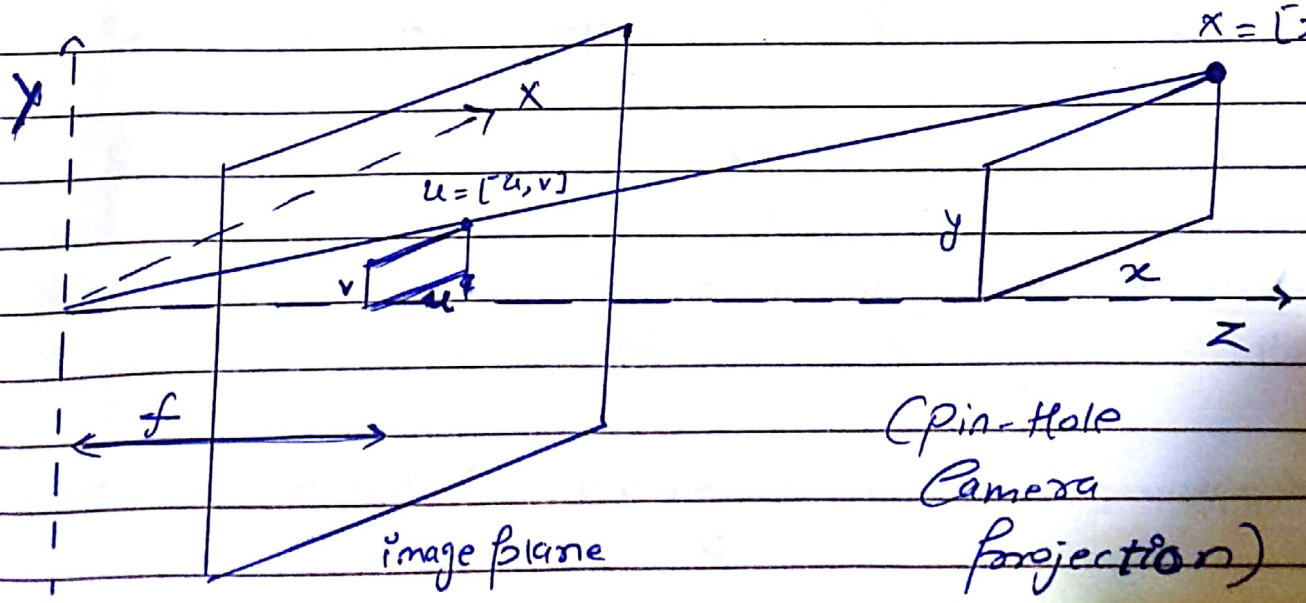
## A) Theoretical question:

### A1) Image formation:

A Professional full-frame digital camera uses an image of size 36mm x 36mm and standard focal length of 50 mm. Let us say that the square sensor provide 16 megapixels. Now you buy smartphone with a 16 megapixel sensor (assuming a square image too), but given a focal length of 4mm so that the phone fits into your pocket.

① Using the pinhole camera projection equation, calculate the size of light-sensitive image sensor of your smart-phone. Calculate the ratio of this size relative to the professional camera sensor size.

Pinhole-Camera Projection:-




(Pin-Hole Camera projection)

The Projected Point u, has co-ordinates (u, v) in 2D image Plane. By Similar triangle, we have following equation:

$$\frac{v}{f} = \frac{y}{z} \quad \text{— (i)} \qquad \frac{u}{f} = \frac{x}{z} \quad \text{— (ii)}$$

$$\frac{v}{y} = \frac{f}{z} \qquad \frac{u}{x} = \frac{f}{z}$$

(*) For Professional Camera:
Sensor size = 36 × 36 mm
focal length = 50 mm.

Equations: $\frac{36}{50} = \frac{X}{Z}$ and $\frac{36}{50} = \frac{y}{z}$

For Smart-phone:-
focal length = 4mm

$$\frac{V_{Smartphone}}{4} = \frac{Y}{Z} \quad \text{and} \quad \frac{U_{Smartphone}}{4} = \frac{X}{Z}$$

$\Rightarrow$ we know $\frac{X}{Z} = \frac{Y}{Z} = \frac{36}{50}$.

$\therefore \frac{U_{Smartphone}}{4} = \frac{V_{Smartphone}}{4} = \frac{36}{50}$.

$$U_{Smartphone} = V_{Smartphone} = \frac{36}{50} \times 4 = 2.88\text{mm}$$

Date: / / Page No.

Therefore, Size of the light-Sensitive image Sensor of Smart-Phone is

$\Rightarrow$ 2.88 mm x 2.88 mm.

Ratio of size relative to professional Camera Sensor size:

$$= \frac{36mm \times 36mm}{2.88mm \times 2.88mm} = \frac{1296}{8.2944} = 156.25$$

⊙ Calculate the size of a Sensor pixel element for the professional and your Smart-phone Cameras. Provide a Short-discussion of eventual advantages/disadvantages of your resulting measures, and reasons why Some professionals or amateurs favor more expensive large Cameras.

Answer) Size of Sensor for professional Camera = 36mm x 36mm.
Professional Camera provides 16 megapixels.
Size of Sensor for Smartphone = 2.88mm x 2.88mm.
Smartphone provides 16 megapixels.

Size of Sensor pixel for professional Camera =

$$= \frac{36mm \times 36mm}{16 \times 10^6} = 8.1 \times 10^{-5} mm^2$$

Size of sensor pixel for Smart phone: $\frac{2.88 \times 2.88}{16 \times 10^6} = 5.184 \times 10^{-7} mm^2$

(*) For given number of pixels, larger the image sensor size, the larger the size of individual pixels. Conversely, the smaller the image, smaller the size of individual pixel. Same number of pixels in to smaller area introduces problem such as noise, blooming (light spilling off the sides of the pixels), which in turn leads to image degradation.

(i) Calculate the storage requirement assuming storage of raw images with color RGB channels, for both cameras.

Answer) Storage size

Resolution = 16 mega pixel

for both professional and smartphone.

- To store 1 pixel in RGB = 24 bits = 3 bytes.

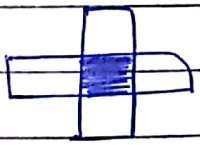
$$\Rightarrow \frac{16 \times 10^6 \times 3}{1024 \times 1024}$$

$$= 45.77 \text{ MB}.$$

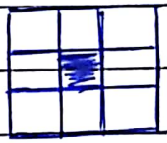
A2) Connectivity foreground / background.

One solution to digitization is to mix Connectivities. Using 8-neighborhood for foreground and 4-neighbor hood for background, examine the Paradoxes shown in the book (Fig 2.7). Discuss the number of components of fore-versus background given this choice. Also discuss the # of components when either using 4-n (and also 8-n) for both fore-and background. And when reversing the notion and using 8-n for background and 4-n for foreground. You can discuss in words and also include sketches of your thoughts to this section.

Answer)



4-neighborhood



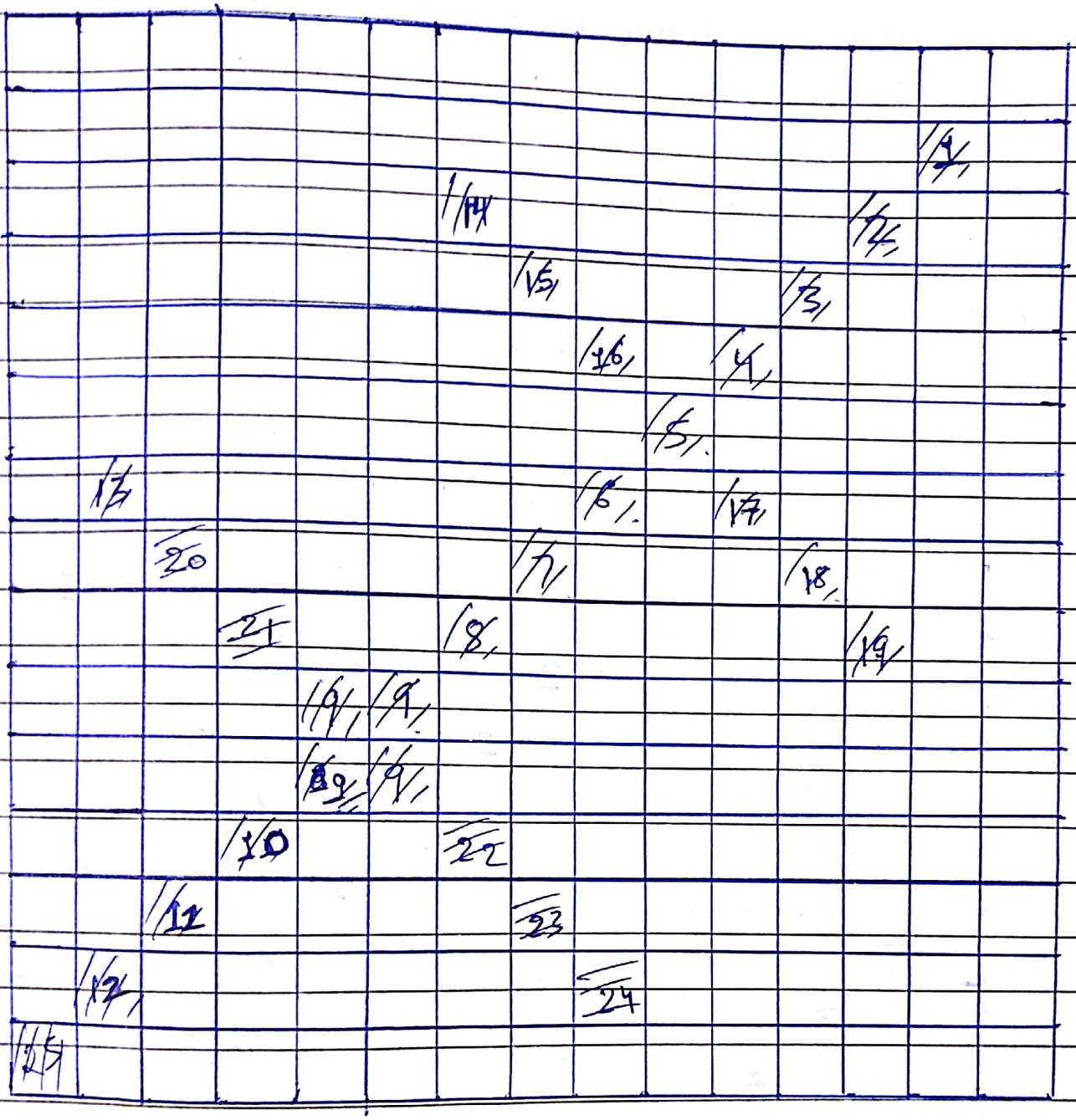
8-neighborhood.

Crossing-Line Paradox:

If there is a path between two pixels, then these pixels are contiguous. Neighborhood and Contiguity definitions on square grid create interesting paradoxes.

Paradox 1: Two digital line intersect with 45° slope. The lines are said to be intersecting, if they have a common point.

Case 1: Using 4-Connectivity for foreground and 8-Connectivity for Back-ground.

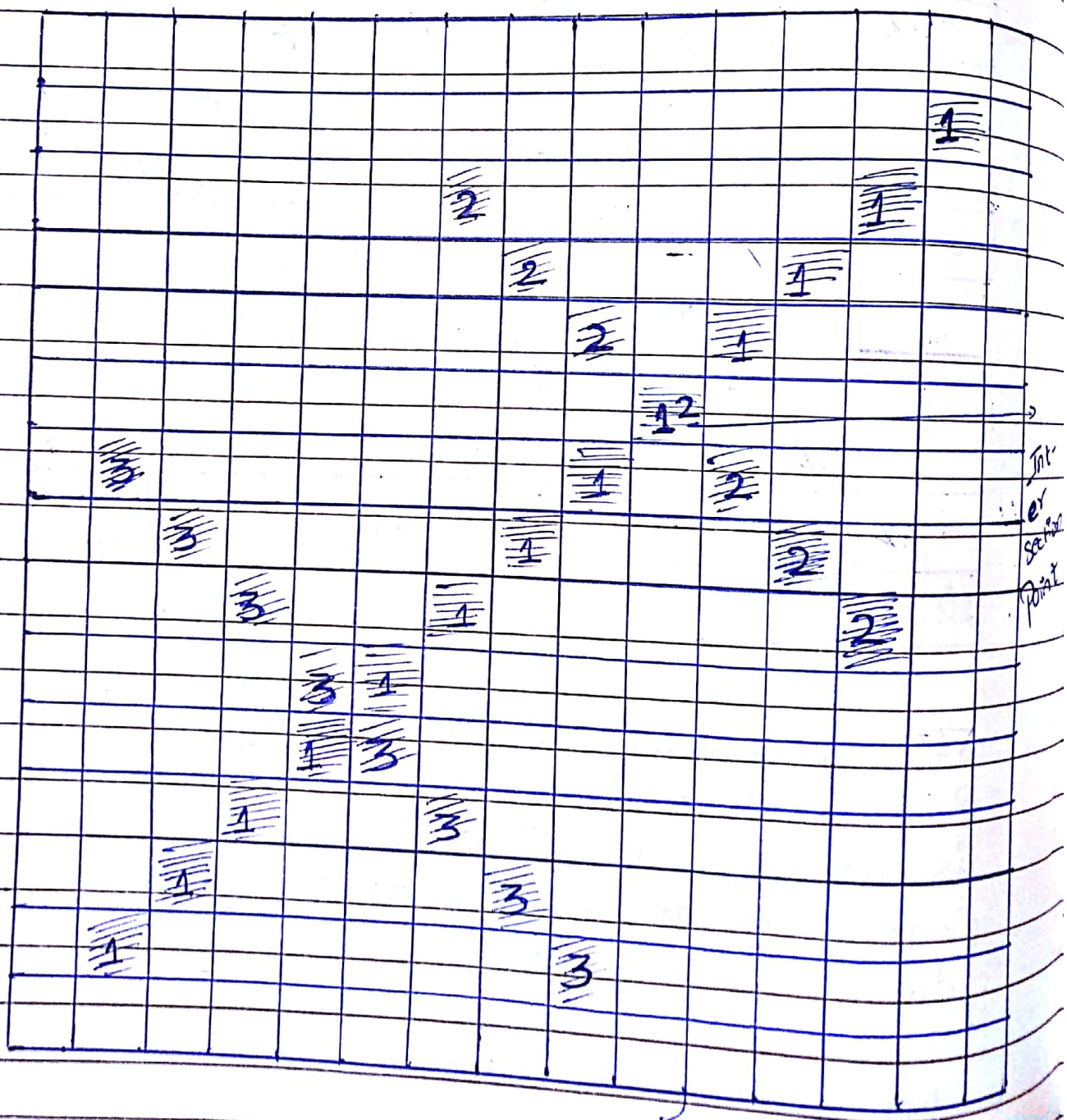



If we assume 8- Connectivity for Background, Background is Contiguous. And when 4-Connectivity is used for foreground, the lines are not Contiguous at each of their points, So they do not intersect.

No. of Connected Components = 25
(for 4-Connectivity)

Date: / / Page No.

When we use 4-Connectivity for Back-ground, Background is contiguous. And 8-Connectivity for fore-ground, the perpendicular lines do intersect in one case (upper right inter-section) and do not intersect in another case (lower left), as they do not have any common point.

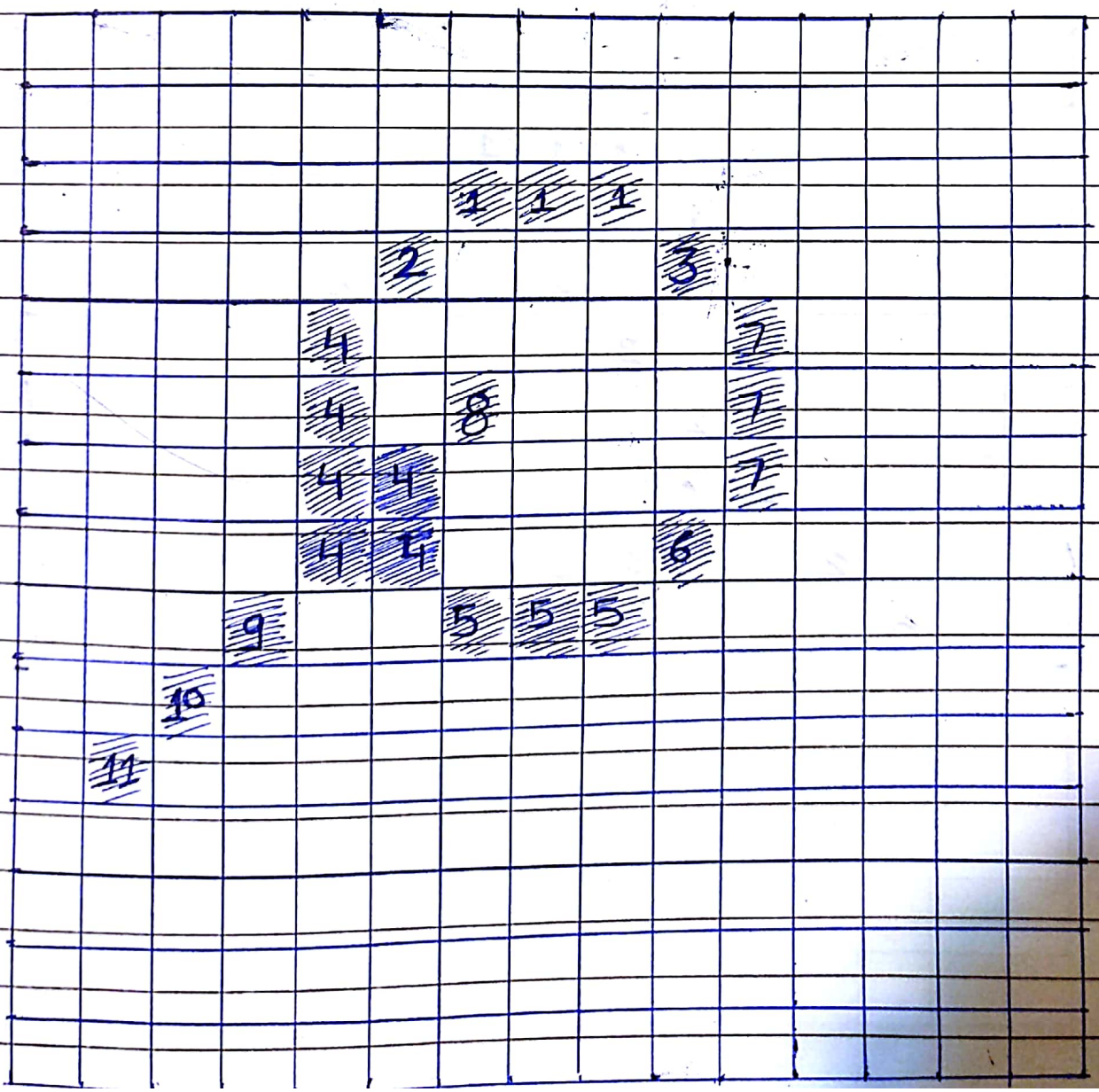


Date: / / Page No.

No. of Connected Components, when Foreground is in 4-Connectivity = 3

⊛ Euclidean Geometry → Euclidean geometry states that each closed curve (e.g a circle) divides the plane into two non-contiguous regions.

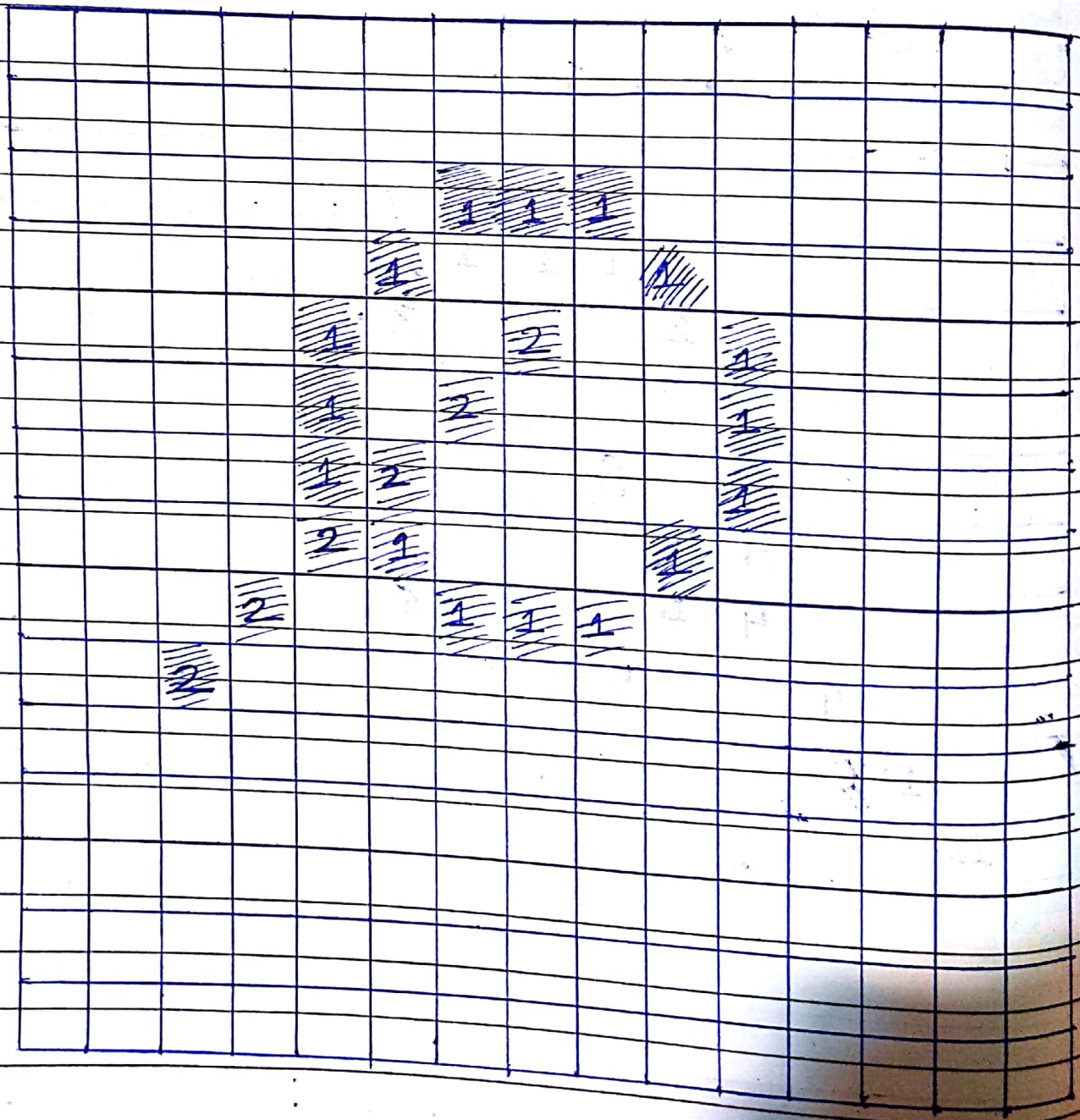
Case 1: When background is assumed to be in 8-Connectivity and fore-ground 4-Connectivity. We do not get a Contiguous circle, so the plane is not divided into two regions.



Date: / / Page No.

Number of Connected in this case : 11

Case2: When background is assumed in 4-Connectivity. Background will be Contiguous. Foreground in 8-Connectivity. We get a Contiguous circular region. It divides the plane in to two non-Contiguous region. Using 8-Connectivity, line can be drawn from the inner part of a closed curve into the outer part which does not intersect the curve.



Number of Connected Components in this Case : 2

A3)

Answer) Because during histogram equalization, in effect, to approximate a continuous integral of the cumulative PDF of the pixels we use discrete sum. In other words, pixel values are discreet integers and the number of pixels is also an integer, this affects the final outcome of Histogram Equalization.