Instruction:
This sample exam paper contains 4 sample exam questions.
In the actual exam paper, there will be 5 questions, each is worth 10 marks.
You will need to answer only FOUR questions.
The total mark is 40 marks.

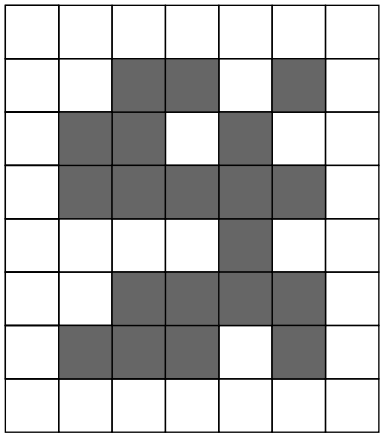
Question 1. (10 marks)

a) (1 mark)

Briefly describe the two types of photo receptors in the retina and what these receptors encode.

b) (4 marks)

Given below is a binary image where dark pixels denote object pixels.



Binary Image

i) (1 mark) Use 4-connectedness and 8-connectedness to sketch the distinct objects in the binary image.

ii) (2 marks) Write down the expression for the first order moments of a binary image. Use these expressions to compute the centroid of the object in the binary image given above. You may assume that the top left pixel has coordinates $(0, 0)$.

iii) (1 mark) Write down the expressions for the second order moments of a binary image.

c) (1 mark)

Briefly describe the difference between diffuse reflection and specular reflection. Use diagrams where necessary in your description.

d) (1 mark)

A greyscale transformation can be applied directly onto a greyscale image to manipulate its pixel values (assuming the range is [0,255]). Draw the diagrams for the following greyscale transformations:

i) (0.5 mark) thresholding the image at pixel value 100.

ii) (0.5 mark) linearly stretch the intensity in the interval [100,200] to [0,255].

e) (3 marks)

When would it be suitable to use histogram equalization? Briefly outline the steps to histogram-equalize a given image.

Question 2. (10 marks)

a) (1 mark)

Let $f(x)$ be a 1-dimensional continuous function. Let $F(\omega)$ be its Fourier transform.

i) (0.5 mark) Write down the expression for $F(\omega)$ as a function of f.

ii) (0.5 mark) Write down the inverse Fourier transform of $F(\omega)$.

b) (4 marks)

Explain how the Fourier Transform is used for *image enhancement* by applying frequency domain filters, such as high-pass filtering, high-boost filtering, and homomorphic filtering. What is (are) the main task(s) for the above 3 filters as far as image processing is concerned?

c) (2 marks)

Describe when it would be suitable to use the Prewitt masks. Use a diagram to illustrate these masks. Sketch the result when <u>one</u> of these masks is applied to the greyscale image below. You only need to compute the values for the central region of the image that is fully covered by the mask.

6	7	7	8	8	9
6	7	8	34	38	39
7	8	9	36	38	39
7	6	36	35	37	40
6	6	8	36	18	39
3	7	8	35	20	39

d) (3 marks)

Describe the Canny edge detector. What are the steps involved in edge detection using this detector. Use diagrams where necessary in your explanation.

Question 3. (10 marks)

a) (3 marks)

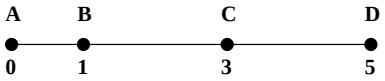
Suppose that we have 4 coplanar scene points projecting onto the image planes of two cameras, giving $\{\mathbf{x}_i = (x_i, y_i, 1)^\top \mid i = 1, \cdots, 4\}$ in the first image and $\{\mathbf{x}'_i = (x'_i, y'_i, 1)^\top \mid i = 1, \cdots, 4\}$ in the second image. Explain how you would compute the homography that maps these two sets of points. Is there any condition you must impose in your computation?

b) (2 marks)

Explain what camera calibration is. What are the steps involved? What do we attempt to recover in camera calibration?

c) (1 mark)

Compute a cross ratio for points in the following diagram:



Is your answer unique?

d) (3 marks)

Describe the epipolar constraint. What entity do you need to compute in order to use this constraint? Describe the step involved for estimating this entity.

e) (1 mark)

Give a window-based function that would be suitable for matching corresponding points in two given image.

Question 4. (10 marks)

a) (1 mark)

Describe briefly what vanishing points and vanishing lines are in an image.

b) (3 marks)

Describe the mathematics involved in computing the 3D coordinates of a point illuminated by a light stripe plane having equation $aX + bY + cZ + d = 0$ using a known camera calibration matrix C.

c) (1 mark)

Explain the distinction between *motion field* and *optical flow* in an image. Use a diagram to illustrate your answer.

d) (1 mark)

Briefly describe the three CIE standard primaries.

e) (3 marks)

Describe in detail how you would use the linear Support Vector Machine (SVM) to classify two classes that are not linearly separable.

f) (1 mark)

Briefly describe a situation where the aliasing problem can occur and how this problem can be overcome.

END OF PAPER