THE UNIVERSITY OF WESTERN AUSTRALIA

FIRST SEMESTER EXAMINATIONS
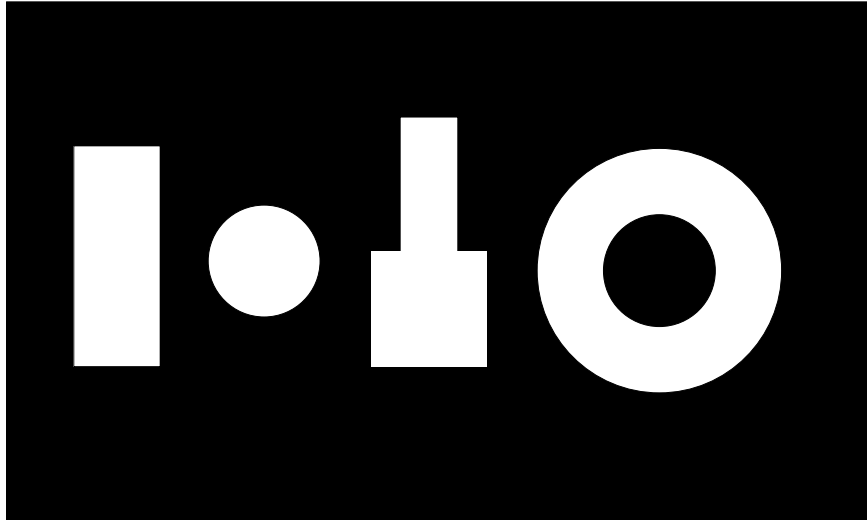
JUNE 2001

COMPUTER VISION 412

Time allowed: 2 hours

Reading time: 10 minutes

Each question is worth 10 marks.
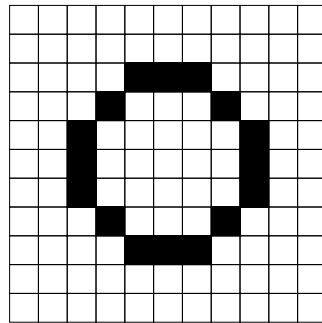All candidates should attempt SIX questions.

1.

(a) The following shapes can appear in a binary image, each in any orientation and at any scale. Describe an algorithm that you could use to recognize each shape.
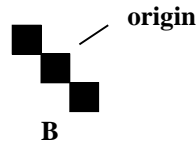

(4)

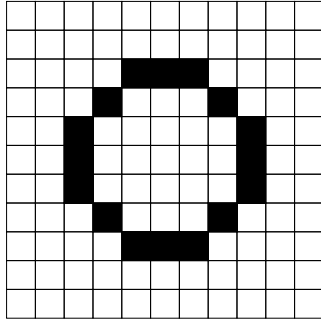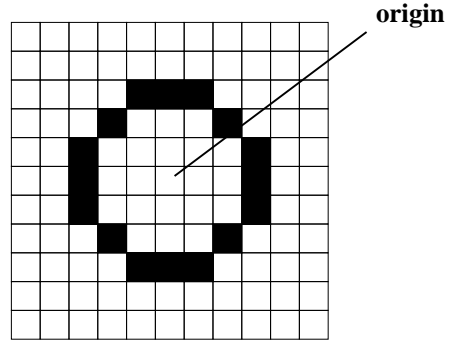(b) Using the 3 pixel structuring element B sketch the dilation of the object shown below.

object

(2)

(c) Sketch the erosion of the object shown below using the structuring element B. (Note that B is identical to the object and note that the origin of B is at the centre.)

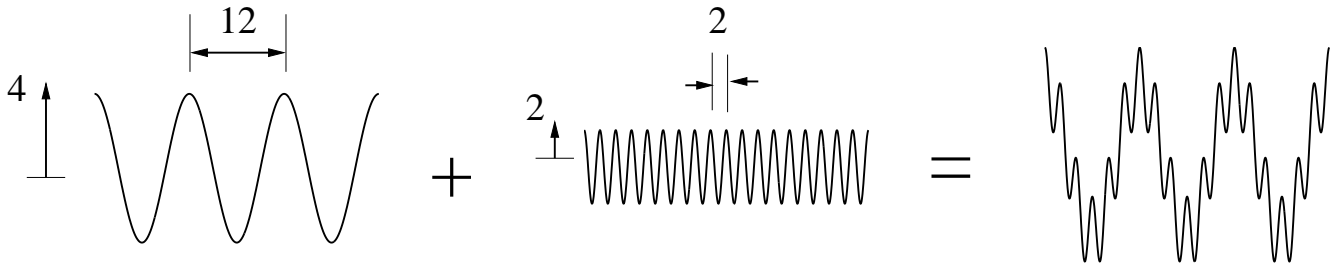**origin**

object   **structuring element B**

(2)

(d) Sketch the opening of the object above using the identical structuring element B.

(2)

2.   A 1D signal is formed from the sum of two cosine waves with amplitudes and wavelengths as shown below


(a) Plot the amplitude of the Fourier transform of this 1D signal. Label the axes and coordinates of your plot clearly.

(3)

(b) What does the zero frequency component represent in the Fourier transform of a signal?

(1)

(c) Plot the form of a high-pass filter having a fairly sharp cutoff frequency of 0.3 .

(1)

(d) Apply this high-pass filter to the signal above. Plot the Fourier transform of the result. In the spatial domain how will the two components that make up this signal be affected?

(2)

(e) Now consider the two sine waves shown above, but this time they are *point-wise multiplied* together to produce a new signal
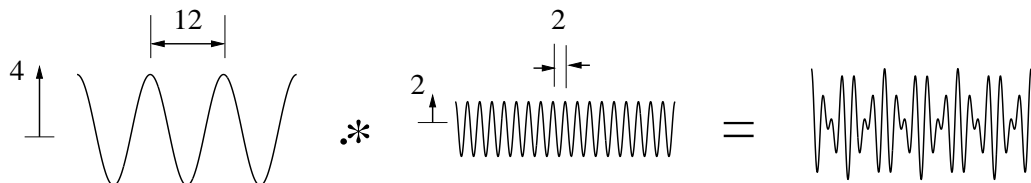
How would you filter out the high frequency component from the combined signal on the right so as to recover the low frequency input signal of wavelength 12? Clearly describe the steps you would take.

(3)

3.

(a) Describe the RGB colour system.

(1)

(b) Define Hue, Saturation and Brightness.
Explain the advantages of describing colour using the HSV system rather than using
RGB.

(3)

(c) What are the differences between diffuse and specular reflection?
Illustrate with a diagram.

(1)

(d) List the six possible edge labels and the four possible junction types.

(2)

(e) Provide a valid labeling of the following line drawing:
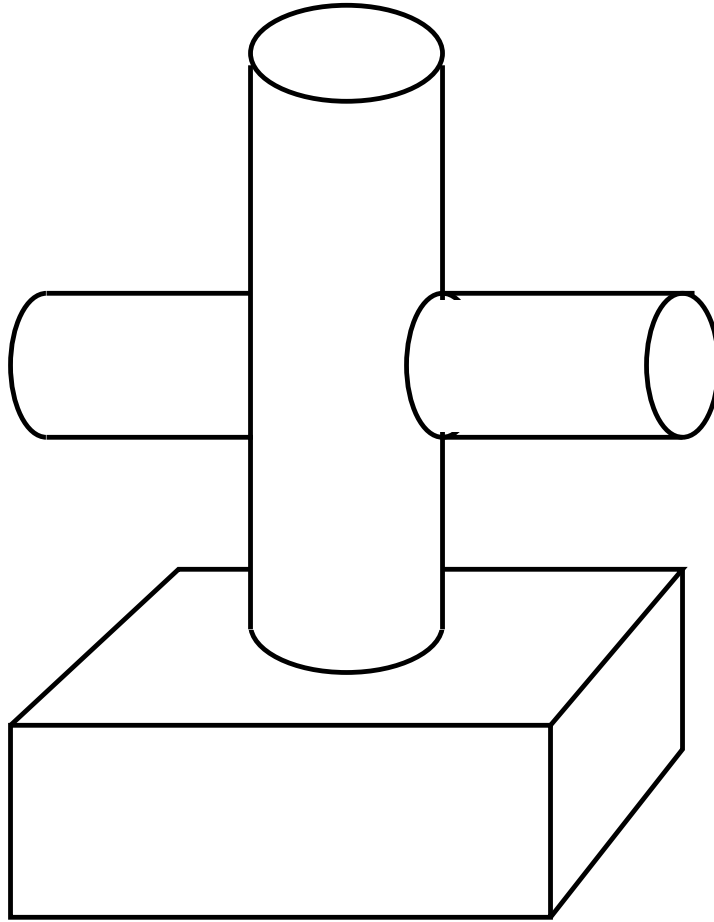
(2)

(f) In terms of line labeling explain why this figure represents an impossible object.
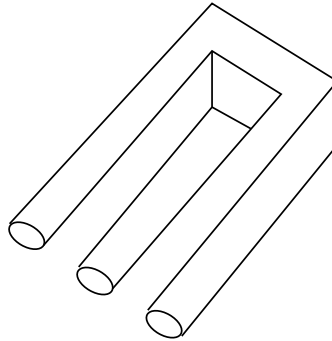
(1)

4.

(a) Describe and briefly discuss 3 different models of connectedness used in binary images.

(2)

(b) Under what conditions is median filtering most effective, and least effective, in improving the quality of an image?

(2)

(c) In what way is median filtering a morphological operation?

(1)

(d) Describe the steps involved in performing histogram equalization.

(4)

(e) After histogram equalization will an image have more, the same, or fewer distinct grey values?

Explain your answer.

(1)

5.

(a) What assumptions does the Canny edge detector make about edges?

List the three main criteria that Canny used to design his edge operator. Explain what each of the criteria aim to achieve, and explain where they might conflict with each other.

(3)

(b) Describe the convolution masks used in the Sobel edge detector. What does each mask attempt to do and how is the edge strength calculated? What properties about a point in the image does the operator attempt to calculate?

(2)

(c) A mask and 1D signal are defined below. Convolve the signal with the mask, assume the signal values are zero outside of the range defined below.

Signal:

1	1	1	4	0	0	1	2	3	4

Mask:

-1	3	-1

(2)

(d) Describe in detail the Marr-Hildreth approach to edge detection.

What advantages, disadvantages and problems does this operator have?

(3)

6.

(a) Define the *focus of expansion of a motion field*, and give an illustration.
    How is the focus of expansion related to stereo geometry?

    (2)

(b) What qualitative information can be deduced from the *divergence* of a flow field?

    (1)

(c) Draw a clear diagram illustrating the construction of epipolar lines in a stereo pair
    of images. Mark the centres of projection, the epipoles, and the epipolar plane.

    (4)

(d) Describe the two main approaches that are used for stereo feature matching.
    What are the advantages/disadvantages of each?

    (3)

7.

(a) How would you represent a 3D point at infinity on the Y-axis using homogeneous coordinates?

(1)

(b) Given a camera calibration matrix

$$C = \begin{bmatrix} q_{11} & q_{12} & q_{13} & q_{14} \\ q_{21} & q_{22} & q_{23} & q_{24} \\ q_{31} & q_{32} & q_{33} & q_{34} \end{bmatrix}$$

what will the image coordinates of the X, Y and Z vanishing points be?

(2)

(c) Define the cross-ratio.
What important property does the cross-ratio have?

(3)

(d) Imagine you have a scene which is structured such that you can find the image coordinates of the vanishing points of three orthogonal directions.
How would you use this information to perform a partial camera calibration of the scene in terms of these orthogonal directions?
What knowledge is missing from the calibration?

(4)