



THE UNIVERSITY  
*of* LIVERPOOL

**JANUARY 2002 EXAMINATIONS**

Bachelor of Arts : Year 3  
Bachelor of Engineering : Year 3  
Bachelor of Science : Year 3  
Bachelor of Science : Year 4

**IMAGE PROCESSING, COMPUTER VISION AND GRAPHICS**

**TIME ALLOWED : Two Hours and a Half**

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**INSTRUCTIONS TO CANDIDATES**

Section A : Answer all Questions  
(Section A is worth 50%)  
Section B : Answer 2 out of 4 Questions  
(25 marks for each answer; Section B is worth 50%)

If you attempt to answer more than the required number of questions (in any section), the marks awarded for the excess questions will be discarded (starting with your lowest mark).



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**Section A**

Answer ALL questions in Section A. Section A is worth 50% of the marks available.

- A1 Sketch and name all the different types of result that are possible on performing the boolean intersection of two cubes. (3 marks)
- A2 In human vision where are the rod and cone cells found and what is their purpose? (3 marks)
- A3 What is meant in computer graphics by the term *colour gamut*? (3 marks)
- A4 Sketch four linearization paths for the 2D square tiling. Which of these paths might be the most suitable for an inkjet plotter? (3 marks)
- A5 In image processing why does the size of an image shrink when applying convolving filters? Describe two ways of avoiding the problem. (3 marks)
- A6 A wireframe cube has its centroid at  $x=1.0$ ,  $y=1.0$ , and  $z=1.0$ . In its initial state it has its sides parallel to the  $x$ ,  $y$ , and  $z$ -axes. Describe how you would turn this cube about its centroid by  $\Theta$  degrees in each axis direction. (3 marks)
- A7 In image processing what is meant by *image segmentation*? In your answer identify two criteria by which a segmentation may be done. (3 marks)
- A8 Outline briefly at least six of the important processes involved in a computer animation such as *Luxo Junior* (J. Lasseter, 1987). (3 marks)
- A9 Describe how Marr's hypothesis has been used to define the key stages in computer vision. (3 marks)
- A10 Sketch and label the key elements of the *optic pathway* using colour to identify the pathways from the left and right eye. (3 marks)



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A11

Compare and contrast the procedural and programming language approach to computer graphics. Give examples of each approach and describe where you believe each would be best employed.

(10 marks)

A12

Describe what is meant by the term *morphological image processing*. Sketch the result of applying two morphology operations with which you are familiar on an image consisting of three touching black discs arranged in a horizontal line.

(10 marks)



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**Section B**

Answer 2 questions in Section B. Section B is worth 50% of the marks available.

B1 NW Haptics Ltd are seeking to develop a computer graphics system which features their new 3D scanning device, the haptic pencil. The pencil provides a constant stream of  $x$ ,  $y$ ,  $z$ ,  $h$  values where  $x$ ,  $y$ , and  $z$  are the spatial location values of the pencil point and  $h$  is the haptic (pressure resistance) value which is always in the range 0-1. If  $h$  is low and fluctuates in coarse steps the surface is yielding or soft such as a child's cuddly toy. If  $h$  is large and fluctuates in small steps the surface is hard, such as a marble bust.

- (a) Assuming a standard approach, describe briefly the graphics hardware environment which would be needed to implement the haptic pencil.  
(7 marks)
- (b) In graphics terms how would the haptic pencil be classified and which would be the most appropriate input mode to use given that a mouse is also available for graphics input?  
(7 marks)
- (c) Sketch the function calling code which would implement each of the standard *input modes*.  
(11 marks)

B2 An image processing system is required to count red blood cells appearing in a digital microscope viewing field. Assume that in any blood sample 80% of the cells appear as red discs with a paler red central area.

- (a) Describe the IP functions that might be needed to identify and count the cells.  
(15 marks)
- (b) How effective at getting a correct result would you expect the approach you describe to be?  
(10 marks)



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B3

- (a) In human vision describe the retinal perception reaction known as the *centre-surround mechanism*. (8 marks)
- (b) Describe how the centre-surround mechanism might affect the perception of a cylinder modelled as a series of longitudinally arranged polygonal facets. (9 marks)
- (c) Describe one graphics technique which we might use to ensure that the cylinder appears smooth. (8 marks)

B4

- (a) Compare and contrast a *polygon mesh* and *parametric mesh* approach to handling surface continuity. (9 marks)
- (b) How might the smoothness of the curve patch be controlled if a parametric mesh approach were used? (8 marks)
- (c) Describe what is meant by *specular reflection*. What strategy might be used to handle specular reflection from the surface patch described by a polygon mesh? (8 marks)