COM3404

UNIVERSITY OF EXETER

SCHOOL OF ENGINEERING, COMPUTER SCIENCE AND MATHEMATICS

Modelling and Animation

TWO HOURS

Answer question 1, and two out of the four other questions.
Question 1 is worth 40 marks. Other questions are worth 30 marks each.

Candidates are advised to spend FORTY-FIVE minutes on question 1 and THIRTY-FIVE minutes on other questions.

No electronic calculators of any sort are to be used during the course of this examination.

COM3404

Compulsory question

1. (a) Describe, with the aid of diagrams, how you would model the following:

i. a vase;

ii. a human face;

iii. the wing of a car.

(9 marks)

(b) Explain why it is advantageous to represent polygons by their edges and describe a data structure to represent a surface composed of polygons.

(10 marks)

(c) Explain how *storyboards* are used in the planning of video and film sequences. Describe the principal elements usually found in a well-developed storyboard, illustrating your answer with a sketched example of **one** scene from a storyboard.

(8 marks)

(d) The *radiosity method* describes the radiosity of a patch B_i by the following equation:

$$B_i = E_i + \sum_{j \neq i} B_j F_{ij}$$

Explain what the terms E_I and F_{ij} represent and explain how F_{ij} is calculated.

Outline how the radiosity equations are solved using the *gathering and shooting* method.

(13 marks)

(Total 40 marks)

Please Turn Over

2. (a) Explain how the symbols L, E, D and S are used for describing the capabilities of rendering algorithms. Illustrating your answer with a diagram, give examples of **three** paths that might be found in a scene comprising a light, an opaque cylinder and a semi-transparent cube.

(10 marks)

(b) Describe the operation of a *ray tracing* algorithm. Pseudo-code is not required but your answer should describe the main steps in the algorithm and discuss how the intensity of the ray is calculated. Illustrate your answer by showing how objects in the scene described in (a) would be rendered.

(12 marks)

(c) What factors affect the efficiency of your algorithm? Describe **two** methods for improving the algorithm's efficiency.

(8 marks)

(Total 30 marks)

Please Turn Over

3. (a) Illustrating your answer with appropriate diagrams, distinguish between *diffuse* and *specular* reflection and describe in detail how each is modelled using the *Phong illumination model*.

(10 marks)

(b) Explain what is meant by a *Z-buffer*. Describe and give outline pseudo-code showing how the Z-buffer may be used in conjunction with Phong shading for rendering objects defined by polygonal meshes. Explain why your algorithm is efficient.

(14 marks)

(c) Explain what would be seen if Phong shading is used to render a scene comprising a shiny opaque vase placed in front of a mirror and illuminated from above by a spot-light. How could texture mapping be used to improve the final rendered scene?

(6 marks)

(Total 30 marks)

Please Turn Over

4. (a) Describe in detail how you would specify the animation of the following aspects of an aeroplane model on takeoff, providing sketches as appropriate to illustrate your ideas:

i. the propeller;

ii. the retraction of the wheel assembly;

iii. the aeroplane itself.

Discuss an appropriate interrelationship for the pieces of animation you have defined.

(10 marks)

(b) Explain the basis of hierarchical animation and contrast the methods of *forward-kinematics* and *inverse-kinematics*. Give one example of an appropriate application for each of these methods.

(9 marks)

(c) In a domino rally a series of dominos are stood on end close to each other. The end one is tipped over; it falls against its neighbour, which in turn falls against its neighbour and so on until all the dominos have fallen.

An animation of a domino rally is to be created. Give a detailed description of a technique that could be used to animate this successfully and efficiently. Explain your choice of technique by contrasting it with other animation techniques.

(11 marks)

(Total 30 marks)

Please Turn Over

5. (a) Explain how modelling by *constructive solid geometry* differs fundamentally from *surface* modelling. List **two advantages** and **two disadvantages** of constructive solid geometry modelling compared with surface modelling.

(6 marks)

(b) The following diagram shows heights measured at the intersections of a rectangular grid. Illustrating your answer with a sketched copy of the diagram, explain in detail how the *marching squares algorithm* can be used to generate a contour with height 6.5. Your sketch should show the alternatives that arise from contouring ambiguity. Explain how this ambiguity arises and explain how it might be resolved.

4	4	5	6	9	9	
5	6	5	4	8	7	
4	7	8	7	5	4	
5	8	8	9	4	3	
4	6	7	8	3	2	
3	4	5	4	2	1	

(12 marks)

(c) Explain how the marching squares algorithm is extended for voxel data. What is the effect of ambiguities in the three-dimensional case and how they resolved?

(7 marks)

(d) Briefly describe how *metaballs* may be used for modelling and how they are rendered.

(5 marks)

(Total 30 marks)

End of Paper