University of Bath

DEPARTMENT OF MATHEMATICAL SCIENCES
EXAMINATION

Advanced Computer Graphics

January 1999

No calculators may be brought in and used.

Full marks will be given for correct answers to THREE questions.
Only the best three answers will contribute towards the assessment.

Examiners will attach importance to the number of
well-answered questions.

1. What are the *tri-stimulus experiments*, and what do they show about the response of the human eye?

   Experiments which measure the response of the eye to various combinations of primary-coloured lights. Typically the subject is required to match a sample colour by adding together light from three primary sources.

   They show that the eye has three kinds of colour receptor. Any colour which produces the same stimulus on these three will be perceived theto be the same colour, even though the stimulus may be physically different.

   Explain how negative colours arise in the experiments.

   In practice the three kinds of colour receptor are not independent: their responses overlap. Hence it may be impossible to achieve a perceptual match by adding primary lights, so it is necessary to match a sample colour which has had a colour bias added. Subtracting this bias from the tri-stimulus values can lead to negative results.

   Draw the CIE diagram, and explain in detail each part of it. Define the *normalised chromaticity coordinates* and state their significance.

   Approximate diagram, as in the notes.

   NCD definition in notes. Significance is that they give us a standardised way of defining the basic colour.

   What are the limitations on the gamut of colours a VDU can display? Explain.

   Gamut of any 3-colour device is a triangle on the CIE diagram (show this). Necessarily there will be visible colours outside the triangle which the display cannot show, even with perfect phosphors.

2. Write an essay on ray tracing, including a description of CSG modelling and three optical effects.

   Typical answers will explain the Boolean modelling approach, based on a small set of built-in primitive and binary operations to combine them. It will also explain basic ray-tracing: following a line from the viewpoint, through the pixel and on into the 3D model; need to know nearest intersection and the surface normal at that point. Explain how the CSG tree can be used to work out where the ray is within solid; choose nearest value (smallest parameter). Effects might be: fog, reflection, refraction etc.

3. What is *BitBlt* and why is it used?

A fast memory copy operation, which supports combining rectangular arrays of pixels. i.e. it 'knows' about how the linear memory maps to the 2D screen; and it and operate rapidly even while the memory is being used to refresh the display. It is used because it is fast enough to support direct screen interaction.

Outline the problems BitBlt has to solve in the process of copying one area of the screen to another.

Addressing both source and destination areas. Coping with overlaps of source and destination. Mapping memory to pixels e.g. memory words may contain multiple pixels, so the correct fragments have to be aligned.

Describe the 16 BitBlt functions on a binary screen.

Direct explanation expected.

Show how BitBlt can be used to scale a picture by a factor of two.

Qualitative description: copy each row twice, then copy each column twice. NOT copy each pixel four times!

Describe how BitBlt can be used to implement the fast drawing of text on a screen.

The font is considered to be held as one pattern for each letter, off-screen; together with size information. Writing text consists of locating the start address of the pattern for that letter, then BitBlt-ing it onto the screen. The size determines how much to copy and also allows us to keep track of where the next letter will go.

4. Describe in detail

(a) half toning,

(b) dithering,

(c) error diffusion.

Straight from notes.

What property of the eye/brain do these techniques take advantage of? What is the trade-off in using these techniques?

The eye/brain tends to integrate the patterns and so see a uniform colour, provided the patterns are not so regular that the eye latches on to them. The trade-off is a loss of spatial resolution for an apparent gain of colour/brightness resolution.