ENGINEERING TRIPOS PART IIB

Wednesday 2 May 2012 9 to 10.30

Module 4B20

DISPLAY TECHNOLOGY

Answer not more than ***three*** *questions.*

All questions carry the same number of marks.

The ***approximate*** *percentage of marks allocated to each part of a question is indicated in the right margin.*

There are no attachments.

STATIONERY REQUIREMENTS
Single-sided script paper

SPECIAL REQUIREMENTS
Engineering Data Book
CUED approved calculator allowed

You may not start to read the questions printed on the subsequent pages of this question paper until instructed that you may do so by the Invigilator

tdw02

1. (a) Explain the main differences between radiometric and photometric quantities when considering the performance and characteristics of modern display technologies. Define the following terminology: radiant energy, irradiance, lumen, lux and candela. [20%]

(b) Derive an expression for the solid angle (Ω) subtended from the point P as shown in Figure 1. Why is this an important concept in the definition of brightness in projection displays? [30%]

(c) Explain the difference between photopic and scotopic vision when considering the evaluation of the brightness of a display technology. How are photometric parameters adjusted to account for their effects. [30%]

(d) What is the role of the Commission International de l'Eclairage (CIE) chart in evaluating the colour properties of display technologies? How is a colour gamut generated on the chart and how is it interpreted? Why do laser based displays have an inherent advantage in terms of colour depth? [20%]

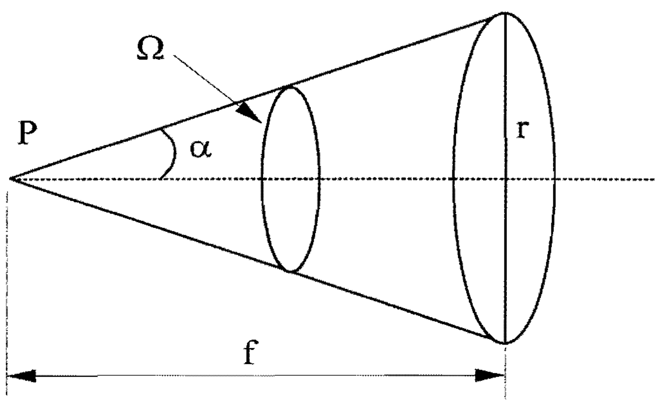

Figure 1

2. With the aid of illustrations and quoting, where applicable, suitable design equations, discuss the following three aspects of backplane addressed display technologies.

(a) Explain the physical mechanisms underlying light controlling display technologies and light generating display technologies, giving examples of each display type. [20%]

(b) What are the benefits and tradeoffs of passive matrix displays versus active matrix displays? Elaborate on the backplane requirements of active matrix organic light emitting diode (AMOLED) displays that make them different from their liquid crystal counterparts. [40%]

(c) Provide three key requirements for display backplanes and summarize four basic thin film transistor (TFT) backplane technologies that are of current interest for AMOLED displays. Tabulate the key performance attributes in terms of mobility, temporal stability, spatial uniformity, scalability, and cost. [40%]

3 (a) Explain why pure ray theory is not sufficient to prove Snell's law. What extra information is required to solve this problem? Using the diagram shown in Figure 2, show how Snell's law can be derived. [30%]

(b) Explain how Snell's law is used to solve the majority of ray tracing problems faced when designing an image based optical projection system. How does it allow the optical designer to find flaws in the design of a multi-element projection lens? What flaws would the designer typically expect to find? [30%]

(c) How does the choice of light modulation technology within an image based projection system dictate its overall performance? List the two main technology choices for this role and highlight how they limit brightness, colour gamut, projection lens and light source. Explain which one is more suitable to three dimensional cinema projection [40%]

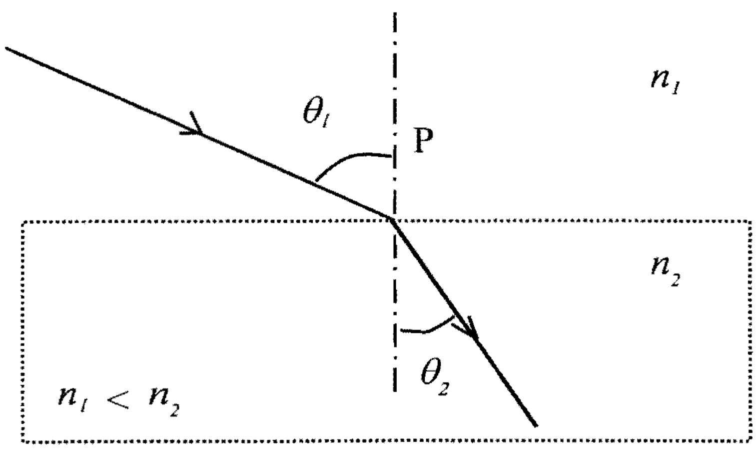

Figure 2

4 (a) Describe, with the aid of diagrams, the operating principles and basic construction of a twisted nematic (TN) liquid crystal display (LCD) device. Explain the meaning of the terms: threshold voltage, Mauguin limit, voltage holding ratio, and isocontrast curve. How does the super-twisted nematic device differ from the TN device and what are the benefits of this mode? [25%]

(b) The transmission of a TN-LCD operating in the normally black mode can be expressed as:

$$T = \frac{1}{2}\frac{\sin^2\left(\frac{\pi}{2}\sqrt{1+u^2}\right)}{1+u^2},$$

where u is the optical retardation. Sketch the Gooch-Tarry curve for the transmission as a function of the optical retardation and find the value of u for the 1st three successive minima. If the birefringence of the liquid crystal is Δn = 0.10 and the incident wavelength is λ = 550 nm, what film thickness is required to operate at either the first or second minima? When constructing a TN-LCD, which minimum is preferred and why? [25%]

(c) Describe, with the aid of diagrams, in-plane switching and vertically aligned nematic display devices. State whether positive or negative dielectric anisotropy liquid crystals are required for each display mode. [25%]

(d) Sketch the equivalent circuit diagrams of a twisted nematic and an in-plane switching display device. For which of the two display modes does the resistance of the liquid crystal have a greater impact on the voltage holding ratio? Specify which mode can use highly polar cyano-based liquid crystal structures. [25%]

END OF PAPER