EGT3
ENGINEERING TRIPOS PART IIB

---

Wednesday 20 April 2016 9.30 to 11

---

**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.*

*Write your candidate number* ***not*** *your name on the cover sheet.*

**STATIONERY REQUIREMENTS**
Single-sided script paper

**SPECIAL REQUIREMENTS TO BE SUPPLIED FOR THIS EXAM**
CUED approved calculator allowed
Engineering Data Book

**10 minutes reading time is allowed for this paper**

**You may not start to read the questions printed on the subsequent pages of this question paper until instructed to do so.**

1 (a) Explain the main differences between radiometric and photometric quantities when considering the performance and characteristics of modern display technologies. What is the convention used to define each class of unit? Define the following terms and where applicable, their units: radiant luminous efficacy, radiance, lumen and candela. [30%]

(b) 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? [25%]

(c) What is the role of the Commission International de l'Éclairage (CIE) chart in evaluating the visual properties of display technologies? Under what conditions is a CIE gamut generated and how can it lead to possible visual errors in a display technology? [25%]

(d) A Liquid Crystal Display (LCD) from Panasonic has been designed using laser sources to drive its backlight. Give two reasons why this display would have a significantly better viewing characteristic than a light emitting diode backlight based LCD. How might the laser sources be used to improve the contrast ratio of the LCD? [20%]

2 (a) Explain the operating principle of the Organic Light Emitting Diode (OLED) and the relative merits of the single-layer and double-heterostructure OLED. [25%]

(b) With the aid of a diagram using circuit functional blocks, highlight in the illustration the primary differences in backplane requirements of Active Matrix OLED (AMOLED) and its Active Matrix Liquid Crystal Display (AMLCD) counterpart. [25%]

(c) Explain why there is growing interest in metal oxide thin film transistor technology for flat panel displays. Concentrate on key performance attributes such as mobility, temporal stability, spatial uniformity, scalability and cost. [25%]

(d) One of the biggest issues in post-fabricated AMOLED test and qualification is yield, which comprises of both soft faults (e.g. Thin Film Transistor (TFT) and OLED parameter non-uniformity and device degradation) and hard faults (e.g. OLED short circuits). Such faults are often indistinguishable in the post-fabricated display, unless very clever pixel circuit designs are implemented for diagnostics. Show one pixel circuit structure along with a description of its operation that provides closed loop electrical feedback to monitor or identify defects/degradation of the TFT backplane and the OLED. [25%]

3 (a) The commonest type of liquid crystal found in a liquid crystal display panel are both calamatic and thermotropic. Explain how the calamatic properties of the liquid crystal molecules lead to thermotropic properties and define the term mesophase. What are three key properties of a liquid crystal molecule that can be used to engineer these properties? [40%]

(b) The liquid crystal materials are invariably made from a eutectic mixture of different components. Explain why eutectic mixtures are essential and identify four key properties that define the mixture that might be made for an active matrix liquid crystal display. [30%]

(c) A popular display mode used in active matrix liquid crystal displays is the In-Plane Switching (IPS) mode. Explain how this mode works and is implemented in a modern display. What are the main limitations of IPS and how can they be improved? [30%]

4 (a) One of the most successful technologies in the projection displays market is the Digital Micromirror Device (DMD) from Texas Instruments. Sketch the basic pixel structure of this device, identifying the key parts of the structure and explain how it can be used to modulate light in a projector. [40%]

(b) What is the main limitation of the DMD? Explain how this limitation is overcome to generate 8-bit greyscale full colour images. Are there any penalties when using this process? [30%]

(c) Describe two ways that a DMD based projection display could be converted to a three dimensional autostereoscopic display. Identify any additional components that might be required for each conversion. Why does neither conversion really generate an ideal three dimensional image? [30%]

**END OF PAPER**

THIS PAGE IS BLANK