

Physics 3
780

CAMEROON GENERAL CERTIFICATE OF EDUCATION BOARD

General Certificate of Education Examination

JUNE 2007

ADVANCED LEVEL

| | |
|---------------|---------|
| Subject Title | Physics |
| Paper No | Paper 3 |
| Paper Code | 780 |

Two and a half hours

Answer all questions

Section I of the paper is designed to be answered in one hour and Section II is designed to be answered in one and a half hours. You are advised to divide your time accordingly, and the invigilators should announce when one hour has elapsed.

You are reminded of the necessity for good English and orderly presentation in your answers.

In calculations you are advised to show all the steps in your working, giving your answers at each stage.

Non programmable calculators may be used.

Turn over

SECTION I
(One hour)

Read the following passage and answer the questions that follow.

Forensic science provides evidence in police investigations. It involves the application of biology in crimes, the chemical analysis of trace materials and the development of techniques for detecting poisons and drug abuse.

Using fingerprints to solve criminal cases involve the use of powder applied with a brush to adhere to ridges of materials that form a fingerprint. The technique is successful. When used on flat shiny surfaces it does not work well on rough surfaces such as fabrics and paper commonly found at criminal scenes.

Research conducted on the physical nature of fingerprints, form a basis for new detection methods. Fingerprints deposits contain a variety of chemicals secreted from the fingers. Fatty acids and esters from glands on other parts of the body also contaminate fingerprints. The surface potential of a fresh fingerprint deposits on a gold film is 300 mV, decreasing to 100 mV after a few days. To eliminate ridge smearing caused by applying powder with a brush, powder is supplied by an electrode held at about 25 mm above the surface and charged up to 12 kV above the surface potential. The powder, charged to the electrode polarity is accelerated to the surface where it is discharged. Some powder adheres to the ridges and the electrode, which is scanned across the object to find and develop fingerprints.

High power argon ion lasers are used to cause fingerprints to fluoresce, thus making latent fingerprints visible without need for processing. The laser emits many wavelengths in the blue and green. It is tuned to one of the strongest wavelengths or all the lines are allowed to lase together. Orange light has a wavelength of 600 nm and lets through long wavelength fluorescence between 550 nm and 900 nm. This technique enables fingerprints to be seen on surfaces that are not exposed to other techniques. Many objects fluoresce more strongly than the fingerprints and the print contrast is lost. Further, work is needed to isolate the fingerprint fluorescence from the background. It is possible to use band filters to enhance contrast.

Police rely on documents as a means of communicating information. A scientific examination of documents, to check validity is needed. A main problem is that numbers and letters are added using ink closely resembling the original ink, physical and chemical differences are used to distinguish the links.

Ultraviolet light allows a difference in fluorescence intensity. More sensitive discrimination is possible with infrared fluorescence procedures. The document is illuminated with blue-green light. Some light is absorbed by ink and paper and raises electrons to excited states. The excited electrons fall down to their ground state by emitting a photon of lower energy level. An image intensifier and a lens are used to focus the fluorescence on to a photocathode to produce an electron image. The electrons are accelerated by high voltage and focused on a phosphor screen to give an intensified image in the visible region. This technique is effective for detecting forgeries on documents such as cheques and account books.

Electrostatics techniques represent a considerable advance in figuring out invisible impressions, the document is laid out on a porous metal plate, covered with a 5 mm thick sheet of clear plastic film and both are pressed into contact with the metal plate by a vacuum pump. A corona discharge unit is moved slowly over the plastic film causing local variations in charge density on the plastic in the region of writing impressions-

A Perspex box covers the plate and a fine cloud of toning powder is blown in. The powder adheres most strongly to the charges along the ridges and enables the writing to be read. This technique is highly sensitive, clear, fast and simple and even works if the document has been badly creased. In particular fresh fingerprints are shown by this technique.

Work is on the way to apply digital computer techniques to restore photographs that are unusual because the area of interest is out of focus or smeared due to camera movement or incorrect exposure. The first step is to read the picture information using an optical scanner capable of reading the optical density at each point up to 256 grey levels. This analogue information is digitized and then put into a video frame store. From here a number of image enhancement and restoration processes can be applied. If problems of blur arise then a more fundamental procedure is necessary requiring operation in the spatial frequency domain.

Questions

1. Explain the meaning of the following terms as used in the passage:
 - (a) Forensic science
 - (b) Fluoresce
 - (c) Latent fingerprint
 - (d) Laser

(6 marks)

2. The use of brushes in obtaining fingerprints pose major problems.
 - (a) What are these problems?
 - (b) Explain how police have used the knowledge of physics to overcome these problems.

(5 marks)

3.
 - (a) In what ways does the human skin act as a hindrance in the development of forensic science in criminal investigation?
 - (b) Briefly explain how fingerprints can be detected without any processing mechanism in police investigation.
 - (c) What is the main effect of this technique?

(6 marks)

4.
 - (a) State two main problems faced by police investigators in deciphering information from documents
 - (b) Why is the electrostatics technique most preferred in eliciting information from documents?

(5 marks)

5.
 - (a) Why are photographs sometimes not very useful in providing information to the police?
 - (b) Why must orange goggles be worn when the argon laser is in use?
 - (c) Name the techniques described in the article that police investigators employ to elicit information in criminal cases

(8 marks)

Turn over

SECTION II

(One and a half hours)

The rate of cooling a body is directly proportional to difference in temperature between the body and it's surroundings provided the temperature difference is small. For such a process it can be shown that

$$T - T_R = (T_i - T_R) \exp \left(\frac{-t}{A} \right) \dots \dots (i)$$

Where:

T is the temperature at any time t in degrees Celsius.

T_R is the room temperature in degrees Celsius.

T_i is the initial temperature in degrees Celsius.

A is a constant

To confirm the validity of this relationship a liquid was cooled and the following results were obtained for a room temperature of 23°C.

| T/°C | t/min |
|------|-------|
| 80.0 | 0 |
| 58.0 | 5 |
| 49.0 | 10 |
| 43.0 | 15 |
| 37.0 | 20 |
| 34.0 | 25 |
| 31.6 | 30 |

6. (i) Plot a graph of T as ordinate and t as abscissa.
 (ii) Determine t_c, the liquids temperature to drop to its initial value. (11 marks)

7. (i) Using equation (i) plot a suitable graph from which the constant A and T_i could be obtained. (4 marks)
 (ii) It can be shown that T_c = 0.693A. Calculate another value for t_c (12 marks)

8. Comment on the accuracy of t_c obtained in 6(ii) and 7(ii). above (3 marks)

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