



# Coimisiún na Scrúduithe Stáit State Examinations Commission

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**LEAVING CERTIFICATE EXAMINATION, 2011**

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**PHYSICS – HIGHER LEVEL**

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**MONDAY, 20 JUNE – MORNING, 9:30 TO 12:30**

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Answer **three** questions from **section A** and **five** questions from **section B**.

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- N.B.** Relevant data are listed in the Formulae and Tables booklet, which is available from the Superintendent.

## SECTION A (120 marks)

Answer **three** questions from this section.  
Each question carries 40 marks.

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1. A student carried out an experiment to verify the principle of conservation of momentum. The student adjusted the apparatus till a body **A** was moving at a constant velocity  $u$ . It was then allowed to collide with a second body **B**, which was initially at rest, and the two bodies moved off together with a common velocity  $v$ .

The following data were recorded:

$$\begin{aligned}\text{mass of body A} &\dots\dots\dots = 230 \text{ g} \\ \text{mass of body B} &\dots\dots\dots = 160 \text{ g} \\ \text{velocity } u &\dots\dots\dots\dots\dots = 0.53 \text{ m s}^{-1} \\ \text{velocity } v &\dots\dots\dots\dots\dots = 0.32 \text{ m s}^{-1}\end{aligned}$$

Draw a labelled diagram of the apparatus used in the experiment.

What adjustments did the student make to the apparatus so that body **A** would move at constant velocity?

(15)

How did the student know that body **A** was moving at constant velocity?

Describe how the student measured the velocity  $v$  of the bodies after the collision.

(15)

Using the recorded data, show how the experiment verifies the principle of conservation of momentum.

How could the accuracy of the experiment be improved?

(10)

2. During an experiment to verify Boyle's law, the pressure of a fixed mass of gas was varied. A series of measurements of the pressure  $p$  and the corresponding volume  $V$  of the gas was recorded as shown. The temperature was kept constant.

$p/\text{kPa}$	325	300	275	250	200	175	150	125
$V/\text{cm}^3$	12.1	13.0	14.2	15.5	19.6	22.4	26.0	31.1

Draw a labelled diagram of the apparatus used in the experiment.

How was the pressure of the gas varied during the experiment?

Describe how the pressure and the volume of the gas were measured.

Why should there be a delay between adjusting the pressure of the gas and recording its value?

(22)

Draw a suitable graph to show the relationship between the pressure and the volume of a fixed mass of gas. Explain how your graph verifies Boyle's law.

(18)

3. In an experiment to measure the wavelength of a monochromatic light source, a narrow beam of light was incident normally on a diffraction grating having 400 lines per mm. A number of bright images were observed. The angles  $\theta$  between the central bright image and the first two images to the left and right of it were measured and recorded in a table, as shown.

	2 <sup>nd</sup> image to left of central image	1 <sup>st</sup> image to left of central image	1 <sup>st</sup> image to right of central image	2 <sup>nd</sup> image to right of central image
$\theta/^\circ$	30.98	14.90	14.81	31.01

Name a source of monochromatic light.

Describe, with the aid of a diagram, how the data were obtained.

Using the data, calculate the wavelength of the monochromatic light. (24)

What effect would each of the following changes have on the bright images formed:

- (i) using a monochromatic light source of longer wavelength
- (ii) using a diffraction grating having 200 lines per mm
- (iii) using a source of white light instead of monochromatic light? (16)

4. A student investigated the variation of the current  $I$  through an electrolyte as the potential difference  $V$  across the electrolyte was changed. The electrolyte used was a solution of copper sulfate. The electrodes used were made of copper.

The student recorded the following data:

$V/V$	0	1	2	3	4	5	6
$I/mA$	0	30	64	93	122	160	195

Draw a suitable circuit diagram for this investigation and label the components.

How was the potential difference changed during the investigation? (12)

Draw a suitable graph to show the relationship between the current and the potential difference in this investigation.

Use your graph to calculate the resistance of the electrolyte. (18)

What was observed at the electrodes as current flowed through the electrolyte? (10)

## Section B (280 marks)

Answer **five** questions from this section.

Each question carries 56 marks.

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5. Answer any **eight** of the following parts (a), (b), (c ), etc.

- (a) A car of mass 1500 kg is travelling at a constant velocity of  $20 \text{ m s}^{-1}$ . What force is required to stop it in a distance of 50 m?
- (b) Why does the value of  $g$ , the acceleration due to gravity, vary at different locations on the surface on the earth?
- (c) Why is a convex mirror used, instead of a plane mirror, as a door mirror on a car?
- (d) What causes the Doppler effect?
- (e) The capacitance of a parallel plate air capacitor is 5 pF. If the plates of the capacitor are 2 cm apart, what is the common area of the plates? Take  $\epsilon_{\text{air}} = \epsilon_0$ .



- (f) A residual current device (RCD) as shown is rated 30 mA. Explain the significance of this rating.
- (g) The physicist Robert Millikan is usually associated with what physical quantity?
- (h) What property of light controls the current in a photocell?
- (i) What is the role of neutrons in a nuclear reactor?
- (j) Give the difference between the quark composition of a baryon and of a meson.  
**or**  
Give two ways of reducing energy loss in a transformer.

$(8 \times 7)$

6. (a) Define the moment of a force.

A toy, such as that shown, has a heavy hemispherical base and its centre of gravity is located at C. When the toy is knocked over, it always returns to the upright position. Explain why this happens. (12)



- (b) State the conditions necessary for the equilibrium of a body under a set of co-planar forces. (9)

Three children position themselves on a uniform see-saw so that it is horizontal and in equilibrium. The fulcrum of the see-saw is at its centre of gravity. A child of mass 30 kg sits 1.8 m to the left of the fulcrum and another child of mass 40 kg sits 0.8 m to the right of the fulcrum.

Where should the third child of mass 45 kg sit, in order to balance the see-saw? (12)

- (c) A simple merry-go-round consists of a flat disc that is rotated horizontally. A child of mass 32 kg stands at the edge of the merry-go-round, 2.2 metres from its centre. The force of friction acting on the child is 50 N.

Draw a diagram showing the forces acting on the child as the merry-go-round rotates.



What is the maximum angular velocity of the merry-go-round so that the child will not fall from it, as it rotates? (18)

If there was no force of friction between the child and the merry-go-round, in what direction would the child move as the merry-go-round starts to rotate?

(5)

7. (a) When making a hot drink, steam at 100 °C is added to 160 g of milk at 20 °C. If the final temperature of the drink is to be 70 °C, what mass of steam should be added? You may ignore energy losses to the surroundings.

A metal spoon, with an initial temperature of 20 °C, is then placed in the hot drink, causing the temperature of the hot drink to drop to 68 °C. What is the heat capacity of the spoon? You may ignore other possible heat transfers. (24)



- (b) Name two processes by which a hot drink cools. How is the energy lost by each of these processes reduced for a hot drink supplied in a disposable cup? (14)

- (c) A thermocouple is used to measure the temperature of the steam.

How would you demonstrate the principle of operation of a thermocouple?

Describe how to establish a calibration curve for a thermocouple. (18)

$$(c_{\text{milk}} = 3.90 \times 10^3 \text{ J kg}^{-1} \text{ K}^{-1}, c_{\text{water}} = 4.18 \times 10^3 \text{ J kg}^{-1} \text{ K}^{-1}, c_{\text{hot drink}} = 4.05 \times 10^3 \text{ J kg}^{-1} \text{ K}^{-1}$$

specific latent heat of vaporisation of water =  $2.34 \times 10^6 \text{ J kg}^{-1}$ )

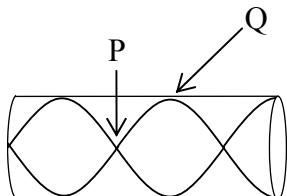
8. (a) Destructive interference can occur when waves from coherent sources meet.  
Explain the underlined term.

Give two other conditions necessary for total destructive interference to occur.

(14)

The diagram shows a standing wave in a pipe closed at one end.  
The length of the pipe is 90 cm.

- (i) Name the points on the wave labelled P and Q.
- (ii) Calculate the frequency of the standing wave.
- (iii) What is the fundamental frequency of the pipe?



The clarinet is a wind instrument based on a pipe that is closed at one end.

What type of harmonics is produced by a clarinet?

(24)



- (b) An audio speaker at a concert emits sound uniformly in all directions at a rate of 100 W. Calculate the sound intensity experienced by a listener at a distance of 8 m from the speaker.

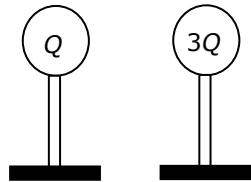
The listener moves back from the speaker to protect her hearing. At what distance from the speaker is the sound intensity level reduced by 3 dB?

(18)

(speed of sound in air =  $340 \text{ m s}^{-1}$ )

9. (a) State Coulomb's law. (6)

Two identical spherical conductors on insulated stands are placed a certain distance apart. One conductor is given a charge  $Q$  while the other conductor is given a charge  $3Q$  and they experience a force of repulsion  $F$ . The two conductors are then touched off each other and returned to their original positions. What is the new force, in terms of  $F$ , between the spherical conductors? (18)



- (b) Draw a labelled diagram of an electroscope.

Why should the frame of an electroscope be earthed?

Describe how to charge an electroscope by induction.

(15)

- (c) How does a full-body metal-foil suit protect an operator when working on high voltage power lines?

Describe an experiment to investigate the principle by which the operator is protected.

(17)



10. Answer either part (a) or part (b).

- (a) List three quantities that are conserved in nuclear reactions. (6)

Write an equation for a nucleus undergoing beta-decay.

In initial observations of beta-decay, not all three quantities appear to be conserved. What was the solution to this contradiction? (12)

List the fundamental forces of nature in increasing order of their strength.

Which fundamental force of nature is involved in beta-decay? (12)

In the Large Hadron Collider, two protons with the same energy and travelling in opposite directions collide. Two protons and two charged pi mesons are produced in the collision.

Why are new particles produced in the collision?

Write an equation to represent the collision. (12)

Show that the kinetic energy of each incident proton must be at least 140 MeV

for the collision to occur. (14)

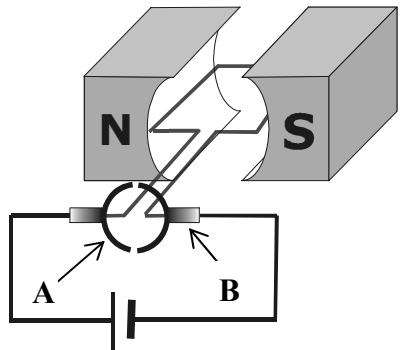
- (b) State the principle of operation of an electric motor. (6)

The diagram shows a simple d.c. motor.

Name each of the parts labelled **A** and **B** on the diagram and state the function of each.

What material is normally used in part **B**? Give two properties of this material that make it suitable for use in a motor.

List three factors that affect the torque (couple) acting on the coil. (18)



If the motor jammed, a larger current than normal would flow through the motor.

Explain why.

What would be the effect on the motor if this happened? (12)

What changes can be made to a d.c. motor to convert it to an a.c. generator?

Draw a sketch of the output voltage from an a.c. generator. (15)

Give two ways in which the output voltage from an a.c. generator can be increased. (5)

**11.** Read the following passage and answer the accompanying questions.

The government has introduced regulations to phase out the use of incandescent filament lamps in the home. The Sustainable Energy Authority of Ireland promotes the use of compact fluorescent lamps (CFL) in place of less energy-efficient filament lamps.

A CFL operates due to the effect of an electric discharge passing through mercury gas at low pressure. Most of the photons that are released from the mercury atoms have a wavelength of 254 nm, which is in the ultraviolet region of the spectrum. These ultraviolet photons are absorbed by electrons in the atoms of the lamp's interior fluorescent coating, causing further photons to be emitted. The photons that are emitted from these interactions have a lower energy than the ones that caused them. The chemicals that make up the fluorescent coating are chosen so that these emitted photons are at wavelengths visible to the human eye.



Light emitting diode (LED) lighting is also recommended and growing in popularity. An LED is a special type of diode that emits light when in forward bias. LEDs emit strongly coloured light, such as red, green, or blue, depending on the semiconductor material used. As the light output of an individual LED is small compared to filament lamps, multiple diodes are used together to give white light.

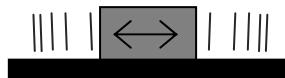


- (a) A 60 W filament lamp provides 8 J of light energy every second, the same as a CFL with a power rating of 11 W. Compare the efficiencies of the two lamps.
- (b) Most of the energy emitted in a CFL is in the form of ultraviolet radiation. How is this changed to white light?
- (c) Calculate the energy of an ultraviolet photon emitted in a CFL.
- (d) How does an electron in an atom of the fluorescent coating emit a photon?
- (e) Why does the fluorescent coating in a CFL get warm during use?
- (f) A light sensor attached to a datalogger indicates that the light emitted from a CFL used in the home is not continuous, but flickers at a frequency that is not detected by the eye. What is the cause of the flickering in the light?
- (g) Draw a circuit diagram of a diode in forward bias.
- (h) How can LEDs be used to produce white light?

(8 × 7)

**12** Answer any **two** of the following parts (a), (b), (c), (d).

(a) State Hooke's law. (6)



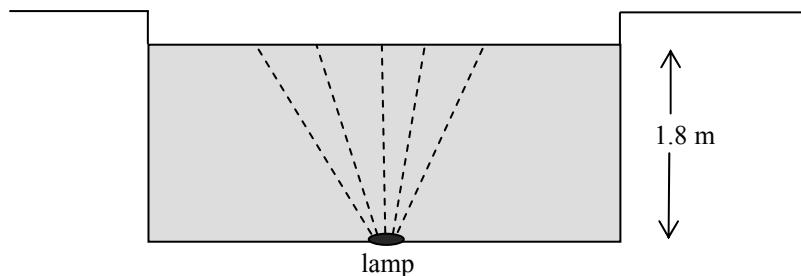
A body of mass 250 g vibrates on a horizontal surface and its motion is described by the equation  $a = -16 s$ , where  $s$  is the displacement of the body from its equilibrium position. The amplitude of each vibration is 5 cm.

Why does the body vibrate with simple harmonic motion? (6)

Calculate the frequency of vibration of the body? (9)

What is the magnitude of (i) the maximum force, (ii) the minimum force, which causes the body's motion? (7)

(b) State the laws of refraction of light. (6)



A lamp is located centrally at the bottom of a large swimming pool, 1.8 m deep.

Draw a ray diagram to show where the lamp appears to be, as seen by an observer standing at the edge of the pool. (7)

At night, when the lamp is switched on, a disc of light is seen at the surface of the swimming pool. Explain why the area of water surrounding the disc of light appears dark.

Calculate the area of the illuminated disc of water. (15)

(refractive index of water = 1.33)

- (c) List the factors that affect the heat produced in a current-carrying conductor. (7)

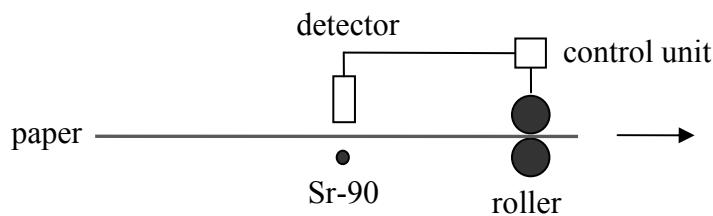
An electric cable consists of a single strand of insulated copper wire. The wire is of uniform cross-sectional area and is designed to carry a current of 20 A. To preserve the insulation, the maximum rate at which heat may be produced in the wire is 2.7 W per metre length.

Calculate

- (i) the maximum resistance per metre of the wire  
(ii) the minimum diameter of the wire. (21)

(resistivity of copper =  $1.7 \times 10^{-8} \Omega \text{ m}$ )

- (d) In the manufacture of newsprint paper, heavy rollers are used to adjust the thickness of the moving paper. The paper passes between a radioisotope and a detector, and a pair of rollers, as shown.



The radioisotope used is Sr-90 and it emits beta-particles, which are recorded by the detector. The output from the detector adjusts the gap between the rollers, so that the paper is of uniform thickness.

- (i) Name a suitable detector. (6)
- (ii) Describe how the reading on the detector may vary as the paper passes by. (9)
- (iii) Why would the radioisotope Am-241, which emits alpha-particles, **not** be suitable for this process? (4)
- (iv) Calculate the number of atoms present in a sample of Sr-90 when its activity is 4250 Bq. The half-life of Sr-90 is 28.78 years. (9)

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