



**Coimisiún na Scrúduithe Stáit**  
**State Examinations Commission**

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**LEAVING CERTIFICATE EXAMINATION, 2019**

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**PHYSICS – HIGHER LEVEL**

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**WEDNESDAY, 19 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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This examination will be marked on screen. The Superintendent will give you a special answerbook. 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. In an experiment to determine the acceleration due to gravity, the time  $t$  for an object to fall from rest through a distance  $s$  was measured. The procedure was repeated for a series of values of  $s$ . The following data were recorded.

$s$ (cm)	30.0	40.0	50.0	60.0	70.0	80.0	90.0
$t$ (ms)	250	285	310	345	380	400	435

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

Between which points was the distance  $s$  measured?

Describe how the time  $t$  was measured. (15)

Draw a suitable graph that can be used to determine the acceleration due to gravity  $g$ .

Hence determine  $g$ . (21)

A small, dense ball was used as the object in this experiment. State an advantage of using this type of ball. (4)

2. In an experiment to determine the focal length of a concave mirror a student first found the approximate focal length of the mirror. He then placed an object in front of the mirror and measured the object distance  $u$  and the corresponding image distance  $v$ . He repeated this procedure for different values of  $u$ . The following data were recorded.

$u$ (cm)	20.0	30.0	40.0	50.0
$v$ (cm)	61.0	29.5	24.0	20.5

How did the student find the approximate focal length?

Why did the student find the approximate focal length at the start of the experiment?

Describe, with the aid of a labelled diagram, how the position of the image was found.

State two precautions that should be taken when measuring  $v$ . (27)

Use all of the data to calculate the focal length of the mirror. (13)

3. In an experiment to determine the specific latent heat of fusion of ice, a student first crushed some ice. She then dried the melting ice before adding it to warm water in an insulated copper calorimeter.

The following data were recorded.

Mass of copper calorimeter	= 56.3 g
Mass of calorimeter and water before adding ice	= 108.5 g
Initial temperature of water	= 29.5 °C
Final temperature of water	= 8.0 °C
Mass of calorimeter and water after adding ice	= 122.9 g

Why did the student (i) crush the ice, (ii) dry the ice?

How was the ice (iii) crushed, (iv) dried?

Why did she (v) use warm water, (vi) use melting ice? (18)

Use the data to calculate the specific latent heat of fusion of ice.

Why could using a very large mass of water lead to a less accurate result in this experiment? (22)

(specific heat capacity of water =  $4180 \text{ J kg}^{-1} \text{ K}^{-1}$ , specific heat capacity of copper =  $390 \text{ J kg}^{-1} \text{ K}^{-1}$ )

4. In an experiment to investigate the variation of current  $I$  with potential difference  $V$  for a semiconductor diode the following data were recorded.

$V$ (mV)	0	50	100	150	200	250	300
$I$ (mA)	0	0	0	2	5	40	110

Draw a circuit diagram for this experiment. (15)

Use the data to draw a graph of current against potential difference.

Use your graph to determine the junction voltage.

What happened in the diode when the junction voltage was exceeded?

Is Ohm's law obeyed for the diode? Justify your answer.

The diode is now reversed and data is recorded. State two other changes that are made to the circuit before recording data for a diode in reverse bias. (25)

## SECTION B (280 MARKS)

Answer **five** questions from this section.

Each question carries 56 marks.

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

(a) A light-year is the distance travelled by light in a vacuum in one year. Calculate this distance in metres.

(b) An apple has a weight of 1 N and its volume is  $121 \text{ cm}^3$ . Calculate the density of the apple.

(acceleration due to gravity =  $9.8 \text{ m s}^{-2}$ )

(c) A book is decelerating as it moves to the right on a horizontal table. Draw a labelled diagram to show the forces acting on the book as it moves on the table.

(d) What is meant by polarisation of light?

(e) What is the thermometric property of (i) a mercury thermometer, (ii) a thermocouple?

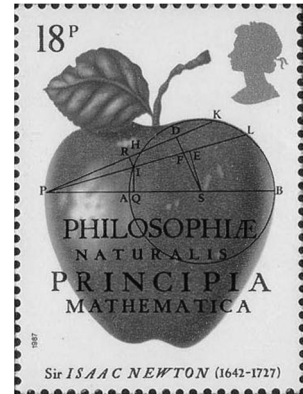
(f) Sketch a graph to show the relationship between resistance  $R$  and temperature  $T$  (in  $^{\circ}\text{C}$ ) for a metallic conductor.

(g) Power  $P$  is generated in a resistor of resistance  $R$  when a potential difference  $V$  is applied across it. Write  $P$  in terms of  $R$  and  $V$ .

(h) Polonium was discovered by Marie and Pierre Curie in 1898. Polonium-218 has a half-life of 3 minutes. Calculate the activity of a sample of polonium-218 that contains 75000 nuclei.

(i) Polonium-218 is produced as the daughter nucleus in the alpha-decay of radon-222. Write a nuclear equation for this reaction.

(j) Neutrinos are sometimes called ghost particles. Why are they very hard to detect?



**or**

Describe how a galvanometer can be converted into an ammeter.

(8 × 7)

6. Satellites, which play an increasing role in the information age, are controlled by the gravitational force. Weather satellites, communications satellites and global positioning satellites (GPS) are used by millions of people every day. Different satellites have different periods and different radii of orbit.

State Newton's law of universal gravitation.

What is the relationship between the period  $T$  and radius of orbit  $r$  of a satellite? (9)

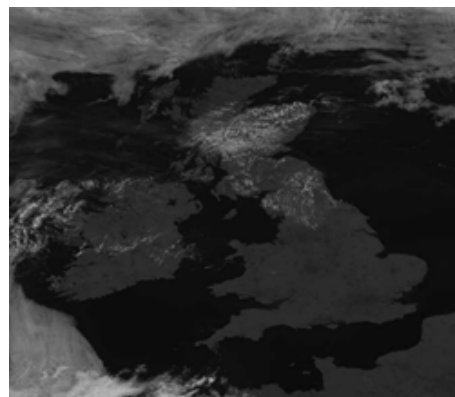
The METEOSAT 11 weather satellite provides MET Éireann with both visible and infrared images. It is in geostationary orbit above the equator.

Which has a longer wavelength, visible or infrared radiation?

Describe how infrared radiation can be detected in the school laboratory.

What is the period of METEOSAT 11?

Calculate its height above the surface of the Earth. (21)



A global positioning satellite is **not** in geostationary orbit. It orbits the Earth with a speed of  $14000 \text{ km hr}^{-1}$ .

Calculate (i) its radius of orbit, (ii) its angular velocity.

Calculate the minimum time it takes a signal to travel from the global positioning satellite to the Earth. (21)



Explain why satellites remain in orbit and do not fall to Earth. (5)

(mass of Earth =  $6.0 \times 10^{24} \text{ kg}$ , radius of Earth =  $6400 \text{ km}$ )

7. In a thunderstorm different parts of a cloud become positively and negatively charged. There is a large electric field and a large potential difference between different parts of the cloud and between the cloud and the ground.



What is meant by potential difference? State its unit.

Define electric field strength.

(15)

Describe how an insulated spherical conductor can be charged positively by induction.

A spherical conductor has a diameter of 12 cm. It is charged positively by induction.

Draw the electric field around the charged conductor.

There is an electric field strength of  $2.3 \text{ N C}^{-1}$  at a distance of 5 cm from the surface of this spherical conductor. Calculate the charge on the conductor.

(21)



Explain how point discharge occurs.

Describe how point discharge can be demonstrated in the laboratory.

(20)

8. Electrons are emitted from metals during photoelectric emission, thermionic emission and radioactive decay. Distinguish between photoelectric and thermionic emission.

What name is given to electrons emitted during radioactive decay?

When current is passed through the vapour in a sodium lamp, light is emitted as a line spectrum.

What is a line emission spectrum? Explain, in terms of the structure of the atom, how this spectrum is produced.

(21)

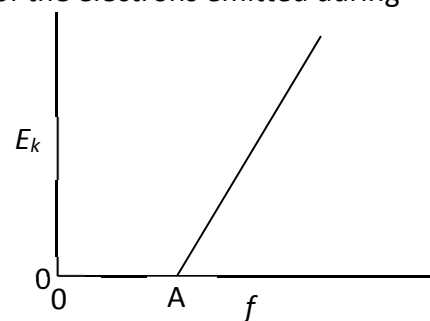
The graph shows the relationship between the kinetic energy  $E_k$  of the electrons emitted during photoemission and the frequency  $f$  of the incident radiation.

Write down Einstein's photoelectric equation.

What physical quantity is represented by (i) point A, (ii) the slope of the graph?

The work function of magnesium is 3.68 eV. Calculate the maximum velocity of the emitted electrons when photons of energy 4.15 eV are incident on magnesium.

(18)



Electrons are produced in an X-ray tube by thermionic emission. Where in the tube are the electrons produced?

The electrons are then accelerated to high velocities. Some of the electrons have their energy converted into X-rays. What is the minimum wavelength of an X-ray produced in a 50 kV tube?

The kinetic energy of each of the other electrons is converted into heat energy. State two design features of an X-ray tube that take account of this.

(17)

9. (a) Both a moving charge and a conductor carrying an electric current experience a force in a magnetic field.

Explain the underlined terms.

Describe an experiment to demonstrate that a current-carrying conductor experiences a force in a magnetic field.

When would a current-carrying conductor in a magnetic field **not** experience a force? (18)

- (b) A straight wire of length 3 cm was placed perpendicular to a magnetic field of uniform magnetic flux density  $B$ . The force  $F$  on the wire was measured for a series of values of current  $I$  flowing in the wire. The following data were recorded.

$I$ (A)	0.5	1.0	1.5	2.0	2.5	3.0	3.5
$F$ (mN)	10	18	31	39	50	59	68

Write down an expression for the force  $F$  on the current-carrying wire in terms of  $I$ ,  $B$  and the length  $l$  of the wire.

Plot a graph on graph paper of force against current. Calculate the slope of the graph and use it to calculate the magnetic flux density of the field. (21)

- (c) Starting with the expression for the force that you wrote in part (b), derive the expression  $F = qvB$  for the force  $F$  acting on a charge  $q$  travelling at a velocity  $v$  perpendicular to a magnetic field of flux density  $B$ .

In a nuclear detector a proton enters a magnetic field of flux density 0.5 T at right angles to the field. The proton initially follows a circular path of radius 2.3 mm. Calculate the speed of the proton as it enters the field. (17)

10. Explain the terms diffraction and interference.

In 1801 Thomas Young performed an experiment to demonstrate that light is a wave.

He passed monochromatic light through two narrow slits and observed a series of bright and dark fringes on a screen.

Explain, with the aid of a labelled diagram, how a series of bright and dark fringes were produced.

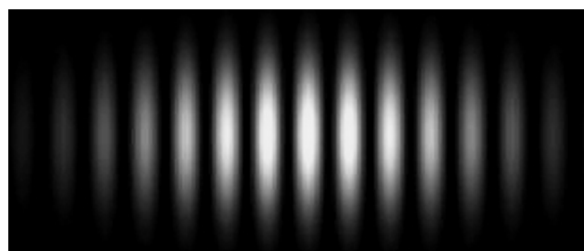


How does this experiment demonstrate that light is a wave?

(21)

The experiment was repeated in the school laboratory.

The slits were 0.5 mm apart and were placed at a distance of 1.25 m from the screen. The distance across 13 bright fringes on the screen was found to be 1.65 cm.



Calculate the wavelength of the monochromatic light.

List two adjustment to the apparatus that could be made to increase the distance between the bright fringes.

(18)

Young was a polymath with many other interests, including the deciphering of Egyptian hieroglyphs, discovery of the purpose of the ciliary muscle in the eye, and the invention of the *Young temperament* which made use of harmonics to tune musical instruments.

When the ciliary muscles contract the lens in the eye becomes thinner. What effect does this have on the power of the lens?

A certain musical instrument can be modelled as a cylindrical pipe that is closed at one end and whose length can be changed. The air column in the pipe vibrates at a frequency of 512 Hz.

Draw diagrams to show the first two harmonics of this instrument.

The lengths of the pipe at the first two positions of resonance are 16.7 cm and 49.8 cm.

Calculate (i) the wavelength of the sound wave, (ii) the speed of sound in air.

(17)



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

### Physics Rivalries

We tend to think of scientists as toiling away in their laboratories, not looking to bother anyone, but that's not always the case. Great minds often come with powerful personalities. The rivalry between Nikola Tesla and Thomas Edison is the most famous example, but it's far from the only one.

Edison's greatest conflict with Tesla was called the current war. It centred around whether a.c. or d.c. should be used to transmit electricity. Edison insisted his d.c. system was superior because it maintained a lower voltage in transmission and was therefore safer. Tesla's a.c. eventually won out but it is still converted to d.c. for use in the home.

In the seventeenth century Robert Hooke was known as Isaac Newton's most enthusiastic antagonist, claiming that much of Newton's work was built on his own. The biggest disagreement involved Newton's law of gravitation. Hooke always maintained that Newton took the idea of an inverse law from him. Hooke also discovered the plant cell using an early microscope.

In 1938 Lise Meitner, using the result of an experiment of Otto Hahn, explained how nuclear fission occurs. This discovery led to a great injustice in science. Hahn was awarded a Nobel Prize for the discovery of nuclear fission. Hahn never fully acknowledged the contribution of Meitner to the understanding of fission. This deeply hurt Meitner, as did the fact that she was not given a share of the Nobel Prize.

Adapted from *Rivals: Conflict as the Fuel of Science* (Michael White); *Plutonium, A History of the World's most Dangerous Element* (Jeremy Bernstein)



- (a) Explain why the transmission of electricity using low voltage is not economical. (7)
- (b) Name the device used to (i) reduce a.c. voltage, (ii) convert current from a.c. to d.c. (7)
- (c) State Hooke's law. (7)
- (d) A ball of mass 110 g is travelling at a speed of  $4 \text{ m s}^{-1}$ . It rebounds from a wall and travels in the opposite direction at the same speed. The ball was in contact with the wall for 0.2 seconds. Use Newton's laws of motion to calculate the force exerted by the wall on the ball. (7)
- (e) A magnifying glass is a basic microscope. Draw a ray diagram to show the formation of an upright image in a magnifying glass. (7)
- (f) A plutonium-239 nucleus undergoes fission when a neutron collides with it. Xenon-134 and zirconium-103 are produced together with some neutrons.

Write a nuclear equation for this fission reaction.

Calculate the energy released in this reaction.

In what form is this energy released? (21)

(masses of:  $\text{Pu-239} = 239.052163 \text{ u}$ ,  $\text{Xe-134} = 133.905395 \text{ u}$ ,  $\text{Zr-103} = 102.926599 \text{ u}$ )

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

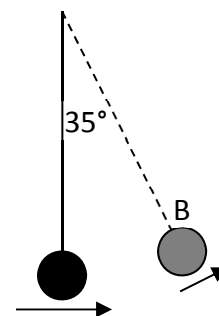
(a) State the principle of conservation of energy.

(3)

A mass hanging at the end of a string of length 80 cm is given an initial horizontal velocity of  $4 \text{ m s}^{-1}$ .

Calculate

- (i) the velocity of the mass at position B,
- (ii) its centripetal acceleration at position B.



Draw a labelled diagram to show the forces acting on the mass when it is at position B. (25)

(acceleration due to gravity =  $9.8 \text{ m s}^{-2}$ )

(b) A RAM (random access memory) integrated chip contains transistors, in which there are doped semiconductors, and capacitors.

What is a semiconductor? What is meant by doping a semiconductor?

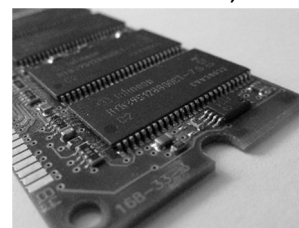
How can a semiconductor be doped so that (i) its majority charge carriers are electrons, (ii) its majority charge carriers are holes? (12)

The capacitance of a capacitor in a RAM chip is 90 fF. It operates at a voltage of 1.2 V.

Calculate

- (i) the energy stored in the capacitor when it is fully charged,
- (ii) the number of additional electrons that are on the negative plate of the capacitor as a result of it being fully charged.

(16)



(c) As light passes from water into air the critical angle may be exceeded and total internal reflection may occur.

Explain the underlined terms.

(9)

A diver is 12 m below the surface in a pool of water. When he looks up he can see a circular window of light on the surface of the water.

Calculate the area of this disc of light.

(12)

Use a labelled diagram to explain why the diver does not appear to be at a depth of 12 m when viewed by an observer outside the pool.

(7)

(refractive index of water = 1.33)



- (d) (i) The new Swiss 200-franc note honours proton-proton collisions in the Large Hadron Collider (LHC) at CERN.

There are two families of hadrons. Name the two families and distinguish between them. (6)

Two protons, each with a velocity of  $0.9c$ , travelling in opposite directions collide. A neutral pion ( $\pi^0$ ) and two protons remain after the collision.

The single pion produced must be neutral. Explain why.

Calculate the total kinetic energy of the three particles after the collision. (15)

The large hadron collider is a circular accelerator.

How are the protons maintained in circular motion?

State the principal advantage of a circular accelerator over a linear accelerator. (7)



**or**

- (ii) Draw the symbol for a transistor and a diagram of its structure. (9)

Transistors and resistors can be used to construct voltage amplifier circuits. Draw a circuit diagram of a voltage amplifier circuit. Label the bias resistor, the load resistor and the input and output voltages.

What is the purpose of the bias resistor?

What is the purpose of the load resistor? (19)

There is no examination material on this page.