



**Coimisiún na Scrúduithe Stáit
State Examinations Commission**

LEAVING CERTIFICATE EXAMINATION, 2012

PHYSICS – HIGHER LEVEL

MONDAY, 18 JUNE – MORNING, 9:30 TO 12:30

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

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

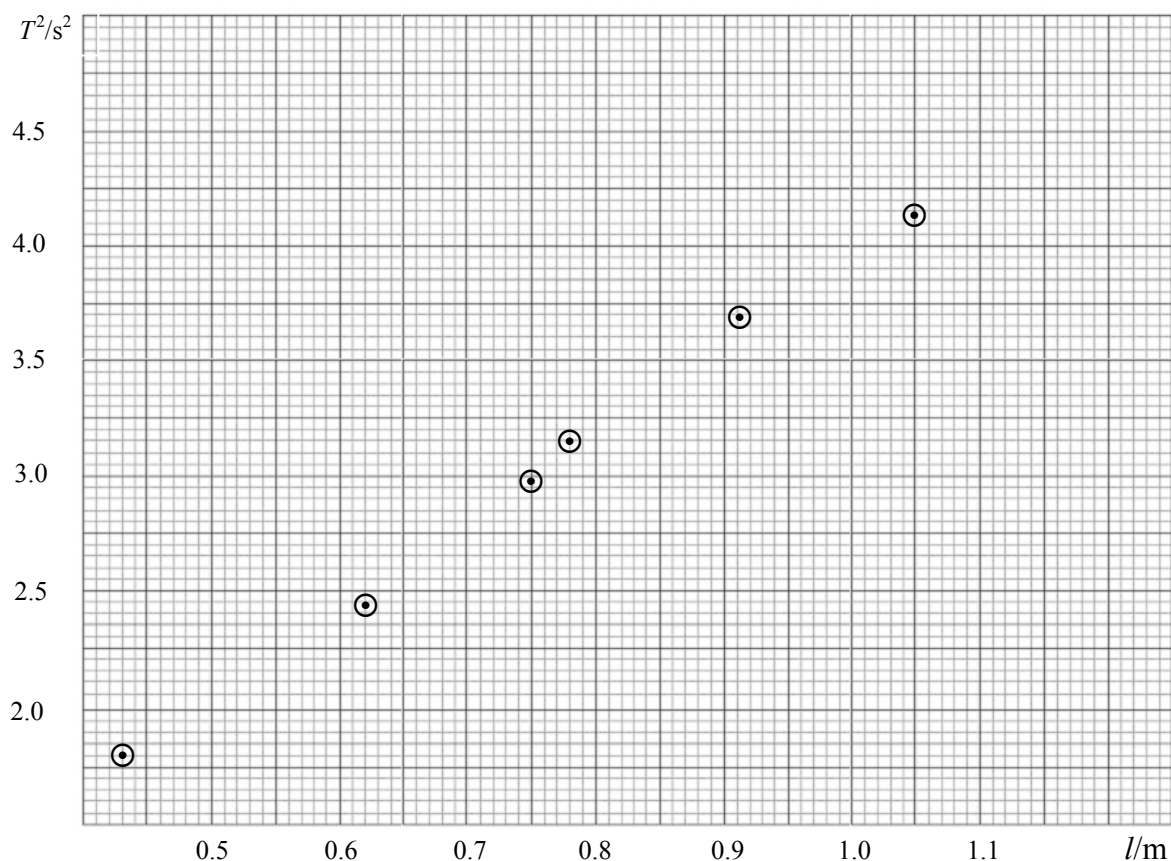
SECTION A (120 marks)

Answer **three** questions from this section.

Each question carries 40 marks.

1. In an experiment to measure the acceleration due to gravity using a simple pendulum, a student obtained values for the length l of the pendulum and the corresponding values for the periodic time T .

The student plotted the following points, based on the recorded data.



Describe how the student obtained a value for the length of the pendulum and its corresponding periodic time.

(18)

Draw the appropriate graph on this examination paper and use it to calculate a value for g , the acceleration due to gravity.

(15)

Give two factors that affect the accuracy of the measurement of the periodic time.

(7)

2. In an experiment to measure the focal length of a converging lens, a student measured the image distance v for each of four different values of the object distance u .

The table shows the data recorded by the student.

u/cm	12.0	18.0	23.6	30.0
v/cm	64.5	22.1	17.9	15.4

Describe, with the aid of a labelled diagram, how the student obtained the data. (15)

Why is it difficult to measure the image distance accurately? (4)

Using all the data in the table, find the value for the focal length of the lens. (15)

Why is it difficult to measure the image distance when the object distance is less than 10 cm? (6)

3. In an experiment to investigate the variation of the fundamental frequency f of a stretched string with its length l , the following data were recorded.

f/Hz	95	102	114	126	141	165	194	232
l/m	0.603	0.553	0.503	0.453	0.403	0.353	0.303	0.253

How were the data obtained? (15)

Using the data, draw a suitable graph on graph paper to show the relationship between the fundamental frequency of the stretched string and its length. (12)

The fundamental frequency of a stretched string depends on factors other than its length. Name one of these factors and give its relationship with the fundamental frequency.

If you were doing an experiment to establish the relationship between the fundamental frequency of a stretched string and this other factor, how would you obtain the relevant data? (13)

4. The following is part of a student's report on an experiment to investigate the variation of the current I with potential difference V for a semiconductor diode.

"I set up the apparatus as shown in the circuit diagram. I measured the current flowing through the diode for different values of the potential difference. I recorded the following data."

V/V	0	0.50	0.59	0.65	0.68	0.70	0.72
I/mA	0	3.0	5.4	11.7	17.4	27.3	36.5

Draw a circuit diagram used by the student.

How did the student vary and measure the potential difference? (15)

Using the data, draw a graph to show how the current varies with the potential difference for the semiconductor diode.

Does the resistance of the diode remain constant during the investigation? Justify your answer. (18)

The student continued the experiment with the connections to the semiconductor diode reversed. What adjustments should be made to the circuit to obtain valid readings? (7)



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) Cork and Sligo are about 330 km apart by road. Using the map of Ireland shown on page 4, estimate the displacement of Sligo from Cork. The scale of the map is 1 cm to 37.5 km.
- (b) A pendulum moves with simple harmonic motion. Give another example of a body that moves with simple harmonic motion.
- (c) The European aerospace group EADS is developing a hypersonic jet aircraft that will fly at four times the speed of sound, 330 m s^{-1} . Express the speed of the aircraft in kilometre per hour.
- (d) What is the focal length of a lens which has a power of -2 m^{-1} ?
- (e) List three conditions necessary for an observer to see a rainbow.
- (f) How is energy transferred from the sun to the earth?
- (g) A person smokes a cigarette at the entrance to a building. Explain how a significant amount of the smoke from the cigarette can enter the building.
- (h) Sketch the magnetic field due to a current in a solenoid.
- (i) It takes 30 minutes for a 100 g sample of a radioactive isotope to decay to 12.5 g. What is the half-life of the radioisotope?
- (j) Which Irish physicist is associated with the development of the linear accelerator?
or
With what invention is the Irish physicist Nicholas Callan associated?

(8 × 7)

6. On 16 August, 1960, Joseph Kittinger established a record for the highest altitude parachute jump. This record remains unbroken. Kittinger jumped from a height of 31 km. He fell for 13 seconds and then his 1.8-metre canopy parachute opened. This stabilised his fall. Only four minutes and 36 seconds more were needed to bring him down to 5 km, where his 8.5-metre parachute opened, allowing him to fall at constant velocity, until he reached the surface of the earth.



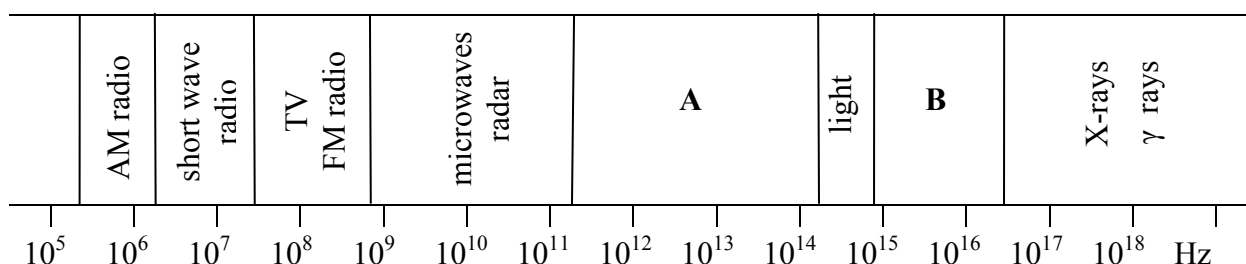
Automatic camera recording of Kittinger as he jumped.

(Adapted from <http://www.centennialofflight.gov>)

- (i) Calculate the acceleration due to gravity at a height of 31 km above the surface of the earth. (12)
- (ii) What was the downward force exerted on Kittinger and his equipment at 31 km, taking their total mass to be 180 kg? (6)
- (iii) Estimate how far he fell during the first 13 seconds. What assumptions did you take in this calculation? (12)
- (iv) What was his average speed during the next 4 minutes and 36 seconds? (9)
- (v) Assuming that the atmospheric pressure remains constant, how much was the force on a hemispherical parachute of diameter 8.5 m greater than that on a similar parachute of diameter 1.8 m? (9)
- (vi) Calculate the upthrust that acted on Kittinger when he reached constant velocity in the last stage of his descent (assume $g = 9.81 \text{ m s}^{-2}$ during this stage). (8)

(radius of earth = $6.36 \times 10^6 \text{ m}$; mass of earth = $5.97 \times 10^{24} \text{ kg}$)

7.



The diagram shows a simplified version of the electromagnetic spectrum.

Name the sections labelled **A** and **B** in the diagram.

Describe how to detect each of these radiations. (15)

An electromagnetic radiation has a wavelength of 4 m.

Name the section of the electromagnetic spectrum in which this radiation is located. (9)

Distinguish between interference and diffraction.

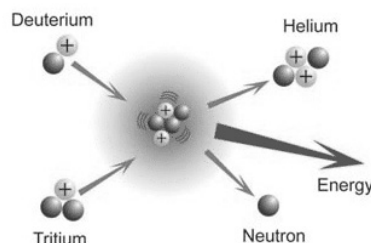
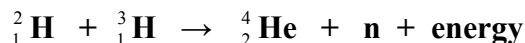
Can a diffraction grating which diffracts light also diffract X-rays? Justify your answer. (21)

Light travels as a transverse wave. Name another type of wave motion and give two differences between these two types of wave motion. (11)

8. Nuclear fission reactors are used as an energy source in many parts of the world, but it is only recently that the use of nuclear fusion as a possible power source is achieving some encouraging results.

The ITER nuclear facility at Caderache in south-east France is a global collaboration that has been formed to “demonstrate that fusion is an energy source of the future”. It is expected to begin testing in 2016.

Energy can be produced in a fusion reaction by combining a deuterium and a tritium nucleus as follows:

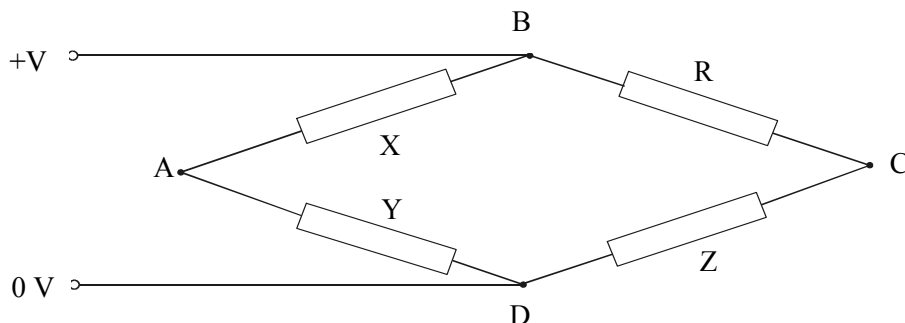


- (i) Distinguish between nuclear fission and nuclear fusion. (12)
- (ii) What are the advantages of fusion over fission in terms of fuel sources and reaction products? (12)
- (iii) How much energy is produced when a deuterium nucleus (${}^2_1\text{H}$), combines with a tritium nucleus (${}^3_1\text{H}$)? (18)
- (iv) Calculate the force of repulsion between a deuterium and a tritium nucleus when they are 2 nm apart in free space. (9)
- (v) Fusion can only take place at very high temperatures. Explain why. (5)

9. Define resistance.

- (i) Two resistors of resistance R_1 and R_2 are connected in series. Derive an expression for the effective resistance of the two resistors in terms of R_1 and R_2 . (18)
- (ii) Two $4\ \Omega$ resistors are connected in parallel. Draw a circuit diagram to show how another $4\ \Omega$ resistor could be arranged with these two resistors to give an effective resistance of $6\ \Omega$. (9)
- (iii) A fuse is a resistor used as a safety device in a circuit. How does a fuse operate? (11)

A Wheatstone bridge circuit is used to measure the resistance of an unknown resistor R . The bridge ABCD is balanced when $X = 2.2\ \text{k}\Omega$, $Y = 1.0\ \text{k}\Omega$ and $Z = 440\ \Omega$.

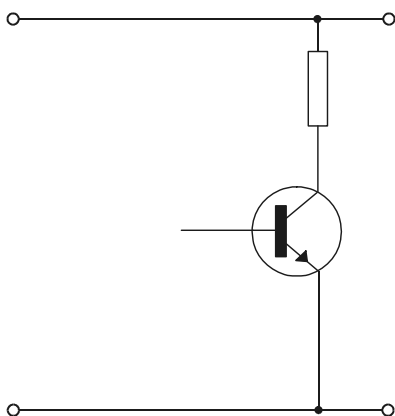


- (iv) What test would you use to determine that the bridge is balanced? (6)
- (v) What is the resistance of the unknown resistor R ? (6)
- (vi) When the unknown resistor R is covered by a piece of black paper, the bridge goes out of balance. What type of resistor is it? Give a use for this type of resistor. (6)

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

- (a) (i) What is a positron? (6)
- (ii) When a positron and an electron meet two photons are produced.
Write an equation to represent this interaction. (6)
- (iii) Why are photons produced in this interaction?
Explain why two photons are produced.
Calculate the minimum frequency of the photons produced.
Explain why the photons produced usually have a greater frequency than your calculated minimum frequency value. (24)
- (iv) Why must two positrons travel at high speeds so as to collide with each other?
How are charged particles given high speeds? (12)
- (v) Explain why two positrons cannot annihilate each other in a collision. (8)
- (b) Draw a labelled diagram to show the basic structure of a bipolar transistor. Indicate the difference in the composition of the parts of the transistor that you have drawn. (18)

The diagram shows part of a circuit in which a transistor is to be used as a voltage inverter.



- (i) Copy the diagram into your answerbook and complete the circuit diagram.
Label each part of the circuit.
Indicate on your diagram the terminals used for the input and output voltages. (15)
- (ii) Draw a sketch of an input voltage and its corresponding output voltage, using the same axes and scale. (9)
- (iii) A voltage inverter can be used as a NOT gate.
Draw the symbol of a NOT gate.
Draw the truth table for a NOT gate. (9)
- (iv) Give another application of a transistor. (5)

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

Windmills have been used for thousands of years to grind grain but the first attempts to use wind turbines to generate electricity were not made until the late 1800s. Viable large scale wind turbines were not produced until the 1980s. At the moment about 12% of Ireland's electricity needs are met by wind energy and it is planned to increase this to 33% by 2020.

Wind is a source of renewable energy and is now one of the most cost-effective methods of electricity generation.

The power P of the wind can be calculated from $P = \rho Av^3$ where ρ is the density of the air, A is the area the wind acts on and v is the speed of the wind. In theory it is possible to extract 58% of this energy in a wind turbine. Much of the loss occurs as the wind is slowed down rather than stopped as it passes the turbine.

The rotating blades of the turbine transfer their energy to an a.c. generator, which produces electricity by electromagnetic induction. The resulting alternating supply has to be changed to match the 230 V, 50 Hz that is used for electrical supply in Ireland.

Many people are concerned about the noise associated with wind turbines. Better blade construction has led to reduced noise. At about 150 m from a turbine, typical sound intensity levels are 45 dB. This reduces to 42 dB at about 200 m away. These values compare favourably with values of around 60 dB in a busy office.



(Adapted from: Renewable Energy, Edited by Godfrey Boyle, Oxford University Press in association with The Open University.)

- (a) What is the effect on the power of the wind if the wind speed is doubled?
- (b) Why is it not possible to extract all of the energy in the wind striking a wind turbine blade?
- (c) What is electromagnetic induction?
- (d) How is the output voltage of a wind turbine changed to 230 V a.c.?
- (e) Estimate the factor by which the sound intensity changes when you move from a position which is about 200 m away to a position which is about 150 m away from a typical wind turbine.
- (f) What is the tip speed (the linear velocity of the outer end) of a blade of radius 30 m when it completes a revolution every 3 seconds?
- (g) Small scale wind turbines are sometimes used to charge batteries. The a.c. output voltage has to be converted to a d.c. voltage. How is this achieved?
- (h) Name one other renewable source of energy.

(8 × 7)

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

(a) An Olympic hammer thrower swings a mass of 7.26 kg at the end of a light inextensible wire in a circular motion. In the final complete swing, the hammer moves at a constant speed and takes 0.8 s to complete a circle of radius 2.0 m.

- (i) What is the angular velocity of the hammer during its final swing? (6)
- (ii) Even though the hammer moves at a constant speed, it accelerates. Explain. (4)

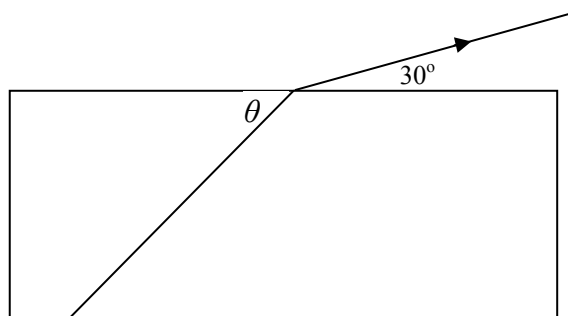
Calculate

- (iii) the acceleration of the hammer during its final swing (9)
- (iv) the kinetic energy of the hammer as it is released. (9)



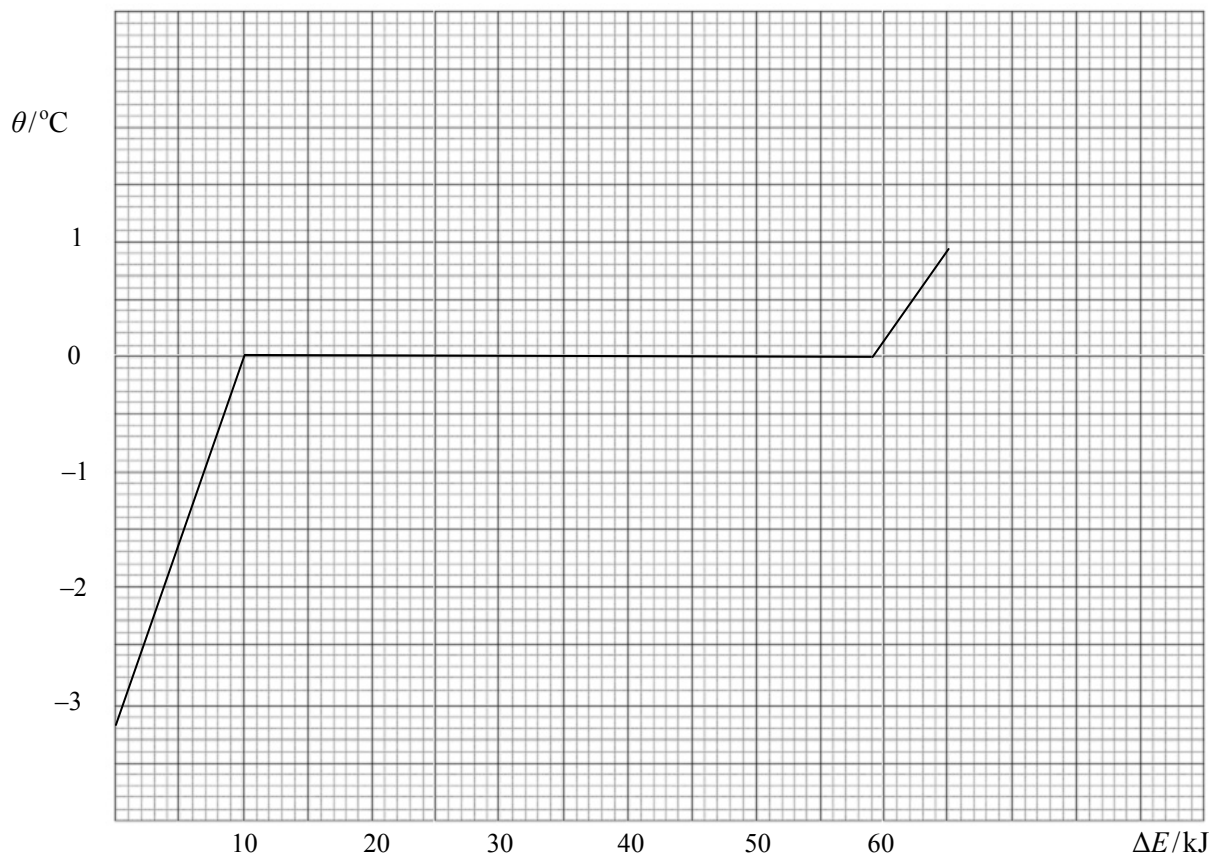
Pat O'Callaghan of Kanturk, who won two Olympic gold medals for the hammer throw.

(b) The diagram shows a ray of light as it leaves a rectangular block of glass. As the ray of light leaves the block of glass, it makes an angle θ with the inside surface of the glass block and an angle of 30° when it is in the air, as shown.



- (i) If the refractive index of the glass is 1.5, calculate the value of θ . (12)
- (ii) What would be the value of the angle θ so that the ray of light emerges parallel to the side of the glass block? (9)
- (iii) Calculate the speed of light as it passes through the glass. (7)

- (c) The graph shows the variation in temperature θ of 150 g of crushed ice when it was supplied with energy ΔE at a constant rate.



- (i) Explain the shape of the graph. (12)
- (ii) Describe how energy could have been supplied at a constant rate. (6)
- (iii) Using the graph, estimate the specific latent heat of fusion of ice. (10)
- (d) (i) Draw a diagram to show the structure of a photocell. (12)
- (ii) Describe an experiment to demonstrate how the current through a photocell can be increased. (12)
- (iii) Give an application of the photoelectric effect. (4)

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