



Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2022

PHYSICS – ORDINARY LEVEL

WEDNESDAY, 22 JUNE – MORNING, 9:30 TO 12:30

Answer **two** questions from **Section A** and **four** questions from **Section B**.

Do not hand this up.
This document will not be returned to the
State Examinations Commission.

SECTION A (80 MARKS)

Answer **two** questions from this section.

Each question carries 40 marks.

1. A student carried out an experiment to measure the velocity of an object.

(i) Draw a labelled diagram of the apparatus used to measure constant velocity. (12)

(ii) Indicate on the diagram what distance the student measured.

(iii) Describe how the student measured the time.

(iv) State the formula used to calculate the velocity. (12)

The student then used the apparatus to measure the acceleration of the object.

(v) What changes did the student make to the apparatus?

(vi) What measurements did the student take to calculate acceleration?

(vii) How did the student use these measurements to calculate acceleration?

(viii) State two precautions that could be taken to improve the accuracy of either of these experiments. (16)

2. A student carried out an experiment to verify Snell's Law and used her measurements to calculate the refractive index (n) of a material. She measured the angle of incidence i and the corresponding angle of refraction r . She repeated this for a different values of i .

Her results are shown in the table below.

i (degrees)	30	40	50	60
r (degrees)	19	25	31	35

(i) Draw a labelled diagram of the apparatus used in this experiment.

(ii) On your diagram, label the angles measured by the student. (18)

(iii) Name the instrument used to measure these angles.

(iv) State the formula used to calculate n .

(v) Use all of the results in the table to calculate an average value for n .

(vi) Do your calculations verify Snell's law? Explain your answer.

(vii) State one precaution used to improve the accuracy of the experiment. (22)

3. A student carried out an experiment to investigate how the fundamental frequency f of a stretched string changes with length l . The student set a length of string vibrating and adjusted the length until resonance occurred. The tension of the string was kept constant throughout the experiment.

(i) Draw a labelled diagram of the apparatus used in this experiment.

(ii) Indicate on your diagram the length of string the student measured.

(iii) Name the instrument used to measure length.

(iv) Explain why the tension of the string must be kept constant. (15)

The student recorded the following results.

f (Hz)	256	320	341	427	480	512
l (cm)	22	18	17	13	12	11
$1/l$ (cm ⁻¹)						

(v) How did the student find the frequency values?

(vi) Describe how the student knew that resonance had occurred.

(vii) In your answerbook, copy and complete the table above.

(viii) Use the data to plot a graph of f against $1/l$. (25)

4. A student carried out an experiment to measure c , the specific heat capacity of water. He added heat energy to water in a copper calorimeter.

The following results were recorded.

Mass of empty copper calorimeter	= 0.0745 kg
Mass of calorimeter and cold water	= 0.1498 kg
Initial temperature of cold water	= 18 °C
Final temperature of water	= 23 °C
Heat energy added	= 1703 J

- (i) Draw a labelled diagram of the apparatus used in this experiment.
- (ii) How did the student supply the heat energy? (12)
- (iii) Calculate the mass of the water.
- (iv) Calculate the increase in temperature of the calorimeter and cold water. (12)
- (v) State the formula used to calculate the heat gained by a material as it changes temperature.
- (vi) Use your answers for (iii), (iv) and (v) to calculate c , the specific heat capacity of water.

Note: Heat energy added = Heat energy gained by water + calorimeter. (16)

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

5. In an experiment to verify Joule's law, a constant current I was passed through a heating coil immersed in water and the rise in temperature $\Delta\theta$ was recorded. This procedure was repeated for a number of different currents. The mass of the water and the length of time for which the current was flowing were both kept constant.

The student recorded the following results.

I (A)	1	1.5	2	2.5	3	3.5
I^2 (A ²)						
$\Delta\theta$ (°C)	1.2	2.7	4.8	7.5	10.8	14.7

- (i) Draw a labelled diagram of the apparatus used in this experiment.
- (ii) Why were the mass and the time kept constant?
- (iii) In your answerbook, copy and complete the table above. (18)
- (iv) Use all of the data to plot a graph of I^2 against $\Delta\theta$.
- (v) Use your graph to find the current that caused a change in temperature of 6 °C.
- (vi) Explain how your graph verifies Joule's law. (22)

SECTION B (224 MARKS)

Answer **four** questions from this section.

Each question carries 56 marks.

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

- (a) State Newton's first law of motion.
- (b) A boy applies a force of 20 N to pull his sleigh for 150 m. Calculate the work done by the boy.
- (c) What is the difference between heat and temperature?
- (d) Draw a labelled diagram to show how light travels through an optical fibre.
- (e) Describe how to charge an electroscope.
- (f) Two resistors of resistance $4\ \Omega$ and $7\ \Omega$ are connected in series. Calculate the combined resistance of the two resistors.
- (g) When the frequency of a sound wave increases, its pitch also increases. What is observed to happen to a sound when its amplitude increases?
- (h) Describe how to show the magnetic field of a bar magnet.

N	S
---	---
- (i) Name the three primary colours of light.
- (j) What is meant by nuclear fission?
- (k) A fuse is a safety device used in an electrical plug. Describe how a fuse works.
- (l) Explain what is meant by the half-life of a radioactive sample. (8 × 7)

7. A train of mass 420000 kg started from rest and accelerated to a velocity of 25 m s^{-1} in a time of 6 minutes.

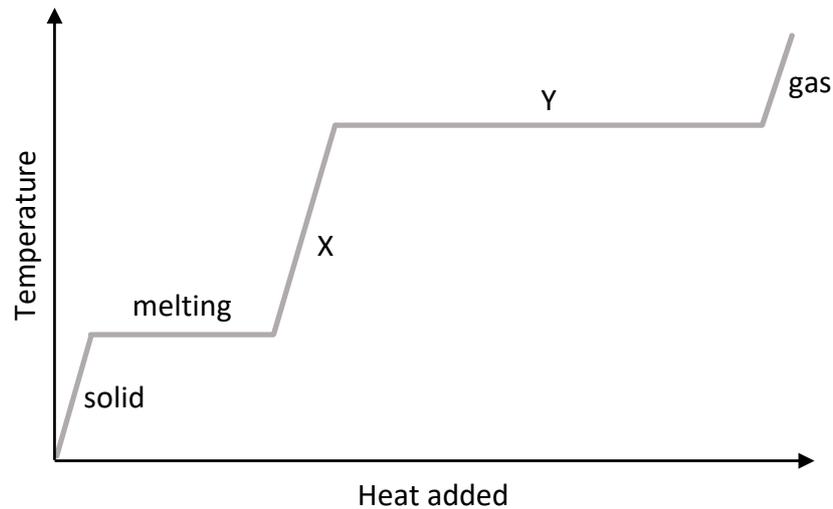


- (i) What is meant by velocity?
- (ii) Convert 6 minutes into seconds.
- (iii) Calculate the acceleration of the train.
Include units in your answer.
- (iv) Calculate the force required to accelerate the train.
- (v) Calculate the distance the train travelled in 6 minutes. (30)

The train then maintained this speed of 25 m s^{-1} for a further 15 minutes.

- (vi) Calculate the distance the train travelled during this 15 minute interval.
- (vii) Draw a labelled diagram to show the forces acting on the train while it is moving with constant speed.
- (viii) An object may have a constant speed but not a constant velocity. Explain why.
- (ix) Draw a speed-time graph for the train during the first 21 minutes of its journey. (26)

8. The graph shows how the temperature and state of water change as the water is heated up.



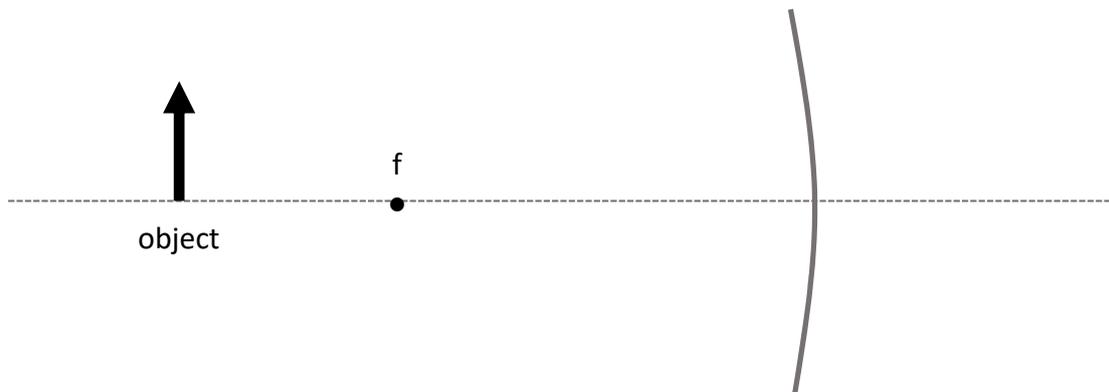
- (i) Explain the shape of the graph at part X.
- (ii) Explain the shape of the graph at part Y.
- (iii) Describe how the energy could have been supplied to the water.
- (iv) Ice has a latent heat of 330000 J kg^{-1} . Calculate how much energy is required to change 0.2 kg of ice to water.
- (v) Explain why a steam burn is more dangerous than a burn from boiling water. (33)

The temperature of the water needs to be measured throughout this experiment. It is measured using a thermometer.

- (vi) A thermometer uses a particular thermometric property to measure temperature. What is meant by a thermometric property?
- (vii) State two examples of thermometric properties.
- (viii) Describe, with the aid of labelled diagram, a laboratory experiment to calibrate a thermometer. (23)

9. When light is reflected from a concave mirror, the image produced may be real or virtual.

- (i) What is meant by reflection?
- (ii) In your answerbook, copy and complete the ray diagram below to show how a magnified image is formed in a concave mirror.



- (iii) The image formed is real. Explain what is meant by a real image. (18)

The object is 20 cm in front of the concave mirror. The mirror has a focal length of 12 cm.

- (iv) Calculate the position of the real image formed.
- (v) The object has a height of 4 cm. Calculate the height of the image. (18)
- (vi) State one use for a concave mirror.

Light is also reflected by convex mirrors.

- (vii) Sketch a convex mirror. Indicate which side of the mirror reflects light.
- (viii) The image produced in a convex mirror is always virtual. Explain what is meant by a virtual image.
- (ix) State one use for a convex mirror. (20)

10. When a person sings, their vocal chords vibrate. These vibrations travel through the air to the listener's ears.

(i) Sound is an example of a mechanical wave which therefore needs a medium to travel through. Describe an experiment to show that sound is a mechanical wave.

(ii) Sound is also an example of a longitudinal wave. What is a longitudinal wave?

(18)



Sound waves can undergo reflection, refraction, diffraction and interference.

(iii) A doorway may cause a sound wave to diffract but it will not cause a light wave to do so. Explain why.

(iv) Describe an experiment to show that sound waves undergo interference.

(v) Sound waves do not undergo polarisation but light waves do. What is meant by polarisation?

(21)

The human ear is most sensitive to sounds with frequencies between 2 kHz and 4 kHz. One reason for this is that sounds in this range can cause resonance to occur in the ear canal.

(vi) What is meant by resonance?

The ear canal can be thought of as a pipe open at one end.

(vii) Draw a labelled diagram to show the first position of resonance for a sound wave in a pipe open at one end.



(viii) The frequency of a sound wave is 2800 Hz and it has a wavelength of 0.12 m. Calculate the speed of the wave.

(17)

11. Benjamin Franklin began experimenting with electricity during the 18th century.



- (i) What is electric current?
- (ii) Name an instrument used to measure electric current.
- (iii) A torch contains a battery, a light bulb and a switch. Draw a circuit diagram to show how these components are connected in a torch. (You may refer to the electrical circuit symbols on pages 72 to 78 of the booklet of *Formulae and Tables*.)
- (iv) The wires in a circuit are made of metal. Explain why.
- (v) Name the subatomic particle that is the charge carrier in a metal. (27)
- (vi) A charge of 30 C passes through a wire in a time of 6 s. Calculate the current flowing in the wire.
- (vii) The wire has a resistance of 3 Ω . Calculate the potential difference (voltage) across the wire.
- (viii) The 3 Ω wire is connected in parallel with another wire of resistance 2 Ω . Calculate the total resistance of the two wires in parallel. (21)

A piece of wire of length 1.5 m has a resistance of 12 Ω .

- (ix) What is the resistance of a 3 m piece of the same wire?
- (x) State the relationship between the resistance of a wire and its cross-sectional area. (8)

12. The Irish physicist George Stoney is most famous for introducing the term *electron*.

(i) State two properties of the electron.

The photoelectric effect is the release of electrons from the surface of a metal when light of a suitable frequency falls on it.

(ii) Describe an experiment to demonstrate the photoelectric effect.

(17)

To ensure the photoelectric effect occurs, the light must be of a suitable frequency to release the electrons. The frequency of the light must be above the threshold frequency.

(iii) Describe what happens if the frequency of the incident light is below the threshold frequency.

(iv) The threshold frequency for zinc is 6.5×10^{14} Hz.

(a) Calculate the wavelength of light of this frequency.

(b) Calculate the energy of a photon of this frequency.

(15)

X-ray production is the inverse process of the photoelectric effect. In an X-ray tube, X-rays are produced when high speed electrons hit a target

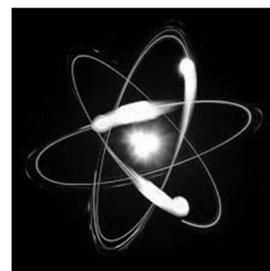
(v) How are electrons produced in an X-ray tube?

(vi) How are electrons accelerated in an X-ray tube?

(vii) Tungsten is often used as the target in an X-ray tube. State one property of tungsten that makes it suitable to use as the target.

(viii) What material could be used to ensure that the X-rays do not escape from the X-ray tube?

(24)



13. Read the following passage and answer the questions below.

Eclipses are among the most spectacular events in astronomy as they are events we can view without a telescope.



Total solar eclipses are the most dramatic of all eclipses. This is when the light from the Sun gets blocked by the Moon for a few minutes and day turns quickly into night. A lunar eclipse, when the Earth's shadow covers the Moon, is a gentler event. The full Moon gradually becomes fainter and redder over a period of a couple of hours. Both types of eclipse can be either total or partial. In a total eclipse, the Earth or the Moon gets completely in the way, while in a partial eclipse only a part of either the Earth or the Moon is in shadow.

Lunar eclipses are far more common than solar eclipses. This is because the Earth's shadow is bigger than the Moon's shadow. At the same time as the Earth's shadow blocks the Moon, some of the light from the Sun will pass through the Earth's atmosphere and then onto the Moon. The Sun's light is refracted as it passes through the Earth's atmosphere. The refracted light is then dispersed into the colours of the rainbow. These processes result in the Moon appearing red.

A rather spectacular version of an eclipse is a Super Blood Moon. This happens when there is an eclipse of the full Moon when it is at its closest to the Earth.

Solar eclipses happen when the Sun, Moon and Earth line up exactly. Total solar eclipses are very rare and only occur when all of the light from the Sun is blocked by the Moon. The last total solar eclipse visible from Ireland was in 1727 and the next one won't be until 2090.

Adapted from: rte.ie

- (i) Describe what happens during a solar eclipse. (7)
- (ii) Lunar eclipses are more common than solar eclipses. Explain why. (7)
- (iii) The light from the Sun is refracted as it passes through the Earth's atmosphere. Explain what is meant by refraction. (7)
- (iv) Name two pieces of laboratory equipment that can be used to disperse light. (7)
- (v) The Moon has a mass of 7.3×10^{22} kg and a radius of 1.7×10^6 m. Calculate g , the acceleration due to gravity on the Moon. (7)
- (vi) An astronaut weighs less on the Moon than she does on Earth. Distinguish between mass and weight. (7)
- (vii) Infrared radiation lies just beyond red light in the electromagnetic spectrum, with a slightly longer wavelength. How can infrared radiation be detected? (7)
- (viii) Name the type of electromagnetic radiation that has a slightly shorter wavelength than visible light. (7)

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

(a) A boy picks up a stone of mass 5 g and throws it vertically upwards with an initial velocity of 15 m s^{-1} . As the stone travels upwards, it loses kinetic energy.

(i) What is meant by kinetic energy?

(ii) State the principle of conservation of energy.

(iii) What is the main type of energy that the stone's kinetic energy is being converted into as it travels upwards? (15)

(iv) Calculate the kinetic energy of the stone when it is thrown.

(v) Calculate the maximum height reached by the stone.

(vi) What is the unit of energy? (13)

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

(b) In order for an observer to see a mirage on a hot day, total internal reflection must occur. Mirages happen when the ground is very hot and the hot air just above the ground and the cool air higher up have different refractive indices. Light undergoes refraction as it travels from the cool air into the hot air.



(i) Describe an experiment to demonstrate total internal reflection. (12)

To see an object clearly, light from an object must enter the eye through the pupil and come to focus on the retina at the back of the eye. The eye focusses the light onto the retina.

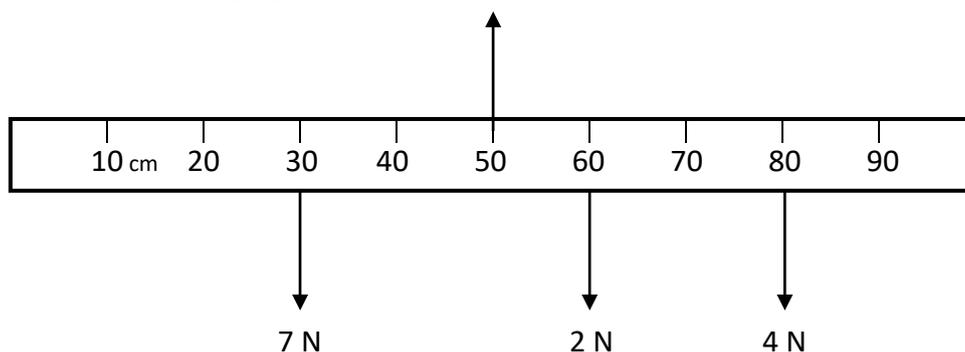
(ii) If the light from a distant object comes to focus in front of the retina, the person will see a blurred image. This person is said to be short sighted. What type of lens is used to correct short sightedness?

(iii) A certain person's eye has a power of 62 m^{-1} . The lens of their glasses has a power of -2 m^{-1} .

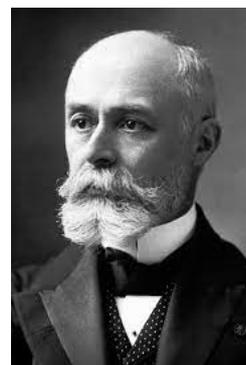
(a) Calculate the power of the combination of the eye and the lens.

(b) Calculate the focal length of the lens in the glasses. (16)

- (c) The diagram shows a metre stick which is suspended from its mid-point (50 cm) with three masses hanging from it. The metre stick is in equilibrium.



- (i) A moment is a turning effect caused by a force. The 2 N force and the 4 N force result in clockwise moments about the midpoint of the metre stick. Calculate the total clockwise moment about the midpoint of the metre stick.
- (ii) The 7 N force results in an anticlockwise moment about the midpoint of the metre stick. Calculate the total anticlockwise moment about the midpoint of the metre stick.
- (iii) State the law of equilibrium verified by the calculations in (i) and (ii). (18)
- (iv) The upward force on the metre stick is 15 N. Calculate the weight of the metre stick.
- (v) Your calculations assume that the centre of gravity of the metre stick acts at the mid-point of the metre stick. What might cause this assumption to be invalid? (10)
- (d) Henri Becquerel was the first person to discover evidence of radioactivity. Radioactivity is the emission of radiation as a result of the decay of atomic nuclei.
- (i) Alpha radiation is one of the three types of radiation. Name the other two types of radiation.
- (ii) Alpha radiation is the least penetrating of the three types of radiation. Describe an experiment to show that the three types of radiation have different penetrating powers. (18)



Radium (Ra_{88}^{226}) is an alpha emitter.

- (iii) How many neutrons are there in an atom of Ra_{88}^{226} ?
- (iv) What is the daughter nucleus when an atom of Ra_{88}^{226} emits two alpha particles? (10)

Acknowledgements

Images

Image on page 5:	State Examinations Commission
Image on page 6:	midwestradio.ie
Image on page 7:	State Examinations Commission
Image on page 8:	State Examinations Commission
Images on page 9:	shutterstock.com; verywellhealth.com
Image on page 10:	wikipedia.org
Image on page 11:	alarmy.com
Image on page 12:	rte.ie
Image on page 13:	medium.com
Images on page 14:	State Examinations Commission; nobelprize.org

Do not hand this up.

This document will not be returned to the
State Examinations Commission.

Copyright notice

This examination paper may contain text or images for which the State Examinations Commission is not the copyright owner, and which may have been adapted, for the purpose of assessment, without the authors' prior consent. This examination paper has been prepared in accordance with Section 53(5) of the *Copyright and Related Rights Act, 2000*. Any subsequent use for a purpose other than the intended purpose is not authorised. The Commission does not accept liability for any infringement of third-party rights arising from unauthorised distribution or use of this examination paper.

Leaving Certificate Examination – Ordinary Level

Physics

Wednesday, 22 June

Morning, 9:30 – 12:30