Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION 2008

PHYSICS – HIGHER LEVEL

MONDAY, 16 JUNE – MORNING 9:30 TO 12:30

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

SECTION A (120 marks)

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

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1. A student investigated the relationship between the period and the length of a simple pendulum.

The student measured the length l of the pendulum.

The pendulum was then allowed to swing through a small angle and the time t for 30 oscillations was measured.

This procedure was repeated for different values of the length of the pendulum.

The student recorded the following data.

l /cm	40.0	50.0	60.0	70.0	80.0	90.0	100.0
t /s	38.4	42.6	47.4	51.6	54.6	57.9	60.0

Why did the student measure the time for 30 oscillations instead of measuring the time for one?

How did the student ensure that the length of the pendulum remained constant when the pendulum was swinging? (9)

Using the recorded data draw a suitable graph to show the relationship between the period and the length of a simple pendulum. What is this relationship? (19)

Use your graph to calculate the acceleration due to gravity. (12)

2. In an experiment to measure the specific latent heat of fusion of ice, warm water was placed in a copper calorimeter. Dried, melting ice was added to the warm water and the following data was recorded.

mass of calorimeter	60.5 g
mass of calorimeter + water	118.8 g
temperature of warm water	30.5 ^{o}C
mass of ice	15.1 g
temperature of water after adding ice	10.2 ^{o}C

Explain why warm water was used.

Why was dried, melting ice used?

Describe how the mass of the ice was found.

What should be the approximate room temperature to minimise experimental error? (22)

Calculate:

(i) the energy lost by the calorimeter and the warm water;

(ii) the specific latent heat of fusion of ice. (18)

(specific heat capacity of copper = 390 J kg^{-1} K^{-1};
specific heat capacity of water = 4200 J kg^{-1} K^{-1})

3. In an experiment to measure the wavelength of monochromatic light, a diffraction pattern was produced using a diffraction grating with 500 lines per mm.
The angle between the first order images was measured.
This was repeated for the second and the third order images.

The table shows the recorded data.

Angle between first order images	Angle between second order images	Angle between third order images
34.2^{o}	71.6^{o}	121.6^{o}

Draw a labelled diagram of the apparatus used in the experiment. (12)

Explain how the first order images were identified.
Describe how the angle between the first order images was measured. (12)

Use the data to calculate the wavelength of the monochromatic light. (16)

4. A student investigated the variation of the resistance *R* of a metallic conductor with its temperature *θ*.

The student recorded the following data.

$\theta/^{o}C$	20	30	40	50	60	70	80
R/Ω	4.6	4.9	5.1	5.4	5.6	5.9	6.1

Describe, with the aid of a labelled diagram, how the data was obtained. (9)

Draw a suitable graph to show the relationship between the resistance of the metal conductor and its temperature. (12)

Use your graph to:

(i) estimate the resistance of the metal conductor at a temperature of $-20\ ^{o}C$;

(ii) estimate the change in resistance for a temperature increase of $80\ ^{o}C$;

(iii) explain why the relationship between the resistance of a metallic conductor and its temperature is **not** linear. (19)

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*) State the law of flotation. (7)

(*b*) The head of a thumbtack has an area of 500 mm^2.
Its point has an area of 0.3 mm^2.
The pressure exerted at the head of the thumbtack is 12 Pa.
What is the pressure exerted at the point of the thumbtack? (7)

(*c*) What is the relationship between the frequency of a vibrating stretched string and its length? (7)

(*d*) Why does diffraction **not** occur when light passes through a window? (7)

(*e*) Why is a fluorescent tube an efficient source of light? (7)

(*f*) What is the force exerted on an electron when it is in an electric field of strength 5 N C^{-1}? (7)

(*g*) What are the charge carriers when an electric current (i) passes through a semiconductor; (ii) passes through an electrolyte? (7)

(*h*) Give two ways of deflecting a beam of electrons. (7)

(*i*) Name an instrument used to detect radioactivity.
What is the principle of operation of this instrument? (7)

(*j*) The existence of the neutrino was proposed in 1930 but it was not detected until 1956.
Give two reasons why it is difficult to detect a neutrino. (7)

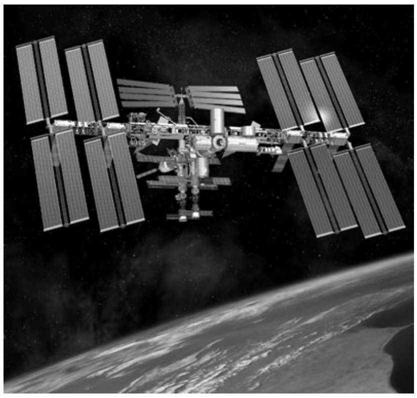
or

Draw a diagram to show how a galvanometer can be converted into a voltmeter. (7)

(charge on electron = 1.6×10^{-19} C)

6. State Newton's law of universal gravitation. (6)

The international space station (ISS) moves in a circular orbit around the equator at a height of 400 km.



What type of force is required to keep the ISS in orbit?
What is the direction of this force? (6)

Calculate the acceleration due to gravity at a point 400 km above the surface of the earth.
An astronaut in the ISS appears weightless.
Explain why. (14)

Derive the relationship between the period of the ISS, the radius of its orbit and the mass of the earth.
Calculate the period of an orbit of the ISS. (18)

After an orbit, the ISS will be above a different point on the earth's surface.
Explain why.
How many times does an astronaut on the ISS see the sun rise in a 24 hour period? (14)

(gravitational constant = 6.6×10^{-11} N m^2 kg^{-2};
mass of the earth = 6.0×10^{24} kg; radius of the earth = 6.4×10^6 m)

7. Define resistivity and give its unit of measurement. (9)

An electric toaster heats bread by convection and radiation.
What is the difference between convection and radiation as a means of heat transfer? (8)

A toaster has a power rating of 1050 W when it is connected to the mains supply.
Its heating coil is made of nichrome and it has a resistance of 12 Ω.
The coil is 40 m long and it has a circular cross-section of diameter 2.2 mm.

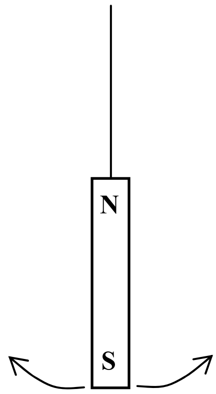
Calculate:
- (i) the resistivity of nichrome;
- (ii) the heat generated by the toaster in 2 minutes if it has an efficiency of 96%. (18)

The toaster has exposed metal parts. How is the risk of electrocution minimised? (9)

When the toaster is on, the coil emits red light.
Explain, in terms of movement of electrons, why light is emitted when a metal is heated. (12)

8. What is electromagnetic induction?
State the laws of electromagnetic induction. (18)

A bar magnet is attached to a string and allowed to swing as shown in the diagram. A copper sheet is then placed underneath the magnet. Explain why the amplitude of the swings decreases rapidly. (12)



What is the main energy conversion that takes place as the magnet slows down? (6)

A metal loop of wire in the shape of a square of side 5 cm enters a magnetic field of flux density 8 T.
The loop is perpendicular to the field and is travelling at a speed of 5 m s^{-1}.

(i) How long does it take the loop to completely enter the field?

(ii) What is the magnetic flux cutting the loop when it is completely in the magnetic field?

(iii) What is the average emf induced in the loop as it enters the magnetic field? (20)

9. What is meant by refraction of light?
State Snell's law of refraction. (12)

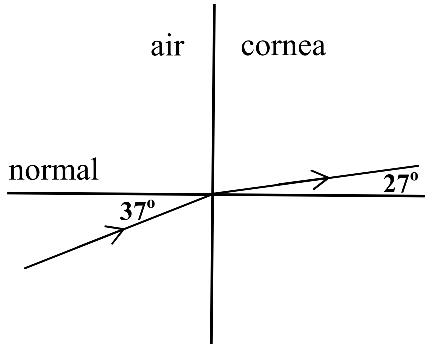
An eye contains a lens system and a retina, which is 2.0 cm from the lens system.
The lens system consists of the cornea, which acts as a fixed lens of power 38 m^{-1}, and a variable internal lens just behind the cornea. The maximum power of the eye is 64 m^{-1}.

Calculate:

(i) how near an object can be placed in front of the eye and still be in focus;

(ii) the maximum power of the internal lens. (15)

Light is refracted as it enters the cornea from air as shown in the diagram.
Calculate the refractive index of the cornea. (6)



Draw a diagram to show the path of a ray of light as it passes from water of refractive index 1.33 into the cornea. (6)

A swimmer cannot see properly when she opens her eyes underwater.
When underwater:

(i) why does the cornea **not** act as a lens?

(ii) what is the maximum power of the eye?

(iii) why do objects appear blurred?

(iv) explain how wearing goggles allows objects to be seen clearly. (17)

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

(*a*) Baryons and mesons are made up of quarks and experience the four fundamental forces of nature.

List the four fundamental forces and state the range of each one. (8)

Name the three positively charged quarks.
What is the difference in the quark composition of a baryon and a meson?
What is the quark composition of the proton? (12)

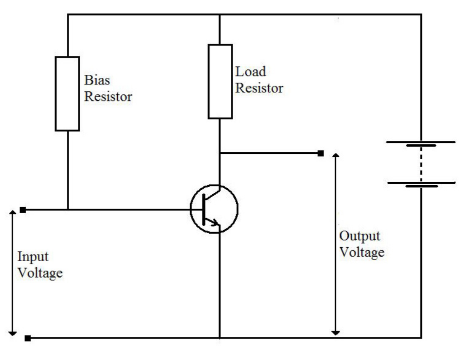
In a circular accelerator, two protons, each with a kinetic energy of 1 GeV, travelling in opposite directions, collide.
After the collision two protons and three pions are emitted.
What is the net charge of the three pions? Justify your answer. (9)
Calculate:

(i) the combined kinetic energy of the particles after the collision;
(ii) the maximum number of pions that could have been created during the collision. (24)

(charge on electron = 1.6022×10^{-19} C; mass of proton = 1.6726×10^{-27} kg;
mass of pion = 2.4842×10^{-28} kg; speed of light = 2.9979×10^{8} m s^{-1})

(*b*) The transistor was one of the most important inventions of the twentieth century.
Draw the basic structure of a bi-polar transistor.
Name the three currents flowing in a transistor
State the relationship between them. (15)

The diagram shows the circuit of a voltage amplifier.
What is the purpose of:
(i) the bias resistor;
(ii) the load resistor? (12)

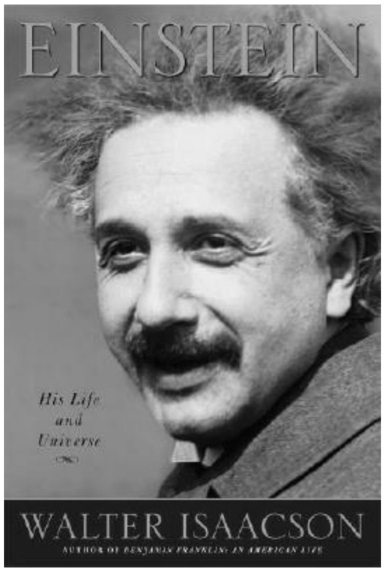


A varying voltage is applied to the amplifier.
Draw a sketch of the input and output voltages, using the same axes and scales. (9)

A NOT gate is a voltage inverter.
Draw a circuit diagram to show how a transistor can be used as a voltage inverter.
Give the truth table of a NOT gate. (20)

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

The Miracle Year: 1905



"There is nothing new to be discovered in physics now," Lord Kelvin reportedly said in 1900. He was wrong.

Isaac Newton had laid the foundations of classical physics in the late seventeenth century. He developed laws that described a mechanical universe: a falling apple and an orbiting moon governed by the same rules of gravity, mass, force and motion. In the mid-1800s, Newtonian mechanics was joined by another great advance. Michael Faraday discovered the properties of electric and magnetic fields. James Clerk Maxwell subsequently showed how changing electric and magnetic fields united to form electromagnetic radiation.

Physics was upended in the early twentieth century by Albert Einstein. In 1905 he devised a revolutionary quantum theory of light to explain the photoelectric effect, helped prove the existence of atoms, united the concepts of space and time, and produced science's best-known equation.

(Adapted from "Einstein: His Life and Universe"; Isaacson; 2007)

(*a*) The SI unit is named in honour of Lord Kelvin.
What is the temperature of the boiling point of water in kelvin? (7)

(*b*) Define the newton, the unit of force. (7)

(*c*) A force of 9 kN is applied to a golf ball by a golf club.
The ball and club are in contact for 0.6 ms.
Using Newton's laws of motion, calculate the change in momentum of the ball. (7)

(*d*) Name three different electromagnetic radiations. (7)

(*e*) What is the photoelectric effect? (7)

(*f*) Why was the quantum theory of light revolutionary? (7)

(*g*) High-energy radiation of frequency 3.3×10^{14} Hz is used in medicine.
What is the energy of a photon of this radiation? (7)

(*h*) 100 MJ of energy are released in a nuclear reaction.
Calculate the loss of mass during the reaction. (7)

(Planck constant = 6.6×10^{-34} J s; speed of light = 3.0×10^{8} m s^{-1})

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

(*a*) State the principle of conservation of energy. (4)

In a pole-vaulting competition an athlete, whose centre of gravity is 1.1 m above the ground, sprints from rest and reaches a maximum velocity of 9.2 m s^{-1} after 3.0 seconds. He maintains this velocity for 2.0 seconds before jumping.

Draw a velocity-time graph to illustrate the athlete's horizontal motion.
Use your graph to calculate the distance travelled by the athlete before jumping. (12)

What is the maximum height above the ground that the athlete can raise his centre of gravity? (12)

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

(*b*) The pitch of a musical note depends on its frequency.
On what does (i) the quality, (ii) the loudness, of a musical note depend? (6)

What is the Doppler effect? (6)

A rally car travelling at 55 m s^{-1} approaches a stationary observer.
As the car passes, its engine is emitting a note with a pitch of 1520 Hz.
What is the change in pitch observed as the car moves away? (12)

Give an application of the Doppler effect. (4)

(*c*)

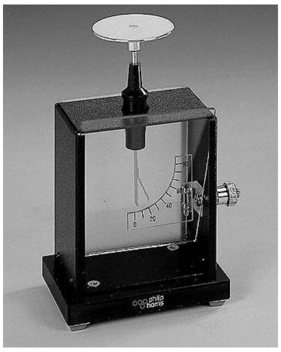
In 1939 Lise Meitner discovered that the uranium isotope U–238 undergoes fission when struck by a slow neutron.
Barium–139 and krypton–97 nuclei are emitted along with three neutrons.

Write a nuclear reaction to represent the reaction. (12)

In a nuclear fission reactor, neutrons are slowed down after being emitted.
Why are the neutrons slowed down?
How are they slowed down? (9)

Fission reactors are being suggested as a partial solution to Ireland's energy needs.
Give one positive and one negative environmental impact of fission reactors. (7)

(*d*) Define capacitance. (6)



Describe how an electroscope can be charged by induction. (10)

How would you demonstrate that the capacitance of a parallel plate capacitor depends on the distance between its plates? (12)

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