Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION 2007

PHYSICS – HIGHER LEVEL

MONDAY 18 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 laws of equilibrium for a set of co-planar forces acting on a metre stick.

The student found that the centre of gravity of the metre stick was at the 50.4 cm mark and its weight was 1.2 N.

How did the student find (i) the centre of gravity, (ii) the weight, of the metre stick?

Why is the centre of gravity of the metre stick not at the 50.0 cm mark?

The student applied vertical forces to the metre stick and adjusted them until the metre stick was in equilibrium.

How did the student know that the metre stick was in equilibrium? (19)

The student recorded the following data.

position on metre stick/cm	11.5	26.2	38.3	70.4	80.2
magnitude of force/N	2.0	4.5	3.0	5.7	4.0
direction of force	down	up	down	up	down

Calculate:

(i) the net force acting on the metre stick

(ii) the total clockwise moment about a vertical axis of the metre stick

(iii) the total anti-clockwise moment about a vertical axis of the metre stick.

Use these results to verify the laws of equilibrium. (21)

2. The specific heat capacity of water was found by adding hot copper to water in a copper calorimeter. The following data was recorded.

mass of calorimeter	55.7 g
mass of calorimeter + water	101.2 g
mass of copper + calorimeter + water	131.4 g
initial temperature of water	16.5 ^{o}C
temperature of hot copper	99.5 ^{o}C
final temperature of water	21.0 ^{o}C

Describe how the copper was heated and how its temperature was measured. (9)

Using the data, calculate:

(i) the energy lost by the hot copper

(ii) the specific heat capacity of water. (16)

Give two precautions that were taken to minimise heat loss to the surroundings.

Explain why adding a larger mass of copper would improve the accuracy of the experiment. (15)

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

3. In an experiment to measure the focal length of a concave mirror, an approximate value for the focal length was found. The image distance v was then found for a range of values of the object distance u. The following data was recorded.

u/cm	15.0	20.0	25.0	30.0	35.0	40.0
v/cm	60.5	30.0	23.0	20.5	18.0	16.5

How was an approximate value for the focal length found?
What was the advantage of finding the approximate value for the focal length? (10)

Describe, with the aid of a labelled diagram, how the position of the image was found. (12)

Calculate the focal length of the concave mirror by drawing a suitable graph based on the recorded data. (18)

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

> I put the diode in forward bias as shown in the circuit diagram. I increased the potential difference across the diode until a current flowed. I measured the current flowing for different values of the potential difference.
> I recorded the following data.

V/V	0.60	0.64	0.68	0.72	0.76	0.80
I/mA	2	4	10	18	35	120

Draw a circuit diagram used by the student.
How did the student vary and measure the potential difference? (15)

Draw a graph to show how the current varies with the potential difference.
Estimate from your graph the junction voltage of the diode. (12)

The student then put the diode in reverse bias and repeated the experiment.
What changes did the student make to the initial circuit?
Draw a sketch of the graph obtained for the diode in reverse bias. (13)

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) State Archimedes' principle. (7)

(b) Why is a filament light bulb **not** an efficient source of light? (7)

(c) Why does the temperature of an athlete reduce when she perspires? (7)

(d) How is infra-red radiation detected? (7)

(e) The refractive index of a liquid is 1.35, what is the critical angle of the liquid? (7)

(f) Calculate the energy stored in a 5 μF capacitor when a potential difference of 20 V is applied to it. (7)

(g) Why does a magnet that is free to rotate point towards the North? (7)

(h) State the principle on which the definition of the ampere is based. (7)

(i) How are electrons accelerated in a cathode ray tube? (7)

(j) A kaon consists of a strange quark and an up anti-quark.
What type of hadron is a kaon? (7)

or

Draw the basic structure of a bi-polar transistor. (7)

6. State Hooke's law. (6)

A stretched spring obeys Hooke's law. When a small sphere of mass 300 g is attached to a spring of length 200 mm, its length increases to 285 mm.
Calculate its spring constant. (9)

The sphere is pulled down until the length of the spring is 310 mm.
The sphere is then released and oscillates about a fixed point.

Derive the relationship between the acceleration of the sphere and its displacement from the fixed point.
Why does the sphere oscillate with simple harmonic motion? (18)

Calculate:

(i) the period of oscillation of the sphere

(ii) the maximum acceleration of the sphere

(iii) the length of the spring when the acceleration of the sphere is zero. (23)

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

7. What is the Doppler effect?
Explain, with the aid of labelled diagrams, how this phenomenon occurs. (18)

The emission line spectrum of a star was analysed using the Doppler effect.
Describe how an emission line spectrum is produced. (12)

The red line emitted by a hydrogen discharge tube in the laboratory has a wavelength of 656 nm. The same red line in the hydrogen spectrum of a moving star has a wavelength of 720 nm.
Is the star approaching the earth? Justify your answer. (8)

Calculate:

(i) the frequency of the red line in the star's spectrum

(ii) the speed of the moving star. (18)

(speed of light = 3.00×10^8 m s^{-1})

8. Define electric field strength and give its unit of measurement. (9)

Describe how an electric field pattern may be demonstrated in the laboratory. (12)

The dome of a Van de Graff generator is charged. The dome has a diameter of 30 cm and its charge is 4 C. A 5 μC point charge is placed 7 cm from the surface of the dome.

Calculate:

(i) the electric field strength at a point 7 cm from the dome

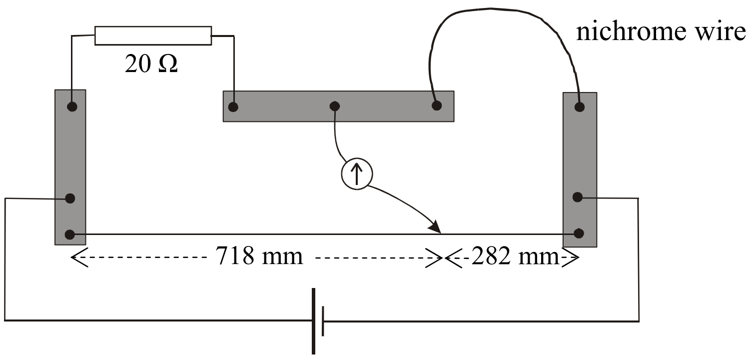
(ii) the electrostatic force exerted on the 5 μC point charge. (15)

All the charge resides on the surface of a Van de Graff generator's dome. Explain why.
Describe an experiment to demonstrate that total charge resides on the outside of a conductor.
Give an application of this effect. (20)

(permittivity of free space = 8.9×10^{-12} F m^{-1})

9. Define (i) resistance, (ii) resistivity. (12)

A metre bridge was used to measure the resistance of a sample of nichrome wire.
The diagram indicates the readings taken when the metre bridge was balanced.
The nichrome wire has a length of 220 mm and a radius of 0.11 mm.



Calculate:

(i) the resistance of the nichrome wire

(ii) the resistivity of nichrome. (18)

Sketch a graph to show the relationship between the temperature and the resistance of the nichrome wire as its temperature is increased. (6)

What happens to the resistance of the wire:

(i) as its temperature falls below 0°C?

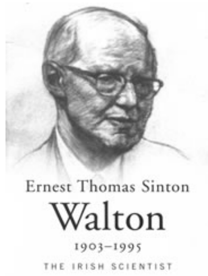
(ii) as its length is increased?

(iii) if its diameter is increased? (11)

Name another device, apart from a metre bridge, that can be used to measure resistance.
Give one advantage and one disadvantage of using this device instead of a metre bridge. (9)

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

(a) Read the following passage and answer the accompanying questions.



Ernest Walton was one of the legendary pioneers who made 1932 the *annus mirabilis* of experimental nuclear physics. In that year James Chadwick discovered the neutron; Carl Anderson discovered the positron; Fermi articulated his theory of radioactive decay; and Ernest Walton and John Cockcroft split the nucleus by artificial means. In their pioneering experiment Cockcroft and Walton bombarded lithium nuclei with high-energy protons linearly accelerated across a high potential difference (*c.* 700 kV). The subsequent disintegration of each lithium nucleus yielded two helium nuclei and energy. Their work gained them the Nobel Prize in 1951.

(Adapted from "Ernest Thomas Sinton Walton 1903 –1995 The Irish Scientist" McBrierty; 2003)

(i) Draw a labelled diagram to show how Cockcroft and Walton accelerated the protons. (6)

What is the velocity of a proton when it is accelerated from rest through a potential difference of 700 kV? (12)

Write a nuclear equation to represent the disintegration of a lithium nucleus when bombarded with a proton. (9)

Calculate the energy released in this disintegration. (12)

(ii) Compare the properties of an electron with that of a positron. (5)

What happens when an electron meets a positron? (3)

(iii) In beta decay it appeared that momentum was not conserved.

How did Fermi's theory of radioactive decay resolve this? (9)

(charge on electron = 1.6022×10^{-19} C; mass of proton = 1.6726×10^{-27} kg;
mass of lithium nucleus = 1.1646×10^{-26} kg; mass of helium nucleus = 6.6443×10^{-27} kg;
speed of light = 2.9979×10^{8} m s^{-1})

(b) State the principle of conservation of energy.

What is the main energy conversion that takes place in an electric motor? (12)

What is the function of (i) the commutator, (ii) the carbon brushes, (iii) the magnet, in an electric motor? (15)

Why does the motor turn when current flows through the coil? (9)

The induction motor was invented by Nicholas Tesla.

Give an advantage of an induction motor over a dc motor. (5)

Describe an experiment to demonstrate the principle on which the induction motor operates. (15)

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

At present, nuclear fission reactors supply a sixth of the world's electricity. Along with hydroelectric stations they are the major source of 'carbon-free' energy today. Nuclear reactors have shown remarkable reliability and efficiency even though the development of nuclear technology was held back by the nuclear accidents at Chernobyl and Three Mile Island.
A nuclear revival is possible. The global reserves of uranium could support a much larger number of reactors than exist today. Nuclear power generation could increase from three hundred gigawatts today to one thousand gigawatts by the year 2050, saving the earth from 1.5 billion tonnes of carbon emissions a year. Already more than twenty gigawatts of nuclear capacity have come online since 2000. Nuclear power would significantly contribute to the stabilisation of greenhouse gas emissions.

The type of reactor that will continue to dominate for the next two decades is the light water reactor, which uses ordinary water (as opposed to heavy water, containing deuterium) as the coolant and moderator.

Solar cells, wind turbines and biofuels are becoming viable energy sources. Solar cells use semiconductor materials, such as silicon, to convert sunlight into electricity, but at the moment they provide only 0.15% of the world's energy needs. Yet sunlight could be harnessed to supply 5000 times as much energy as the world currently consumes.

(Adapted from "Scientific American; Energy's Future beyond Carbon"; September 2006)

(a) What is nuclear fission? (7)

(b) How much energy is generated worldwide every minute by nuclear power today? (7)

(c) At present, why is a fission reactor a more viable source of energy than a fusion reactor? (7)

(d) Deuterium is an isotope of hydrogen, what is an isotope? (7)

(e) What is the function of a moderator in a fission reactor? (7)

(f) Why is silicon a semiconductor? (7)

(g) A large number of solar cells are joined together in series and cover an area of 20 m^2. The efficiency of the solar cells is 20%. If the solar constant is 1400 W m^{-2}, what is the maximum power generated by the solar cells? (7)

(h) What is the source of the sun's energy? (7)

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

(a) What is friction? (6)

A car of mass 750 kg is travelling east on a level road. Its engine exerts a constant force of 2.0 kN causing the car to accelerate at 1.2 m s^{-2} until it reaches a speed of 25 m s^{-1}.

Calculate (i) the net force, (ii) the force of friction, acting on the car. (12)

If the engine is then turned off, calculate how far the car will travel before coming to rest. (10)

(b) Define sound intensity. (6)

A loudspeaker has a power rating of 25 mW. What is the sound intensity at a distance of 3 m from the loudspeaker? (9)

The loudspeaker is replaced by a speaker with a power rating of 50 mW.
What is the change:
(i) in the sound intensity?
(ii) in the sound intensity level? (9)

The human ear is more sensitive to certain frequencies of sound.
How is this taken into account when measuring sound intensity levels? (4)

(c) State Faraday's law of electromagnetic induction. (6)

Describe an experiment to demonstrate Faraday's law. (12)

A resistor is connected in series with an ammeter and an ac power supply. A current flows in the circuit. The resistor is then replaced with a coil. The resistance of the circuit does not change.
What is the effect on the current flowing in the circuit? Justify your answer. (10)

(*d*) Explain the term half-life. (6)

A sample of carbon is mainly carbon-12 which is not radioactive, and a small proportion of carbon-14 which is radioactive. When a tree is cut down the carbon-14 present in the wood at that time decays by beta emission.
Write a nuclear equation to represent the decay of carbon-14. (9)

An ancient wooden cup from an archaeological site has an activity of 2.1 Bq.
The corresponding activity for newly cut wood is 8.4 Bq.
If the half-life of carbon-14 is 5730 years, estimate the age of the cup. (6)

Name an instrument used to measure the activity of a sample.
What is the principle of operation of this instrument? (7)

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