Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2005

PHYSICS – HIGHER LEVEL

MONDAY, 20 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. In an experiment to verify the principle of conservation of momentum, a body A was set in motion with a constant velocity. It was then allowed to collide with a second body B, which was initially at rest and the bodies moved off together at constant velocity.
The following data was recorded.

Mass of body A = 520.1 g		
Mass of body B = 490.0 g		
Distance travelled by A for 0.2 s before the collision	=	10.1 cm
Distance travelled by A and B together for 0.2 s after the collision	=	5.1 cm

Draw a diagram of the apparatus used in the experiment. (9)

Describe how the time interval of 0.2 s was measured. (6)

Using the data,
- calculate the velocity of the body A (i) before, (ii) after, the collision;
- show how the experiment verifies the principle of conservation of momentum. (18)

How were the effects of friction and gravity minimised in the experiment? (7)

2. In an experiment to measure the specific latent heat of vaporisation of water, cool water was placed in an insulated copper calorimeter. Dry steam was added to the calorimeter. The following data was recorded.

Mass of calorimeter	=	50.5 g
Mass of calorimeter + water	=	91.2 g
Initial temperature of water	=	10 ^{o}C
Temperature of steam	=	100 ^{o}C
Mass of calorimeter + water + steam	=	92.3 g
Final temperature of water	=	25 ^{o}C

Calculate a value for the specific latent heat of vaporisation of water. The specific heat capacity of copper is 390 J kg^{-1} K^{-1} and the specific heat capacity of water is 4200 J kg^{-1} K^{-1}. (24)

Why was dry steam used? How was the steam dried? (10)

A thermometer with a low heat capacity was used to ensure accuracy. Explain why. (6)

3. In an experiment to verify Snell's law, a student measured the angle of incidence i and the angle of refraction r for a ray of light entering a substance. This was repeated for different values of the angle of incidence. The following data was recorded.

i/degrees	20	30	40	50	60	70
r/degrees	14	19	26	30	36	40

Describe, with the aid of a diagram, how the student obtained the angle of refraction. (9)

Draw a suitable graph on graph paper and explain how your graph verifies Snell's law. (18)

From your graph, calculate the refractive index of the substance. (9)

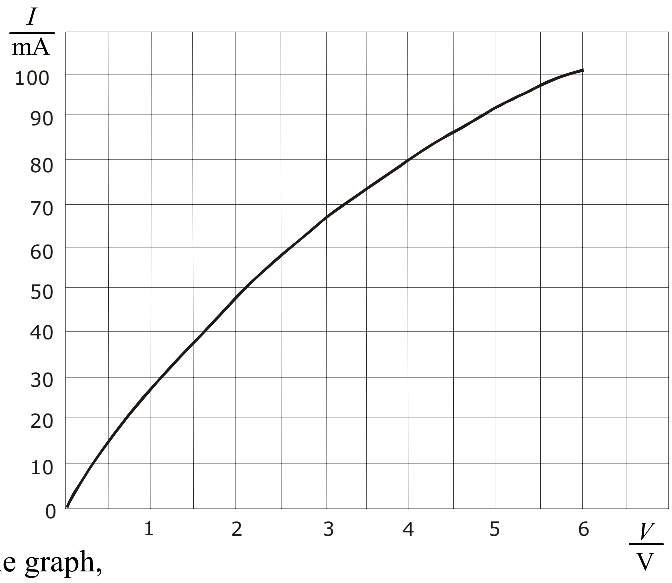
The smallest angle of incidence chosen was 20°. Why would smaller values lead to a less accurate result? (4)

4. A student investigated the variation of the current I flowing through a filament bulb for a range of different values of potential difference V.

Draw a suitable circuit diagram used by the student.

Describe how the student varied the potential difference. (16)

The student drew a graph, as shown, using data recorded in the experiment.



With reference to the graph,

(i) explain why the current is not proportional to the potential difference;

(ii) calculate the change in resistance of the filament bulb as the potential difference increases from 1 V to 5 V. (18)

Give a reason why the resistance of the filament bulb changes. (6)

SECTION B (280 marks)

Answer **five** questions from this section.
Each question carries 56 marks.

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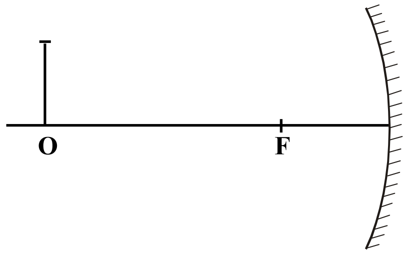
5. Answer any **eight** of the following parts *(a), (b), (c),* etc.

(a) A container contains 5.0 kg of water. If the area of the base of the container is 0.5 m^2 calculate the pressure at the base of the container due to the water.
(acceleration due to gravity = 9.8 m s^{-2}) (7)

(b) State Boyle's law. (7)

(c) What is the thermometric property of a thermocouple? (7)

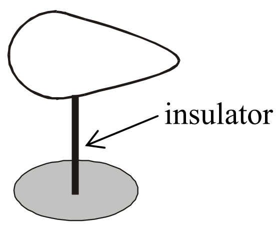
(d) An object O is placed 30 cm in front of a concave mirror of focal length 10 cm.
How far from the mirror is the image formed? (7)



(e) A capacitor of capacitance 100 μF is charged to a potential difference of 20 V. What is the energy stored in the capacitor? (7)

(f) Draw a sketch of the magnetic field due to a long straight current-carrying conductor. (7)

(g) A pear-shaped conductor is placed on an insulated stand is shown. Copy the diagram and show how the charge is distributed over the conductor when it is positively charged. (7)



(h) Explain why high voltages are used in the transmission of electrical energy. (7)

(i) How are electrons produced in an X-ray tube? (7)

(j) Name the fundamental force of nature that holds the nucleus together.

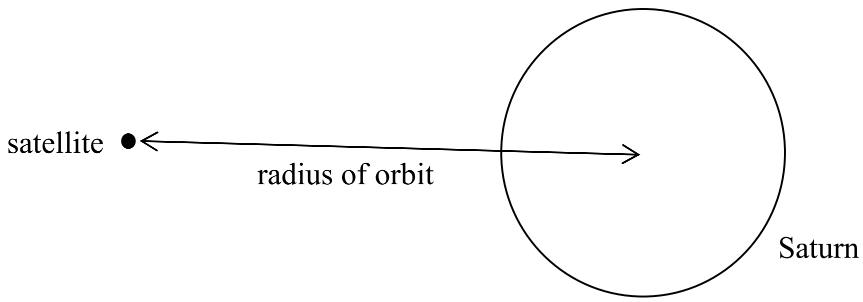
or

Draw the truth table for an AND gate. (7)

6. Define (i) angular velocity, (ii) centripetal force.

State Newton's Universal Law of Gravitation (18)

A satellite is in a circular orbit around the planet Saturn. Derive the relationship between the period of the satellite, the mass of Saturn and the radius of the orbit. (15)



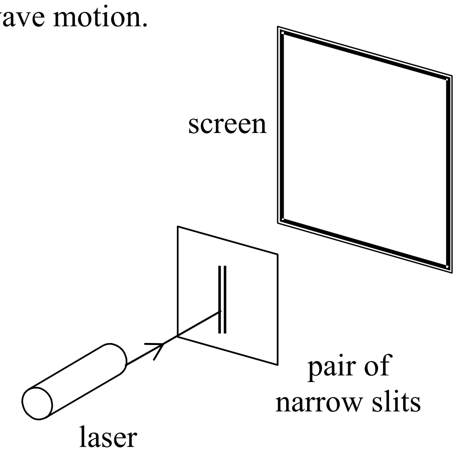
The period of the satellite is 380 hours. Calculate the radius of the satellite's orbit around Saturn. (9)

The satellite transmits radio signals to earth. At a particular time the satellite is 1.2×10^{12} m from earth. How long does it take the signal to travel to earth? (9)

It is noticed that the frequency of the received radio signal changes as the satellite orbits Saturn. Explain why. (5)

(universal gravitational constant = 6.7×10^{-11} N m^2 kg^{-2} mass of Saturn = 5.7×10^{26} kg;
speed of light = 3.0×10^{8} m s^{-1})

7. A student used a laser, as shown, to demonstrate that light is a wave motion.



(i) Name the two phenomena that occur when the light passes through the pair of narrow slits. (6)

(ii) A pattern is formed on the screen. Explain how the pattern is formed. (12)

(iii) What is the effect on the pattern when
(a) the wavelength of the light is increased.
(b) the distance between the slits is increased. (8)

Describe an experiment to demonstrate that sound is also a wave motion. (12)

Sound travels as longitudinal waves while light travels as transverse waves. Explain the difference between longitudinal and transverse waves. (9)

Describe an experiment to demonstrate that light waves are transverse waves. (9)

8. Nuclear disintegrations occur in radioactivity and in fission.

Distinguish between radioactivity and fission. (12)

Give an application of (i) radioactivity, (ii) fission. (6)

Radioactivity causes ionisation in materials. What is ionisation?

Describe an experiment to demonstrate the ionising effect of radioactivity. (15)

Cobalt–60 is a radioactive isotope with a half-life of 5.26 years and emits beta particles.

(i) Write an equation to represent the decay of cobalt–60.

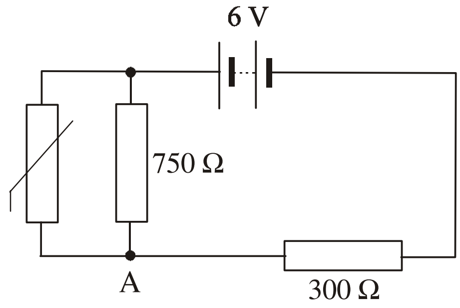
(ii) Calculate the decay constant of cobalt–60.

(iii) Calculate the rate of decay of a sample of cobalt–60 when it has 2.5×10^{21} atoms. (23)

(Refer to Mathematics Tables, p. 44.)

9. Define (i) potential difference, (ii) resistance. (12)

Two resistors, of resistance R_1 and R_2 respectively, are connected in parallel. Derive an expression for the effective resistance of the two resistors in terms of R_1 and R_2. (12)



In the circuit diagram, the resistance of the thermistor at room temperature is 500 Ω.
At room temperature, calculate
(i) the total resistance of the circuit;
(ii) the current flowing through the 750 Ω resistor. (18)

As the temperature of the room increases, explain why
(iii) the resistance of the thermistor decreases;
(iv) the potential at A increases. (14)

10. Define electric field strength.
State Coulomb's law of force between electric charges. (12)

Why is Coulomb's law an example of an inverse square law? (6)

Give two differences between the gravitational force and the electrostatic force between two electrons. (6)

Describe an experiment to show an electric field pattern. (12)

Calculate the electric field strength at the point B, which is 10 mm from an electron.
What is the direction of the electric field strength at B?

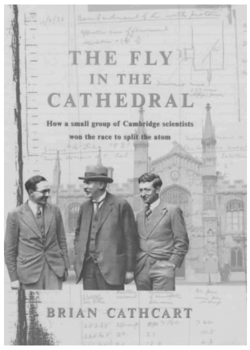
A charge of 5 μC is placed at B. Calculate the electrostatic force exerted on this charge. (20)

(permittivity of free space = 8.9×10^{-12} F m^{-1}; charge on the electron = 1.6×10^{-19} C)

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

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

Ernest Rutherford made the following point:



If the particles that come out naturally from radium are no longer adequate for my purposes in the laboratory, then maybe the time had come to look at ways of producing streams of fast particles artificially. High voltages should be employed for the task. A machine producing millions of alpha particles or protons would be required. These projectiles would be released close to a high voltage and would reel away at high speed. It would be an artificial particle accelerator. Potentially such apparatus might allow physicists to break up all atomic nuclei at will.

(Adapted from "The Fly in the Cathedral" Brian Cathcart; 2004)

(i) What is the structure of an alpha particle? (7)

(ii) Rutherford had bombarded gold foil with alpha particles. What conclusion did he form about the structure of the atom? (7)

(iii) High voltages can be used to accelerate alpha particles and protons but not neutrons. Explain why. (7)

(iv) Cockcroft and Walton, under the guidance of Rutherford, used a linear particle accelerator to artificially split a lithium nucleus by bombarding it with high-speed protons. Copy and complete the following nuclear equation for this reaction. (7)

$$^{7}_{3}\text{Li} \; + \; ^{1}_{1}\text{H} \; \longrightarrow$$

(v) Circular particle accelerators were later developed. Give an advantage of circular accelerators over linear accelerators. (7)

(vi) In an accelerator, two high-speed protons collide and a series of new particles are produced, in addition to the two original protons. Explain why new particles are produced. (7)

(vii) A huge collection of new particles was produced using circular accelerators. The quark model was proposed to put order on the new particles. List the six flavours of quark. (7)

(viii) Give the quark composition of the proton. (7)

(Refer to Mathematics Tables, p. 44.)

11. *(b)* Read the following passage and answer the accompanying questions.

The scientist whose research would unite electricity and magnetism was Michael Faraday. He developed the first electric motor in 1821, showing that a current-carrying conductor could be made to revolve around a magnet. He went on to expand on Oersted's observation that an electric current produces a magnetic effect. Perhaps, Faraday thought, the opposite was also true: a moving magnetic field could generate an electric current. This was to be called electromagnetic induction. Soon he had created the first electric generator, and everyday life would never be the same again. His experiments with induced currents produced the transformer.

(Adapted from Milestones of Science; Curt Supple; 2000)

(i) List three factors that affect the force on a current-carrying conductor placed near a magnet. (7)

(ii) What energy transformation takes place in an electric motor? (7)

(iii) What is the function of a commutator in a dc motor? (7)

(iv) Draw a sketch of the output voltage from an ac generator. (7)

(v) How are the slip rings connected to an external circuit in an ac generator? (7)

(vi) A transformer and an induction coil can both be used to change a small voltage into a larger voltage. What is the basic difference in the operation of these two devices? (7)

(vii) Name the Irish physicist who invented the induction coil. (7)

(viii) Give two factors that affect the efficiency of a transformer. (7)

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

(a) State the principle of conservation of energy. (6)

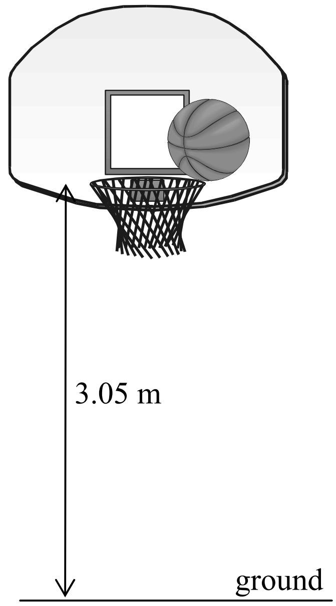
A basketball of mass 600 g which was resting on a hoop falls to the ground 3.05 m below.

What is the maximum kinetic energy of the ball as it falls? (9)

On bouncing from the ground the ball loses 6 joules of energy. What happens to the energy lost by the ball? (4)

Calculate the height of the first bounce of the ball. (9)

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



(b) Define magnetic flux. (6)

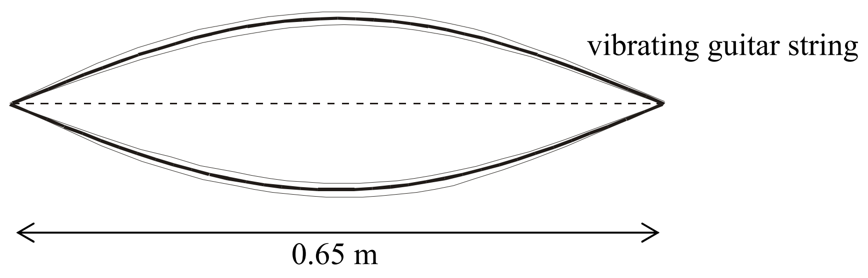
State Faraday's law of electromagnetic induction. (6)

A square coil of side 5 cm lies perpendicular to a magnetic field of flux density 4.0 T. The coil consists of 200 turns of wire.

(i) What is the magnetic flux cutting the coil? (9)

(ii) The coil is rotated through an angle of 90^{o} in 0.2 seconds. Calculate the magnitude of the average e.m.f. induced in the coil while it is being rotated. (7)

(c) The frequency of a stretched string depends on its length.
Give two other factors that affect the frequency of a stretched string. (6)



The diagram shows a guitar string stretched between supports 0.65 m apart. The string is vibrating at its first harmonic. The speed of sound in the string is 500 m s^{-1}. What is the frequency of vibration of the string? (9)

Draw a diagram of the string when it vibrates at its second harmonic. (7)

What is the frequency of the second harmonic? (6)

(d) One hundred years ago, Albert Einstein explained the photoelectric effect.

What is the photoelectric effect? (6)

Write down an expression for Einstein's photoelectric law. (9)

Summarise Einstein's explanation of the photoelectric effect (9)

Give one application of the photoelectric effect. (4)

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