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Pre-Leaving Certificate Examination
Triailscrúdú na hArdteistiméireachta

PRE-LEAVING CERTIFICATE EXAMINATION, 2011

PHYSICS — HIGHER LEVEL

TIME: 3 HOURS

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

SECTION A (120 marks)

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

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1. In an experiment to verify the principle of the conservation of momentum a student wrote "I measured the mass m_1 of trolley 1 and the mass m_2 of trolley 2. I measured the distance s_1 travelled by trolley 1 for 0.2 seconds before it collided with trolley 2. The trolleys stuck together as a result of the collision. I then measured the distance s_2 travelled by the combination for 0.2 seconds immediately after the collision."

The student recorded the following data:

Attempt	m_1 / g	m_2 / g	s_1 / cm	s_2 / cm
First	250	250	15	7.6
Second	500	250	16	10.7
third	500	500	19.5	9.8

Draw and label a diagram of the experimental arrangement. (6)

How might the student ensure the trolleys join together as a result of the collision? (3)

Using the data above, show how the conservation of momentum was verified. (18)

The distances measured correspond to a time interval of 0.2 seconds.
How might this time interval be measured. (7)

Give two precautions that the student might take to improve the accuracy of the experiment. (6)

2. In an experiment to measure the specific heat capacity of a liquid, a quantity of the liquid was heated electrically in a copper calorimeter. The energy supplied was measured with a joulemeter. The following measurements were obtained.

Mass of calorimeter	=	28 g
Mass of calorimeter and liquid	=	75.5 g
Initial temperature of liquid and calorimeter	=	15°C
Final temperature of liquid and calorimeter	=	20°C
Electrical energy supplied	=	600 J

Using these measurements calculate the specific heat capacity of the liquid given that the specific heat capacity of copper is 390 J kg^{-1} K^{-1}. (18)

Draw and label a diagram of the experimental arrangement. (9)

If a joulemeter was not available how would the electrical energy supplied be measured. (6)

Explain why the rise in temperature is the least accurate quantity measured in the experiment and state how the accuracy of this measurement could be improved. (7)

3. In a laboratory experiment to measure the speed of sound in air, a student sounded a tuning fork of known frequency above the open end of a hollow glass tube. The tube was submerged in a tall graduated cylinder of water. The tube was adjusted in the water until resonance was found. The length of the tube above the water level was measured and recorded. The procedure was repeated with several tuning forks. The internal diameter of the tube was measured as 2 cm. The following data were obtained.

Frequency / Hz	256	288	320	341	384	480	512
Length of tube / cm	33	28.5	25.5	24	21.5	17	15.5

Draw and label a diagram of the experimental arrangement. (6)

How did the student detect resonance in this experiment? (3)

How did the student ensure that the resonance detected was the first position of resonance? (3)

By drawing a suitable graph on graph paper show how the relationship between frequency and wavelength could be illustrated. What is this relationship?

By using the graph calculate a value for the speed of sound in air. (21)

The student decided to repeat the experiment with a set of tuning forks of much higher frequencies than those listed in the table above. Explain why this would result in a less accurate value for the speed of sound in air. (7)

4. Joule's law was verified experimentally by passing an electric current through a heating coil in a plastic calorimeter containing water. The rise in temperature $\triangle\theta$ was measured for a series of values of the current *I*. The time for which the current flowed in each case was 3 minutes.

The following data were collected:

I / A	1.0	1.5	2.0	2.5	3.0	3.5
$\triangle\theta$ / ^{o}C	3.2	7.2	12.8	20	28.8	39.2

Draw and label a diagram of the experimental arrangement. (9)

Use the above data to draw a suitable graph on graph paper and show how this graph verifies Joule's law. (12)

The resistance of the heating coil was 8 Ω. The specific heat capacity of the water was 4180 J kg^{-1} K^{-1}. Assuming that all the electrical energy supplied was absorbed by the water, use the graph to calculate the mass of water in the calorimeter. (12)

The largest value for a rise in temperature in the above table is 39.2^{o}C.
What problem would arise with a value of temperature rise greater than this value? (7)

SECTION B (280 marks)

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

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

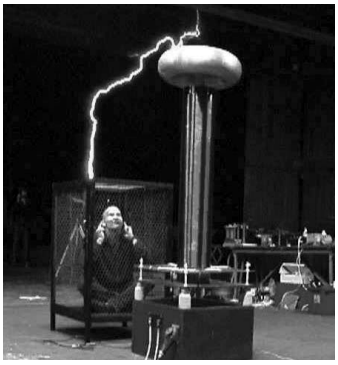
(*a*) The earth spins about an axis through the geographical poles once every day. Using this information calculate the angular speed of this spin. (7)

(*b*) State Boyle's law for gases. (7)

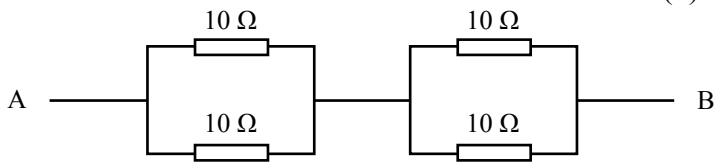
(*c*) State two factors on which the natural frequency of a stretched string depend. (7)

(*d*) Name two uses for a convex mirror. (7)

(*e*) Michael Faraday once shocked a live audience by standing inside a metal cage which was charged to a very high voltage. He was unharmed.
What principle of physics was illustrated by this. (7)



(*f*) Calculate the total resistance between points A and B in the circuit illustrated by the diagram below. (7)



(*g*) Name two thermometric properties. (7)

(*h*) Calculate the force on an electron travelling at 2×10^{7} m s^{-1} in a magnetic field of magnetic flux density 4 T. (charge on electron = 1.6×10^{-19} C) (7)

(*i*) Beta particles are more penetrating than alpha particles. Explain in terms of ionisation why this is so. (7)

(*j*) Name the Irish scientist who shared the Nobel prize with J. D. Cockcroft in 1951.
or
Name the Irish scientist who invented an induction coil in the 19th century. (7)

6. State Newton's three laws of motion. (9)

Explain clearly the difference between weight and mass and calculate the weight of a mass of 350 grams. (9)

A person of mass 72 kg stands on the floor of an elevator. Calculate the force the floor of the elevator exerts on the person when

(i) the elevator is ascending with a uniform speed.

(ii) the elevator is descending with an acceleration of 2.5 ms^{-2}. (18)

If the support cable snaps the elevator would be in free fall.
Show mathematically why the person would experience weightlessness. (9)

The astronauts on board the International Space station experience weightlessness even though the value of the acceleration due to gravity at that altitude is approximately 8.7 ms^{-2}. Explain how this is so and comment on how the prolonged experience of weightlessness can cause problems for astronauts. (11)

($g = 9.8 m s^{-2}$)

7. State the laws of refraction. (6)

Draw a ray diagram to show the formation of a virtual image with a converging lens. (12)

The image formed in a converging lens of focal length 16 cm is twice the size of the object. Calculate the positions of the object for this to happen. (12)

Explain why a diverging lens can not be used as a magnifying glass. (5)

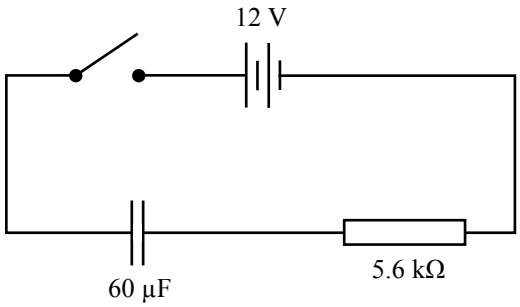
Draw and label a diagram of the human eye. Name two common defects of the human eye and state clearly the type of lens used to correct each defect. (21)

8. Define capacitance and potential difference. (6)

Name the three factors on which the capacitance of a parallel plate capacitor depends. Outline a demonstration experiment to verify one of the factors that you named. (14)

Give two uses of capacitors in electrical circuits. (6)

In the circuit diagram below a 5.6 kΩ resistor in connected in series with a 60 μF capacitor, a 12 V battery and a switch. After closing the switch the current flowing for an instant was 0.9 mA. When the capacitor was fully charged the current flowing was zero.



Calculate:

(i) the potential difference across the resistor for the instant that the current was 0.9 mA.

(ii) the potential difference across the capacitor for this same instant.

(iii) the charge on the capacitor for this same instant.

(iv) the charge on the capacitor when it is fully charged.

(v) the energy stored in the capacitor when it is fully charged. (30)

9. What is the photoelectric effect? (6)

Outline a demonstration experiment for the photoelectric effect. (9)

Name two uses of the photoelectric effect. (6)

Albert Einstein explained the photoelectric effect in the early part of the 20th century. Give an outline of this explanation. (9)

It is sometimes stated that the photoelectric effect is the reverse process of making X-rays. Explain why this statement would be made. (6)

Ultraviolet light of wavelength 260 nm is incident on a metal of work function 4.3 eV.

Calculate:

(i) the threshold frequency of the metal.

(ii) the maximum kinetic energy of an emitted electron.

(iii) the maximum speed of an emitted electron. (20)

(Planck's constant = 6.6×10^{-34} J s; speed of light = 3×10^{8} m s^{-1}; 1 eV = 1.6×10^{-19} J)
(Mass of electron = 9.1×10^{-31} *kg*)

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

(*a*) In nuclear reactions charge, momentum and mass-energy are conserved. Explain clearly the meaning of this statement. (12)

An example of α decay is given by $^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He + E$

Calculate:

(i) the energy released and state the nature of the energy.

(ii) the energy of both particles after the reaction. (24)

(mass of *U* = 238.050784 u; mass of Th = 234.043593 u; mass of He = 4.002603 u; 1u = 1.66×10^{-27} kg; speed of light = 3×10^{8} ms^{-1})

Name the four fundamental forces of nature and give two properties of each. (12)

Give the quark composition of the proton and the neutron. (8)

(*b*) Draw and label a simple diagram of the moving coil galvanometer. (12)

For the moving coil galvanometer:

(i) state the principle on which it is based.

(ii) how would you show that the scale is linear.

(iii) how would you increase the sensitivity. (18)

A galvanometer gives a full scale deflection for 5×10^{-4} A and has a resistance of 10 Ω.

(a) Calculate the value of the resistance needed to convert it to a voltmeter reading 5 V full scale.

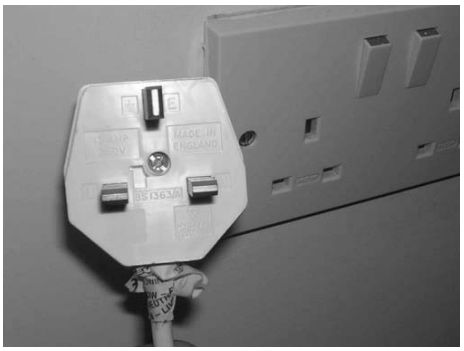
(b) Calculate the value of the resistance needed to convert it to an ammeter reading 5 A full scale. (20)

The scale of the analog ohmmeter decreases as you go from left to right. Explain why this is so. (6)

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

Electricity in the home as a source of energy for heating, lighting and powering electrical appliances is taken so much for granted that life seems almost unimaginable without it.

Used properly with appropriate cables, switches, sockets and plugs, it can be quite safe. However, physical contact with live wires can be disastrous. Nevertheless, there are some basic electrical tasks that everyone should be able to do:- wiring a plug and selecting a fuse.



(*a*) Name the three effects of an electric current. (7)

(*b*) What is the purpose of a fuse in an electrical circuit. (7)

(*c*) Why do only some domestic appliances have an earth connection. (7)

(*d*) What is the colour code for the wires in a three pin plug. (7)

(*e*) The voltage in Irish homes has a peak value of 325 V. What is the corresponding value of the root-mean-square voltage. (7)

(*f*) Calculate the resistance of an electrical cable of length 3 km, diameter 2 mm which has a resistivity of 1.6×10^{-6} Ω m. (7)

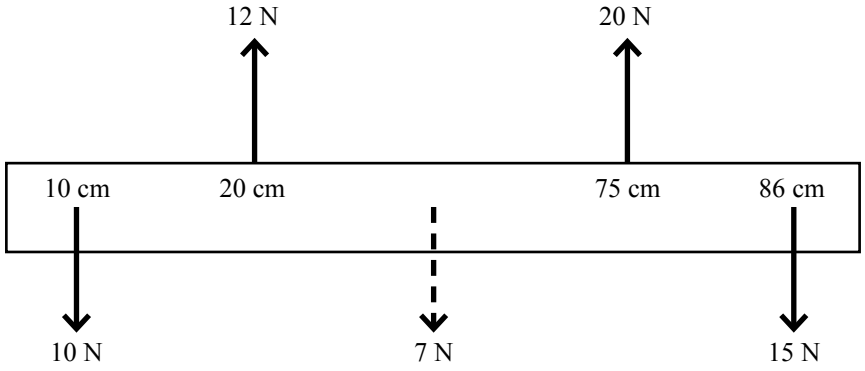
(*g*) If a 24 W bulb was inserted into a circuit where the voltage was 12 V, which of the following fuses would be most suitable; 1 A, 3 A; 5 A. Explain your choice. (7)

(*h*) During the 1970's consideration was given to building a nuclear power station for generating electricity in Ireland. Give two advantages that nuclear power stations have to offer. (7)

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

(*a*) State the two conditions needed for a body to be in equilibrium. (6)

The uniform metre stick below has a weight of 7 N. Is it in equilibrium? Prove you answer by using the relevant mathematics.



(18)

What is the purpose of a lever. (4)

(*b*) Define sound intensity. (6)

Explain the difference between the threshold of hearing and the range of frequencies audible to the human ear. (6)

Sound is emitted equally in all directions from a point source of 3 W. If no sound energy is absorbed or reflected calculate the sound intensity at a distance of 2.5 m from the source. (12)

If the sound intensity is increased by a factor of 4 what is the increase in the sound intensity level. (4)

(*c*) Name and state the two laws of electromagnetic induction. (12)

A copper pipe 1.5 m long is held vertically. A strong cylindrical shaped magnet is allowed to fall freely down the inside of the pipe. The time for the fall is greater than it would be if the pipe was made of plastic. Explain why this is so. (12)

Name an electrical device that is based on the principle of electromagnetic induction. (4)

(*d*) What is the meaning of half life for a radioactive substance. (6)

The decay constant for a radioactive substance is $1.9254 \times 10^{-4}\ s^{-1}$.
What percentage of the substance is still radioactive after 4 hours. (12)

Name a device for measuring levels of radioactivity. (3)

Name two sources of background radiation on the earth. (7)

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