Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE 2011

MARKING SCHEME

PHYSICS

HIGHER LEVEL

General Guidelines

In considering this marking scheme the following points should be noted:

1. In many instances only key words are given – words that must appear in the correct context in the candidate's answer in order to merit the assigned marks.

2. Words, expressions or statements separated by a solidus, /, are alternatives which are equally acceptable. Words which are separated by a solidus and which are underlined, must appear in the correct context by including the rest of the statement to merit the assigned mark.

3. Answers that are separated by a double solidus, //, are answers which are mutually exclusive. A partial answer from one side of the // may not be taken in conjunction with a partial answer from the other side.

4. The descriptions, methods and definitions in the scheme are not exhaustive and alternative valid answers are acceptable.

5. The detail required in any answer is determined by the context and manner in which the question is asked and also by the number of marks assigned to the answer in the examination paper. Therefore, in any instance, it may vary from year to year.

6. For omission of appropriate units, or incorrect units, one mark is deducted, where indicated.

7. Each time an arithmetical slip occurs in a calculation, one mark is deducted.

8. Any named apparatus within an answer must be consistent with the method described in the experiment or demonstration.

SECTION A (120 marks)

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

Question 1

A student carried out an experiment to verify the principle of conservation of momentum. The student adjusted the apparatus till a body A was moving at a constant velocity u. It was then allowed to collide with a second body B, which was initially at rest, and the two bodies moved off together with a common velocity v.

The following data were recorded:

mass of body A..... = 230 g
mass of body B ..... = 160 g
velocity u ..... = 0.53 m s^{-1}
velocity v ..... = 0.32 m s^{-1}

Draw a labelled diagram of the apparatus used in the experiment.

track/means of coalescing, two trolleys, labeled means of measuring time/velocity (e.g. motion sensor)
3 marks per component 3 × 3

What adjustments did the student make to the apparatus so that body A would move at constant velocity?

adjust gradient of track, lubricate trolley wheels, polish/brush track, clear holes (air track), etc. any *two* 2 × 3

How did the student know that body A was moving at constant velocity?

dots on the ticker tape were equally spaced / same time interval shown by both light gates / horizontal line on v vs. t graph (datalogging method) 6

Describe how the student measured the velocity v of the bodies after the collision.

Δt between dots = 0.02 s = $\frac{1}{50}$ s || measure length l of card || select number of points on (s vs. t) graph 3
measure distance for n intervals || read Δt from light gate || (use) slope (tool) 3
velocity = $\frac{\Delta s}{\Delta t}$ or in words || velocity = $\frac{\Delta l}{\Delta t}$ or in words || slope = ($\frac{\Delta s}{\Delta t}$) = velocity 3

Using the recorded data, show how the experiment verifies the principle of conservation of momentum.

momentum = mass × velocity / $\vec{p}=m\times\vec{v}$ / $p=m\times v$ 2
initial momt = (0.230)(0.53) / 0.1219 (kg m s^{-1}) 2
final momt = (0.390)(0.32) / 0.1248 (kg m s^{-1}) 2
principle verified since 0.1219 kg m s^{-1} ≈ 0.1248 kg m s^{-1} or equivalent 2
(–1 for omission of or incorrect unit)

How could the accuracy of the experiment be improved?

use digital balance / select more dots / select greater distance/displacement /avoid parallax error 2

Question 2

During an experiment to verify Boyle's law, the pressure of a fixed mass of gas was varied. A series of measurements of the pressure p and the corresponding volume V of the gas was recorded as shown. The temperature was kept constant.

p / kPa	325	300	275	250	200	175	150	125
V / cm^3	12.1	13.0	14.2	15.5	19.6	22.4	26.0	31.1

Draw a labelled diagram of the apparatus used in the experiment.

gas container, pressure gauge, scale for reading volume, means of adjusting p or V, e.g. pump/valve

(–1 if no label) 3 marks per component 4×3

How was the pressure of the gas varied during the experiment?

pump // rotate wheel/screw // move piston/plunger // adjust liquid level in reservoir tube //open valve 3

Describe how the pressure and the volume of the gas were measured.

(pressure) from the (Bourdon) gauge/pc screen : (volume) from the scale on the gas container/syringe 2×2

Why should there be a delay between adjusting the pressure of the gas and recording its value?

allow for gas to cool /to reach thermal equilibrium // allow oil (level) to settle 3

Draw a suitable graph to show the relationship between the pressure and the volume of a fixed mass of gas. Explain how your graph verifies Boyle's law.

label axes correctly on graph paper 3

plot six points correctly **(–1 per each incorrect point; –1 mark if inappropriate scale)** 3

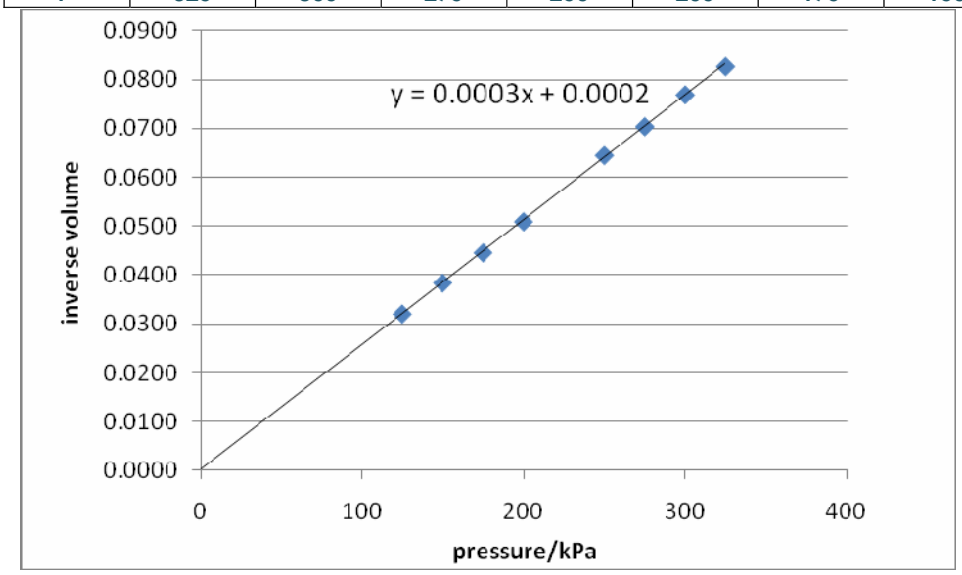
straight line 3

good distribution 3

straight line through the origin 3

$p \propto \frac{1}{V}$ // pV = constant 3

V / cm^3	12.1	13.0	14.2	15.5	19.6	22.4	26.0	31.1
1 / V	**0.0826**	**0.0769**	**0.0704**	**0.0645**	**0.0510**	**0.0446**	**0.0385**	**0.0322**
P	**325**	**300**	**275**	**250**	**200**	**175**	**150**	**125**



Question 3

In an experiment to measure the wavelength of a monochromatic light source, a narrow beam of light was incident normally on a diffraction grating having 400 lines per mm. A number of bright images were observed. The angles θ between the central bright image and the first two images to the left and right of it were measured and recorded in a table, as shown.

	2nd image to left of central image	1st image to left of central image	1st image to right of central image	2nd image to right of central image
θ / °	30.98	14.90	14.81	31.01

Name a source of monochromatic light.
sodium (Na) lamp / laser 3

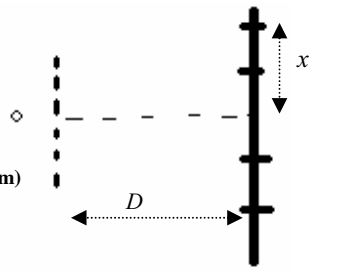
Describe, with the aid of a diagram, how the data were obtained.

diagram showing: monochromatic light source, spectrometer, grating (on turntable) **(–1 if no diagram)** 3

focus on n^{th} image on l.h.s read scale/angle 3

repeat for n^{th} image on r.h.s. 3

Alternative: diagram showing: light source, grating,(metre rule)
measure x for nth image and measure D
determine angle θ (using trigonometry/tan θ)
(–1 if no diagram)



Using the data, calculate the wavelength of the monochromatic light.

$$n\lambda = d\sin\theta$$ 3

$$d = \frac{1}{400}$$ 3

any λ value 3

λ_{ave}= 642.3nm 3

(–1 if all given data not used; –1 for omission of or incorrect unit)

What effect would each of the following changes have on the bright images formed:

(i) using a monochromatic light source of longer wavelength

larger θ / images more spaced out /any valid statement 6

(ii) using a diffraction grating having 200 lines per mm

smaller θ / images closer together /any valid statement 6

(iii) using a source of white light instead of monochromatic light?

each fringe/image is a spectrum (of white light) // each fringe/image has many colours 4

('A spectrum is formed/seen' … 4 marks)

Question 4

A student investigated the variation of the current I through an electrolyte as the potential difference V across the electrolyte was changed. The electrolyte used was a solution of copper sulfate. The electrodes used were made of copper.

The student recorded the following data:

V/V	0	1	2	3	4	5	6
I/mA	0	30	64	93	122	160	195

Draw a suitable circuit diagram for this investigation and label the components.

arrangement: power supply unit, label ammeter, label voltmeter, electrolyte, electrodes 3 × 3

(–3 marks per missing component)

How was the potential difference changed during the investigation?

adjusting (dial/selector on) variable p.s.u. // adjusting rheostat 3

Draw a suitable graph to show the relationship between the current and the potential difference in this investigation.

label axes correctly on graph paper 3

plot six points correctly **(–1 per each incorrect point; –1 mark if inappropriate scale)** 3

straight line 3

good distribution 3

Use your graph to calculate the resistance of the electrolyte.

method for slope 3

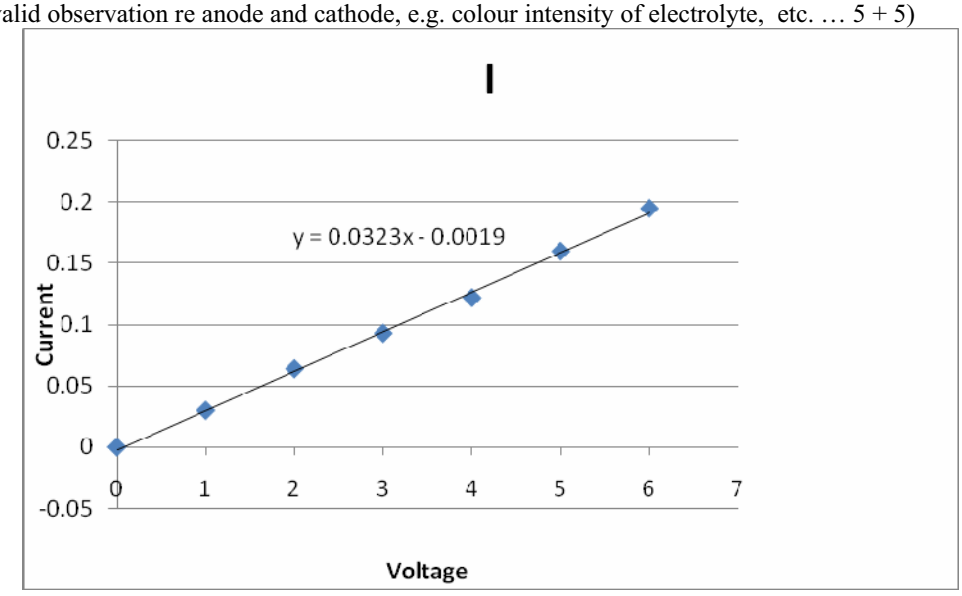
$R =$ 1/0.0323 / 30.96 / ≈ 31 Ω **(–1 for omission of or incorrect unit)** 3

What was observed at the electrodes as current flowed through the electrolyte?

cathode got heavier /coated with fresh copper 5

anode got lighter 5

(Any valid observation re anode and cathode, e.g. colour intensity of electrolyte, etc. … 5 + 5)



Section B (280 marks)

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

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

(***a***) **A car of mass 1500 kg is travelling at a constant velocity of 20 m s^{-1}. What force is required to stop it in a distance of 50 m?**

$v^2 = u^2 + 2as$ / $0 = 20^2 + 2(a)(50)$ / $a = 4\,\text{m s}^{-2}$ // $E_k = \frac{1}{2}mv^2$ / $\frac{1}{2}(1500)(20^2)$ 4

$F = ma$ / $F = (1500)(4)$ / $F = 6000\,\text{N}$ // $W = F \times s$ / $F = 6000\,\text{N}$ 3

(***b***) **Why does the value of *g*, acceleration due to gravity, vary at different locations on the surface on the earth?**

locations are at different distances from the earth's centre / earth is not perfectly spherical / etc. 7

(***c***) **Why is a convex mirror used, instead of a plane mirror, as a door mirror on a car?**

wider / greater field of view / any valid answer 7

(***d***) **What causes the Doppler effect?**

(relative) motion 4

between source (of waves) and observer 3

(definition of effect…… 7 marks)

(***e***) **The capacitance of a parallel plate air capacitor is 5 pF. If the plates of the capacitor are 2 cm apart, what is the common area of the plates? Take $\varepsilon_{air} = \varepsilon_0$.**

$C = \frac{\varepsilon A}{d}$ 4

$A = \frac{(5\times10^{-12})(2\times10^{-2})}{8.854\times10^{-12}}$ / $A = 0.0113\,\text{m}^2$ / $A = 113\,\text{cm}^2$ 3

(***f***) **A residual current device (RCD) as shown is rated 30 mA. Explain the significance of this rating.**

RCD / device trips 4

if more than 30 mA flows to earth / the current difference between *L* and *N* is greater than 30 mA 3

(***g***) **The physicist Robert Millikan is usually associated with what physical quantity?**

charge (on the electron) / $1.6 \times 10^{-19}\,\text{C}$ 7

(reference to 'oil drop'/ 'electron' experiment … 4 marks)

(***h***) **What property of light controls the current in a photocell?**

(light) intensity/ brightness / photoelectric effect / any valid answer 7

(***i***) **What is the role of neutrons in a nuclear reactor?**

to cause (nuclear) fission / to initiate reaction / any valid answer 7

(***j***) **Give the difference between the quark composition of a baryon and of a meson.**

baryon → 3 quarks meson → quark and antiquark 4+3

or

Give two ways of reducing energy loss in a transformer.

laminate the core, wire of lower resistance, reduce hysteresis, reduce magnetic flux leakage, etc. 4+3

Question 6

(*a*) Define the moment of a force.

($T =$) force × (perp) distance / $F \times d$ 6

When the toy is knocked over, it always returns to the upright position. Explain why this happens.
(toy non-vertical) c.g. has a (turning) moment about fulcrum / point of support/contact /
(c.g. has) zero turning moment when toy is in vertical position 6
(any valid reference, e.g. 'low c.g.', 'equilibrium', 'turning moment', … 3 marks)

(*b*) State the conditions necessary for the equilibrium of a body under a set of co-planar forces.

(vector/algebraic) sum of the forces = zero // forces up = forces down // $\Sigma F = 0$ 6+3

sum of the (turning) moments (about any point) = zero // CTM = ACTM // $\Sigma T = 0$

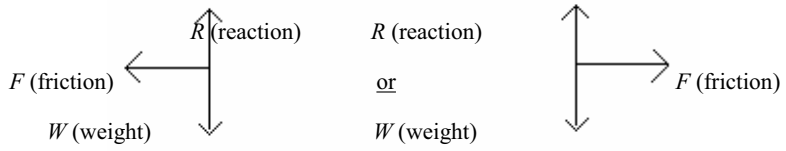
Three children position themselves on a uniform see-saw so that it is horizontal and in equilibrium. The fulcrum of the see-saw is at its centre of gravity. A child of mass 30 kg sits 1.8 m to the left of the fulcrum and another child of mass 40 kg sits 0.8 m to the right of the fulcrum. Where should the third child of mass 45 kg sit, in order to balance the see-saw?

$30g(1.8)$ / $40g(0.8)$ / $45g(x)$ 6

$30g(1.8) = 40g(0.8) + 45g(x)$ 3

$x =$ 0.488 m / 0.49 m / 49 cm **(–1 for omission of or incorrect unit)** 3

(*c*) A simple merry-go-round consists of a flat disc that is rotated horizontally. A child of mass 32 kg stands at the edge of the merry-go-round, 2.2 metres from its centre. The force of friction acting on the child is 50 N. Draw a diagram showing the forces acting on the child as the merry-go-round rotates.



(–1 per each unlabelled force; 3 marks per each correct force) 3×3

What is the maximum angular velocity of the merry-go-round so that the child will not fall from it, as it rotates?

$F = m\omega^2 r$ 3

$50 = (32)(\omega)^2(2.2)$ 3

$\omega = 0.842\ \text{rad s}^{-1}$ **(–1 for omission of or incorrect unit)** 3

If there was no force of friction between the child and the merry-go-round, in what direction would the child move as the merry-go-round starts to rotate?

child remains stationary / any appropriate answer, e.g. '*it depends on the frame of reference*' 5

Question 7

(*a*) When making a hot drink, steam at 100 °C is added to 160 g of milk at 20 °C. If the final temperature of the drink is to be 70 °C, what mass of steam should be added? You may ignore energy losses to surroundings.

$(mc\Delta\theta)_{\text{m}} = (ml)_{\text{steam}} + (mc\Delta\theta)_{\text{cond}}$ 2+2+2

$(0.160)(3.90\times10^{3})(50) = m_S(2.34\times10^{6}) + (m_S)(4.18\times10^{3})(30)$ 3

$m_S = \dfrac{31.2\times10^{3}}{2.4654\times10^{6}}$ / $12.655\times10^{-3}\,\text{kg}$ / $12.66\,\text{g}$ **(–1 for omission of or incorrect unit)** 3

A metal spoon, with an initial temperature of 20 °C, is then placed in the hot drink, causing the temperature of the hot drink to drop to 68 °C. What is the heat capacity of the spoon? You may ignore other possible heat transfers.

energy gained by spoon = energy lost by hot drink (state/imply) 3

$(C\Delta\theta)_{\text{spoon}} = (mc\Delta\theta)_{\text{hot drink}}$ (where $C=mc$) 3

$48C = (0.17266)(4.05\times10^{3})(2)$ / 1.3985×10^{3} 3

$C = 29.14\,\text{J K}^{-1}$ **(–1 for omission of or incorrect unit)** 3

(If c values for milk and water used instead of c for hot drink, answer obtained = 28.2 J K^{-1} ….. –1 mark)

(*b*) Name two processes by which a hot drink cools. How is the energy lost by each of these processes reduced for a hot drink supplied in a disposable cup?

conduction	radiation	convection	evaporation	(any two)	4+4
insulating material	bright (inside) surface/ insulating material / lid	lid/insulation	lid	(any two)	3+3

(*c*) A thermocouple is used to measure the temperature of the steam. How would you demonstrate the principle of operation of a thermocouple?

one junction (reference junction) kept cold / at constant temp 3

other junction heated 3

observation: e.g. emf /voltage developed // meter reading 3

Describe how to establish a calibration curve for a thermocouple.

one junction at constant temperature, other junction in water with (Hg) thermometer **(state/imply)** 3

heat water (in steps of 10 °C approx) and note temperature and emf values (each time) 3

plot graph of emf vs. temperature 3

($c_{\text{milk}} = 3.90\times10^{3}$ J kg^{-1} K^{-1}, $c_{\text{water}} = 4.18\times10^{3}$ J kg^{-1} K^{-1}, $c_{\text{hot drink}} = 4.05\times10^{3}$ J kg^{-1} K^{-1}

specific latent heat of vaporisation of water = 2.34×10^{6} J kg^{-1})

Question 8

(*a*) Destructive interference can occur when waves from <u>coherent sources</u> meet. Explain the underlined term.

same <u>frequency</u>/<u>wavelength</u> 3

in phase / constant phase difference 3

Give two other conditions necessary for total destructive interference to occur.

same amplitude 4

out of phase by: $\frac{1}{2}\lambda$ / $\frac{1}{2}cycle$ / 180° / π / when crest meets trough 4

The diagram shows a standing wave in a pipe closed at one end. The length of the pipe is 90 cm.

(i) Name the points on the wave labelled P and Q.

P: node Q: antinode 3+3

(ii) Calculate the frequency of the standing wave.

$1\frac{1}{4}\lambda = 0.90\,\text{m}$ // $\lambda = 0.720\,\text{m}$ (state/imply) 3

$v = f\lambda$ 3

$f = \frac{340}{0.720}$ / $f = 472.2$ Hz **(–1 for omission of or incorrect unit)** 3

(iii) What is the fundamental frequency of the pipe?

$\frac{\lambda}{4} = 0.90$ / $\lambda = 3.60\,\text{m}$ 3

$f_o = \frac{340}{3.60}$ / $f_o = 94.44\,\text{Hz}$ **(–1 for omission of or incorrect unit)** 3

The clarinet is a wind instrument based on a pipe that is closed at one end.
What type of harmonics is produced by a clarinet?

odd (multiples of the fundamental) 3

(*b*) An audio speaker at a concert emits sound uniformly in all directions at a rate of 100 W.
Calculate the sound intensity experienced by a listener at a distance of 8 m from the speaker.

$\text{SI} = \frac{\text{Power}}{\text{Area}}$ 3

$\text{SI} = \frac{100}{4\pi(8)^2}$ / $0.124\,\text{W m}^{-2}$ **(–1 for omission of or incorrect unit)** 3

The listener moves back from the speaker to protect her hearing. At what distance from the speaker is the sound intensity level reduced by 3 dB? (speed of sound in air = 340 m s^{-1})

SIL decreased by 3 dB → SI halved (state/imply) 3

$\text{SI} \propto \frac{1}{\text{R}^2}$ // $0.062 = \frac{100}{4\pi R^2}$ 3

$\frac{I_1}{I_2} = \frac{R_2^2}{R_1^2}$ // $2 = \frac{R_2^2}{64}$ // $R^2 = \frac{100}{4\pi(0.062)}$ / 128.35 3

$R_2 = 11.32\,\text{m}$ // $\text{R} = 11.33\,\text{m}$ **(–1 for omission of or incorrect unit)** 3

Question 9

(*a*) State Coulomb's law.

force proportional to product of charges // $F \propto \frac{q_1 q_2}{d^2}$ / $F = k\frac{q_1 q_2}{d^2}$ / $F = \frac{q_1 q_2}{4\pi\varepsilon d^2}$ 3

(force) inversely proportional to square of distance // correct notation 3

Two identical spherical conductors on insulated stands are placed a certain distance apart. One conductor is given a charge *Q* while the other conductor is given a charge *3Q* and they experience a force of repulsion *F*. The two conductors are then touched off each other and returned to their original positions. What is the new force, in terms of *F*, between the spherical conductors?

$F = \frac{Q(3Q)}{4\pi\varepsilon d^2}$ / $\frac{(3Q^2)}{4\pi\varepsilon d^2}$ // $F \propto (Q)(3Q)$ 6

$F' = \frac{2Q(2Q)}{4\pi\varepsilon d^2}$ / $\frac{4Q^2}{4\pi\varepsilon d^2}$ // $F' \propto (2Q)(2Q)$ 6

$F' = \frac{4}{4\pi\varepsilon d^2}\left(\frac{4\pi\varepsilon d^2 F}{3}\right)$ // $\frac{F'}{F} = \frac{4Q^2}{3Q^2}$ 3

$F' = \frac{4}{3}F$ // $F' = \frac{4}{3}F$ 3

(*b*) Draw a labelled diagram of an electroscope.

(metal) cap, labelled leaves, chassis/frame **(–1 if no label)** 3

Why should the frame of an electroscope be earthed?

p.d. between leaves and <u>chassis</u>/<u>frame</u> (determines degree of deflection of leaves) / for safety 3
(reference to 'zero volt' … 3 marks)

Describe how to charge an electroscope by induction.

hold (say) + charged rod near cap of (uncharged) GLE 3

earth cap (touch with finger) 3

remove finger and then remove + rod 3

(*c*) How does a full-body metal-foil suit protect an operator when working on high voltage power lines?

(suit) blocks out external electrical fields / no field lines inside (hollow conductor) 5

Describe an experiment to investigate the principle by which the operator is protected.

apparatus 3

procedure 3

observation 3

conclusion 3

Question 10

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

(*a*) List three quantities that are conserved in nuclear reactions.

momentum, charge, mass-energy, nucleons, etc. (any *three* valid answers) 2+2+2

Write an equation for a nucleus undergoing beta-decay.

$^{228}_{88}X \rightarrow {}^{228}_{89}Y + {}^{0}_{-1}e$ 3×3

In initial observations of beta-decay, not all three quantities appear to be conserved. What was the solution to this contradiction?

proposal/discovery of the neutrino/ υ 3

List the fundamental forces of nature in increasing order of their strength.

gravitational < weak (nuclear) < electromagnetic < (strong) nuclear 3×3

(3 marks for naming any two; 2×3 marks for naming the correct four; 3 marks for correct order)

Which fundamental force of nature is involved in beta-decay?

weak (nuclear) 3

In the Large Hadron Collider, two protons with the same energy and travelling in opposite directions collide. Two protons and two charged pi mesons are produced in the collision. Why are new particles produced in the collision?

energy is converted into mass / $E = mc^2$ 3

Write an equation to represent the collision.

$$p + p \rightarrow p + p + \pi^+ + \pi^-$$ 3×3

(3 marks for showing 2 *p* before and after; 3 marks for showing two pions ; 3 marks for correct format)

Show that the kinetic energy of each incident proton must be at least 140 MeV for the collision to occur.

mass of $\pi^+ = 273\, m_e \;/ = 273\left(9.109\times 10^{-31}\right)\text{kg}$ 3

$E = mc^2$ 3

$E = 2\left(2.4869\times 10^{-28}\right)\left(3\times 10^{8}\right)^2 \;/\; 44.76\times 10^{-12}\,\text{J}$ 3

$$\text{E} = \frac{44.76\times 10^{-12}}{1.602\times 10^{-19}} \;/\; \approx 279.94\times 10^{6}\ \text{eV} \;/\; \approx 280(\text{MeV})$$ 3

$\text{energy per proton} = 140(\text{MeV})$ 2

Question 10

(*b*) State the principle of operation of an electric motor.

a current-carrying conductor in a magnetic field // a current-carrying coil in a magnetic field 3

experiences a force // experiences a torque/turning moment 3

The diagram shows a simple d.c. motor. Name each of the parts labelled A and B on the diagram and state the function of each.

A – a split ring commutator 3
B – a brush 3

function:
A – to ensure that coil rotates in the same direction (continuously)
B – to allow current flow from battery into coil as it rotates **(both functions correct)** 3

What material is normally used in part B? Give two properties of this material that make it suitable for use in a motor.

carbon / graphite 3

lubricant, soft, conductor, etc. any *two* 2 + 1

List three factors that affect the torque (couple) acting on the coil.

magnetic flux density (*B*) , size of current (*I*), number of turns (*N*), area of coil (*A*) 3 × 1

If the motor jammed, a larger current than normal would flow through the motor. Explain why.

no back/opposing emf (induced) 6

What would be the effect on the motor if this happened?

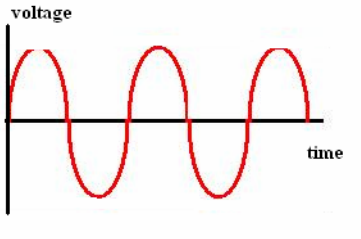
motor would burn out / overheat 6

What changes can be made to a d.c. motor to convert it to an a.c. generator?

(split ring commutator) replaced by slip rings 3

attach handle to rotate coil 3

Draw a sketch of the output voltage from an a.c. generator.



label any axis 3

correct shape of graph 6

(–3 if a.c. display is unclear)

Give two ways in which the output voltage from an a.c. generator can be increased.

rotate handle faster / more turns of wire / more powerful magnet (any t*wo*) 3+2

Question 11

Read the following passage and answer the accompanying questions.

The government has introduced regulations to phase out the use of incandescent filament lamps in the home. The Sustainable Energy Authority of Ireland promotes the use of compact fluorescent lamps (CFL) in place of less energy-efficient filament lamps…

(*a*) **A 60 W filament lamp provides 8 J of light energy every second, the same as a CFL with a power rating of 11 W. Compare the efficiencies of the two lamps.**

$E_{FL}\ (=\frac{8}{60}) = 0.133$ // F.L: $(\frac{8\times100}{60})$ / 13.33% (efficient) 4

$E_{CFL}\ (=\frac{8}{11}) = 0.727$ // CFL: $(\frac{8\times100}{11})$ / 72.73% (efficient) 3

$[[\frac{E_{CFL}}{E_{FL}} = \frac{0.727}{0.133}$ / 5.45 // $\frac{E_{FL}}{E_{CFL}} = \frac{0.133}{0.727}$ / 0.183 .....7 marks]]

(*b*) **Most of the energy emitted in a CFL is in the form of ultraviolet radiation. How is this changed to white light?**

UV (radiation) absorbed (by electrons) in the fluorescent coating (which) 4
emits visible (white) light / photons of lower energy 3

(*c*) **Calculate the energy of an ultraviolet photon emitted in a CFL.**

$E = hf$ // $E = \frac{hc}{\lambda}$ 4

$E = \frac{(6.63\times10^{-34})(3\times10^{8})}{254\times10^{-9}}$ / 7.83×10^{-19} J **(–1 for omission of or incorrect unit)** 3

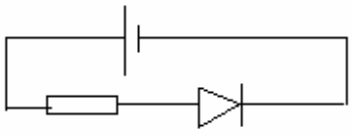
(*d*) **How does an electron in an atom of the fluorescent coating emit a photon?**
electron absorbs UV photon and jumps to higher energy level 4
(then) drops back (to lower level) emitting a photon 3

(*e*) **Why does the fluorescent coating in a CFL get warm during use?**

due to absorption // energy difference 4
(of) UV photons / energy // between incident and emitted photons 3

(*f*) **A light sensor attached to a datalogger indicates that the light emitted from a CFL used in the home is not continuous, but flickers at a frequency that is not detected by the eye. What is the cause of the flickering in the light?**
(house) power supply is alternating / a.c. (state/imply) 7

(*g*) **Draw a circuit diagram of a diode in forward bias.**



(correct diode symbol / structure … 3 marks) 7

(4 marks only if no suitable device, e.g. *R* or a bulb, shown in series with diode and p.s.u.)

(*h*) **How can LEDs be used to produce white light?**
mixture of leds (4)
red, green and blue leds 7
('coat LEDs with fluorescent/phosphorescent material' …. 7 marks)

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

(*a*) State Hooke's law.

(restoring) force proportional // $F \propto -s$ / $F = -ks$ 3

displacement / distance // correct notation for F and s 3

A body of mass 250 g vibrates on a horizontal surface and its motion is described by the equation $a = -16s$, where s is displacement of the body from its equilibrium position. The amplitude of each vibration is 5 cm. Why does the body vibrate with simple harmonic motion?

acceleration proportional to displacement / $a \propto (-)s$ 6

Calculate the frequency of vibration of the body?

$\omega^2 = 16$ / $\omega = 4$ 3

$f = \frac{\omega}{2\pi}$ 3

$f = 0.64\,\text{Hz} / \text{s}^{-1}$ **(–1 for omission of or incorrect unit)** 3

What is the magnitude of (i) the maximum force, (ii) the minimum force, which causes the body's motion?

$a_{max} =$ (–)16(0.05) / 0.80 // F_{max} occurs when acceleration / displacement is a maximum 3

$F_{max} =$ (0.250)(0.800) / 0.20 N **(–1 for omission of or incorrect unit)** 2

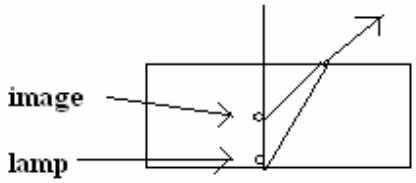
$F_{min} = 0$ 2

(*b*) State the laws of refraction of light.

incident ray, refracted ray and normal in same plane 3

$\frac{\sin \hat{i}}{\sin \hat{r}} = \text{constant}$ 3

A lamp is located centrally at the bottom of a large swimming pool, 1.8 m deep. Draw a ray diagram to show where the lamp appears to be, as seen by an observer standing at the edge of the pool.



correct emergent ray 4

image position correctly indicated 3

At night, when the lamp is switched on, a disc of light is seen at the surface of the swimming pool. Explain why the area of water surrounding the disc of light appears dark.

(no light emerges from pool due to) total internal reflection / appropriate diagram 3

Calculate the area of the illuminated disc of water.

$n = \frac{1}{\sin i_C}$ (=1.33) 3

$i_C = 48.76°$ 3

(radius of disc =) $r = 1.8 \tan 48.76$ / 2.053 (m) 3

$area = \pi r^2$ / 13.24 m^2 3

Question 12

(*c*) List the factors that affect the heat produced in a current-carrying conductor.

resistance, current (squared), time, (any valid answer) 3+2+2

An electric cable consists of a single strand of insulated copper wire. The wire is of uniform cross-sectional area and is designed to carry a current of 20 A. To preserve the insulation, the maximum rate at which heat may be produced in the wire is 2.7 W per metre length.

Calculate: (i) the maximum resistance per metre of the wire 3

$P = RI^2$

$2.7 = R(20)^2$ 3

$R = 6.75\times10^{-3}\,\Omega$ 3

(–1 for omission of or incorrect unit)

(ii) the minimum diameter of the wire.

$\rho = \frac{RA}{l}$ 3

$r^2 = \frac{\rho l}{\pi R}$ 3

$r^2 = \frac{\left(1.7\times10^{-8}\right)(1)}{\pi\left(6.75\times10^{-3}\right)}$ // 8.017×10^{-7} 3

$r = 9.0\times10^{-4}\,\text{m}$ / $0.9\,\text{mm}$ / $\text{diameter} = 1.8\,\text{mm}$ 3

(–1 if value for diameter not given in final answer; –1 for omission of or incorrect unit)

(*d*) In the manufacture of newsprint paper, heavy rollers are used to adjust the thickness of the moving paper. The paper passes between a radioisotope and a detector, and a pair of rollers, as shown.

(i) Name a suitable detector.

solid state detector / GM tube (linked with a ratemeter/scaler) 6

(ii) Describe how the reading on the detector may vary as the paper passes by.

(count rate) would decrease 3

with increasing paper thickness 6

(or vice versa)

(iii) Why would the radioisotope Am-241, which emits alpha-particles, not be suitable for this process?

paper would (easily) block alpha-particles / alpha-particles have poor penetrating power 4

(iv) Calculate the number of atoms present in a sample of Sr-90 when its activity is 4250 Bq. The half-life of Sr-90 is 28.78 years. (Accept: 1 year = 365 days or 365.25 days)

$\lambda\, T_{\frac{1}{2}} = 0.693$ / $\lambda = 7.77\times10^{-10}\,\text{s}^{-1}$ / $\lambda = 7.63\times10^{-10}\,\text{s}^{-1}$ 3

$\text{activity}\left(=\frac{dN}{dt}\right) = (-)\lambda N$ / $4250 = \left(7.77\times10^{-10}\right)N$ / $4250 = \left(7.63\times10^{-10}\right)N$ 3

$N = 5.47\times10^{12}$ (atoms) / 5.57×10^{12} (atoms) 3