Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2012

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, when indicated.

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

SECTION A (120 marks)

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

Question1

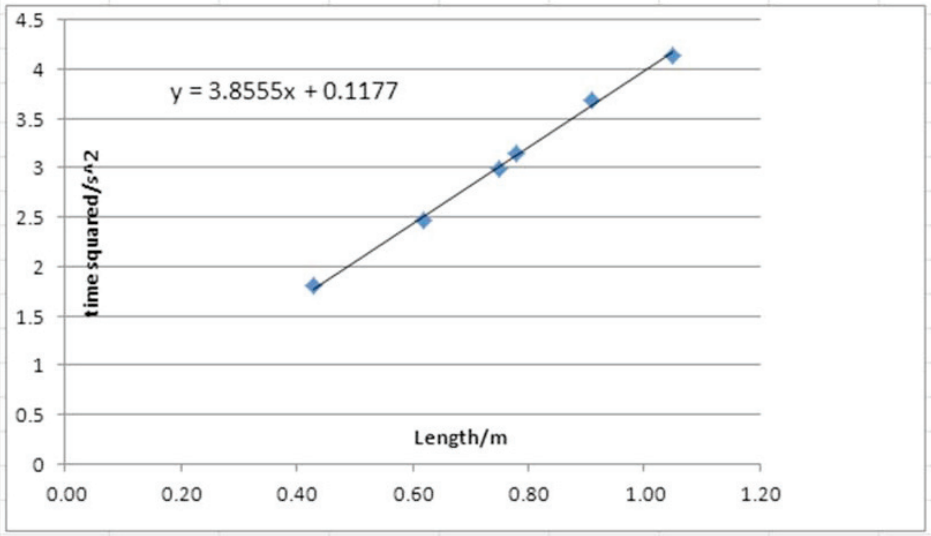
In an experiment to measure the acceleration due to gravity using a simple pendulum, a student obtained values for the length l of the pendulum and the corresponding values for the periodic time T.
The student plotted the following points, based on the recorded data.

Describe how the student obtained a value for the length of the pendulum and its corresponding periodic time.
measure length (l) from fixed point to top of bob (using metre stick) 3
measure diameter/radius (r) of bob 3
length = $l + r$ (stated or implied) 3
reference to metre rule and Vernier calipers (or micrometer) 3

measure time for n oscillations 3
divide (total time) by n 3

Draw the appropriate graph on this examination paper and use it to calculate a value for g.

l/m	T^2/s^2
0.43	1.8
0.62	2.46
0.75	2.98
0.78	3.15
0.91	3.68
1.05	4.14



correct method for slope **(–1 if (0,0) chosen as point on graph)** 3
correct slope value ($3.47 \leq m \leq 4.14$ s^2 m^{-1}) 6

$g = 4\pi^2 \frac{l}{T^2}$ state/imply 3
value for g ($9.5 \leq g \leq 11.0$ m s^{-2}) **(–1 for omission of or incorrect units)** 3

Give two factors that affect the accuracy of the measurement of the periodic time.
Number of oscillations selected / the precision of the timer / repetition (of measurement for average) /
smaller % error in T with longer lengths / nature of the string e.g. 'inextensible string'

any *two* factors 4+3

Question 2

In an experiment to measure the focal length of a converging lens, a student measured the image distance v for each of four different values of the object distance u. The table shows the data recorded by the student.

u/cm	12.0	18.0	23.6	30.0
v/cm	64.5	22.1	17.9	15.4

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

apparatus: e.g. ray box, convex lens, screen 3
correct arrangement of apparatus **(–1 if screen is not labelled)** 3
adjust to get image in sharp focus 3
measure u and v 3
repeat for different positions of object 3

Why is it difficult to measure the image distance accurately?
difficult to locate sharp image / centre of lens 4

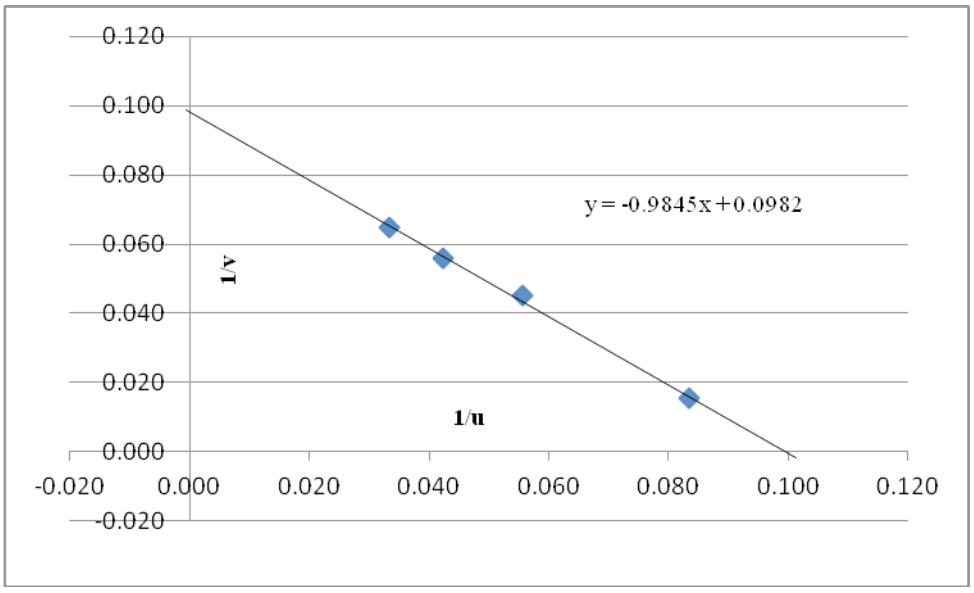
Using all the data in the table, find the value for the focal length of the lens.
formula 3
derivation of f (3 marks per each correct value for f – max mark 3×3) 3×3
average f (= 10.0 ± 0.2) cm 3

Why is it difficult to measure the image distance when the object distance is less than 10 cm?
image is virtual / image on same side as object / no image formed on screen 6

Graphical method:

inverse values for u and v	3
plot points on graph	3
straight line	3
read intercept	3
correct value for f (= 10.0 ± 0.2) cm	3

1/u	**1/v**	**1/u+1/v**	***f***
0.083	0.016	0.099	10.12
0.056	0.045	0.101	9.92
0.042	0.056	0.098	10.18
0.033	0.065	0.098	10.18
		Average	**10.10 cm**



Question 3

In an experiment to investigate the variation of the fundamental frequency f of a stretched string with its length l, the following data were recorded.

f / Hz	95	102	114	126	141	165	194	232
l / m	0.603	0.553	0.503	0.453	0.403	0.353	0.303	0.253

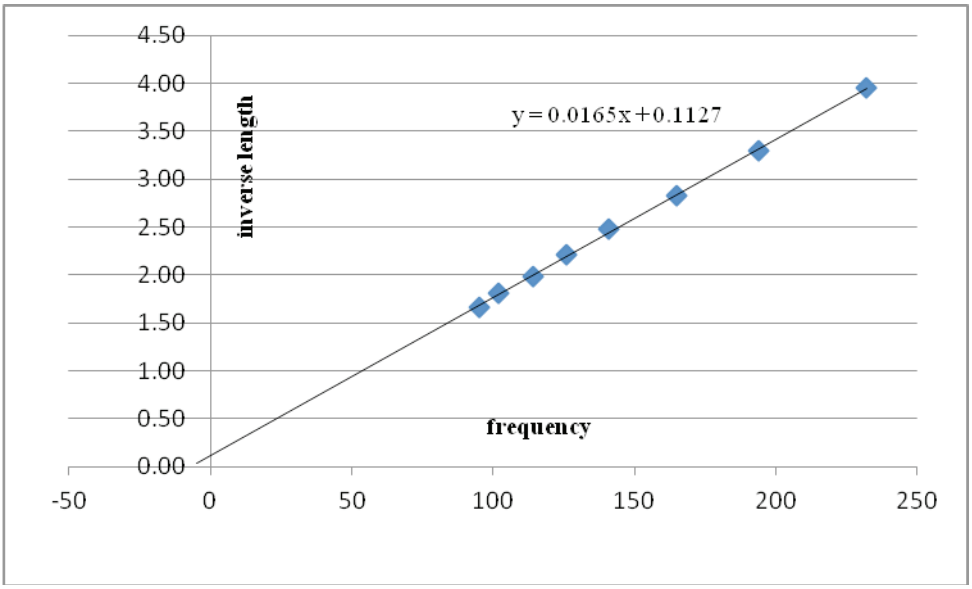
How were the data obtained?

arrangement showing string, means of changing l , pulley and pan / newton balance / fixed at both ends 3
vibrating fork placed on bridge **(–1 per item omitted)** 3
adjust length until standing wave formed / resonance occurs /rider falls 3
measure length (between nodes / bridges) 3
repeat with forks of different frequencies --- stated/implied 3

Using the data, draw a suitable graph on graph paper to show the relationship between the fundamental frequency of the stretched string and its length.

inverse l values 3
plot points **(–1 per each incorrect point)** 2×3
straight line (through origin) 3

l	0.603	0.553	0.503	0.453	0.403	0.353	0.303	0.253
f	95	102	114	126	141	165	194	232
$1/l$	1.66	1.81	1.99	2.21	2.48	2.83	3.30	3.95



The fundamental frequency of a stretched string depends on factors other than its length.
Name one of these factors and give its relationship with the fundamental frequency.

tension (in string) / mass per unit length (of string) 3
valid relationship ➔ $f \propto \sqrt{T}$ / $\sqrt{\frac{1}{\mu}}$ 3

If you were doing an experiment to establish the relationship between the fundamental frequency of a stretched string and this other factor, how would you obtain the relevant data?

For tension factor: find resonance for a fork f_1 by changing tension 3
method for changing/measuring tension // keep l fixed 3
repeat for forks of different frequencies 1

Question 4

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

"I set up the apparatus as shown in the circuit diagram. I measured the current flowing through the diode for different values of the potential difference. I recorded the following data."

V / V	0	0.50	0.59	0.65	0.68	0.70	0.72
I / mA	0	3.0	5.4	11.7	17.4	27.3	36.5

Draw a circuit diagram used by the student.

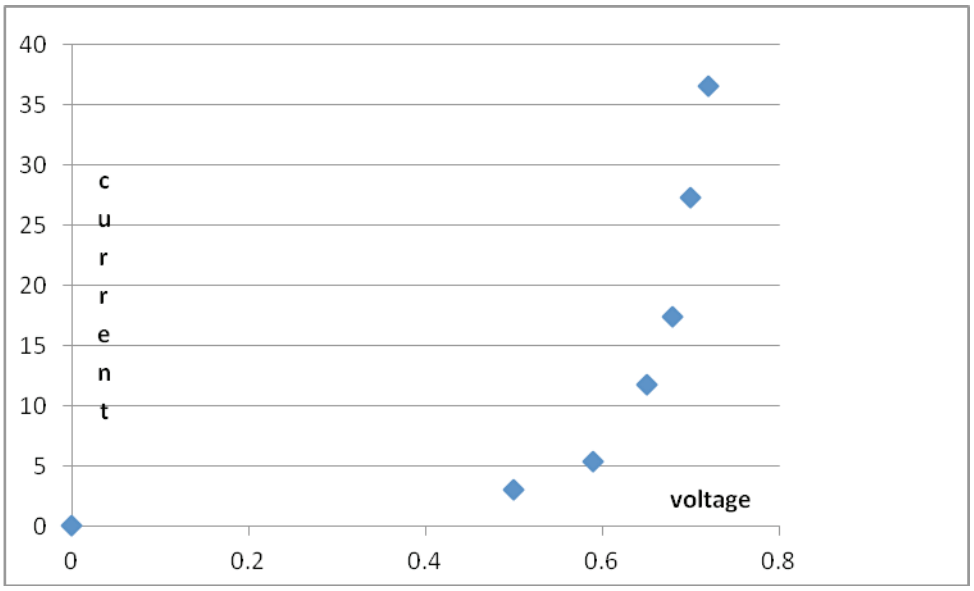
apparatus: p.s.u., ammeter, voltmeter, diode **(–1 per missing item)** 3
correct arrangement 3
diode in forward bias (state/imply) 3

How did the student vary and measure the potential difference?

vary using rheostat /variable resistor / dial on (variable) p.s.u. 3

measure p.d. from voltmeter (across diode – stated or implied) 3

Using the data, draw a graph to show how the current varies with the potential difference for the semiconductor diode.



label axes correctly 3
plot points **(–1 per each incorrect point)** 2×3
good distribution **(–1 if not drawn from the origin)** 3

Does the resistance of the diode remain constant during the investigation? Justify your answer.

no / 'resistance not constant' 3
I not proportional to V or equivalent, e.g. 'graph is not a straight line through origin'. 3
(–1 if 'through origin' omitted)

The student continued the experiment with the connections to the semiconductor diode reversed.
What adjustments should be made to the circuit to obtain valid readings?

microammeter used (instead of ammeter/milliammeter) // voltmeter placed across diode and microammeter, etc.

any *two* 4 + 3

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*) **Cork and Sligo are about 330 km apart by road. Using the map of Ireland shown on page 4, estimate the displacement of Sligo from Cork. The scale of the map is 1 cm to 37.5 km.**
distance = 77.(3) mm = 7.7(3) cm 4
displacement = (290 ± 3) km, north **(–1 for omission of direction)** 3

(*b*) **A pendulum moves with simple harmonic motion. Give another example of a body that moves with SHM.**
any valid answer, e.g. a mass oscillating on a spring 7

(*c*) **The European aerospace group EADS is developing a hypersonic jet aircraft that will fly at four times the speed of sound, 330 m s^{-1}. Express the speed of the aircraft in kilometre per hour.**
speed of jet = 1320 (m s^{-1}) 4
➔ 4752 (km h^{-1}) 3

(*d*) **What is the focal length of a lens which has a power of –2 m^{-1}?**
$P = \frac{1}{f}$ 4
f = (–)0.50 m = (–)50 cm **(–1 for omission of or incorrect units)** 3

(*e*) **List three conditions necessary for an observer to see a rainbow.**
any valid answer: observer's back to sun / (bright) sunlight /(suspended) droplets of water /proper angle of viewing, etc. Any *one* condition: 4
two additional conditions: 3
(any reference to *refraction* or *total reflection*, award 4 marks)

(*f*) **How is energy transferred from the sun to the earth?**
(by means of) radiation / photons / electromagnetic waves 7

(*g*) **A person smokes a cigarette at the entrance to a building. Explain how a significant amount of the smoke from the cigarette can enter the building.**
(reference to) convection currents / diffusion / wind assisted / pressure variations, etc. 7

(*h*) **Sketch the magnetic field due to a current in a solenoid.**
uniform field inside solenoid / divergent field outside (–1 if incomplete field line) 7

(*i*) **It takes 30 minutes for a 100 g sample of a radioactive isotope to decay to 12.5 g.**
What is the half-life of the radioisotope?
$3T_{\frac{1}{2}}$ 4
$T_{\frac{1}{2}}$ = 10 minutes **(–1 for omission of or incorrect units)** 3

(*j*) **Which Irish physicist is associated with the development of the linear accelerator?**
Walton 7

or

With what invention is the Irish physicist Nicholas Callan associated?
induction 4
coil 3

Question 6

On 16 August, 1960, Joseph Kittinger established a record for the highest altitude parachute jump. This record remains unbroken. Kittinger jumped from a height of 31 km. He fell for 13 seconds and then his 1.8-metre canopy parachute opened. This stabilised his fall. Only four minutes and 36 seconds more were needed to bring him down to 5 km, where his 8.5-metre parachute opened, allowing him to fall at constant velocity, until he reached the surface of the earth.

(i) **Calculate the acceleration due to gravity at a height of 31 km above the surface of the earth.**

equation: $\frac{g_1}{g} = \frac{d^2}{d_1^2}$ // $g_1 = \frac{GM}{d_1^2}$ 6

substitution: $\frac{(9.81)(6.36\times10^6)^2}{(6.391\times10^6)^2}$ // $g_1 = \frac{(6.6742\times10^{-11})(5.97\times10^{24})}{(6.391\times10^6)^2}$ 3

answer: $g_1 = 9.7(15)$ m s^{-2} // $g_1 = 9.96$ m s^{-2} **(–1 for omission of or incorrect units)** 3

(ii) **What downward force was exerted on Kittinger and equipment at 31km, taking their total mass as 180 kg?**

($W = F =$) mg 3

$F = 180(9.715)$ / 1748.7 N **(–1 for omission of or incorrect units)** 3

(iii) **Estimate how far he fell during the first 13 seconds.**

equation $s = ut + \frac{1}{2}at^2$ 3

substitution $\frac{1}{2}(9.715)(13)^2$ 3

answer $s = 820.(92)$ m **(–1 for omission of or incorrect units)** 3

What assumptions did you take in this calculation?

u taken as zero / g_1 constant / no atmospheric resistance / no buoyancy due to atmosphere any *two* 2+1

(iv) **What was his average speed during the next 4 minutes and 36 seconds?**

average speed = distance ÷ time 3

distance = 31000 – 820.(92) –5000 / ≈ 25180 3

average speed = 25180 ÷ 276 / ≈ 91.23 m s^{-1} **(–1 for omission of or incorrect units)** 3

(v) **How much was the force on a hemispherical parachute of diameter 8.5 m greater than that on a similar parachute of diameter 1.8 m?**

pressure = force ÷ area 3

$\frac{F}{F'} = \frac{(PA)}{(PA)'} / \frac{2\pi R^2}{2\pi r^2}$ 3

$\frac{F}{F'} = \frac{(4.25)^2}{(0.9)^2} / \frac{(8.5)^2}{(1.8)^2}$ / 22.3 3

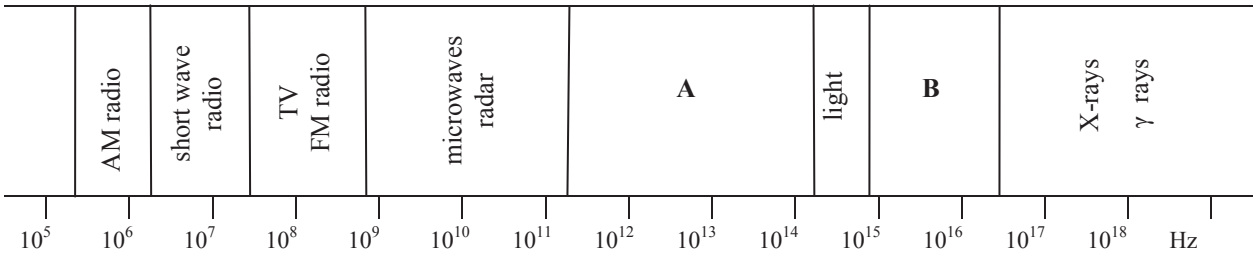
(vi) **Calculate the upthrust that acted on Kittinger when he reached constant velocity in the last stage of his descent (assume $g = 9.81$ m s^{-2} during this stage).**

upthrust (U) = mg 3

= (180)(9.81) 3

≈ 1766 N **(–1 for omission of or incorrect units)** 2

Question 7



The diagram shows a simplified version of the electromagnetic spectrum. Name the sections A and B in the diagram.

A: infra red /I.R 3

B: ultra violet / U.V 3

Describe how to detect each of these radiations.

A: thermometer (with blackened bulb) / temperature sensor /photographic plate / mobile phone camera/ etc 3

effect e.g. rise in temperature 2

B: (shine on) Vaseline/detergents / phosphor 2

effect e.g. fluorescence / glows 2

An electromagnetic radiation has a wavelength of 4 m. Name the section of the electromagnetic spectrum in which this radiation is located.

$c = f\lambda$ 3

$f = 7.5 \times 10^7$ Hz (≈ 75 MHz) 3

short wave radio / TV FM radio 3

Distinguish between interference and diffraction.

interference:

when waves from different sources overlap // when waves superimpose 3

a new wave is formed // to form a resultant wave (of greater or lower amplitude) 3

(suitable diagram could merit {3 + 3})

diffraction:

the spreading of a wave // the bending of waves // the spreading of waves 3

into the (geometrical) shadow of an obstacle // around obstacles // by passing them through an aperture 3

(suitable diagram could merit {3 + 3})

Can a diffraction grating which diffracts light also diffract X-rays?

no 3

Justify your answer.

line spacing must be similar to the wavelength of the radiation (for diffraction to occur) /

the spacing between lines in (such) a grating is too large (for diffraction to occur) /

for x-ray diffraction, gratings in which lines are separated by infinitesimal distances are required 6

(award 3 marks for: '$\lambda_{light} > \lambda_{x\text{-}ray}$')

Light travels as a transverse wave. Name another type of wave motion.

longitudinal 3

Give two differences between these two types of wave motion.

transverse can be polarized – longitudinal cannot // (medium) vibrates perpendicular to direction wave travels – (medium) vibrates parallel to direction (longitudinal) wave travels

any *two* 4+4

Question 8

Nuclear fission reactors are used as an energy source in many parts of the world, but it is only recently that the use of nuclear fusion as a possible power source is achieving some encouraging results. The ITER nuclear facility at Caderache in south-east France is a global collaboration that has been formed to "demonstrate that fusion is an energy source of the future". It is expected to begin testing in 2016.

Energy can be produced in a fusion reaction by combining a deuterium and a tritium nucleus as follows:

$$ {}^{2}_{1}\mathbf{H} + {}^{3}_{1}\mathbf{H} \rightarrow {}^{4}_{2}\mathbf{He} + \mathbf{n} + \mathbf{energy} $$

(i) Distinguish between nuclear fission and nuclear fusion.

fission: large nucleus splits 3

into two smaller nuclei (of similar size) 3

fusion: two small nuclei join 3

to form a larger nucleus **(–1 if '*atoms*' referred to)** 3

(ii) What are the advantages of fusion over fission in terms of fuel sources and reaction products?

(hydrogen) fuel (from the sea) is plentiful – (uranium for fission is scarce) 6

no radioactive waste with fusion – (fission results in radioactive waste) 6

(iii) How much energy is produced when a deuterium nucleus ${}^{2}_{1}\mathbf{H}$ combines with a tritium nucleus ${}^{3}_{1}\mathbf{H}$?

(reactants:) 2.014102 + 3.016049 / 5.030151 3

(products:) 4.002603 + 1.008672 / 5.011275 3

Δm = 0.018875 u / 3.1344×10^{-29} kg 3

$E = mc^2$ 3

substitution 3

E= 2.82(096) $\times 10^{-12}$ J **(–1 for omission of or incorrect units)** 3

[If method used utilises: 1u ≡ 931 MeV ➔ E = 2.81(17) $\times 10^{-12}$ J]

(iv) Calculate the force of repulsion between a deuterium and a tritium nucleus when they are 2 nm apart in free space.

$$F = \frac{q_1 q_2}{4\pi\varepsilon d^2}$$ 3

$$F = \frac{(1.602\times10^{-19})^2}{4\pi(8.854\times10^{-12})(2\times10^{-9})^2}$$ 3

F = 5.7(664) $\times 10^{-11}$ N **(–1 for omission of or incorrect units)** 3

(v) Fusion can only take place at very high temperatures. Explain why.

nuclei must have very high speeds / energy if they are to combine /

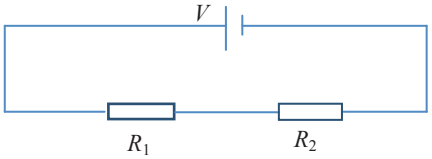
to overcome force of repulsion between the nuclei 5

Question 9

Define resistance.

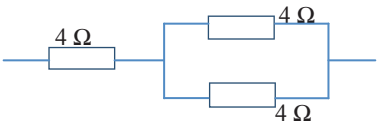
voltage ÷ current / ratio of voltage to current / $V \div I$ plus correct notation 3

(i) Two resistors of resistance R_1 and R_2 are connected in series. Derive an expression for the effective resistance of the two resistors in terms of R_1 and R_2.



diagram/circuit 3
$V = V_1 + V_2$ 6
$IR_s = IR_1 + IR_2$ 3
$R_s = R_1 + R_2$ 3

(ii) Two 4 Ω resistors are connected in parallel. Draw a circuit diagram to show how another 4 Ω resistor could be arranged with these two resistors to give an effective resistance of 6 Ω.



draw parallel branch 3
arrangement for effective $R = 6\ \Omega$ 6

(iii) A fuse is a resistor used as a safety device in a circuit. How does a fuse operate?

fuse in live part of circuit 3
gets hot if current exceeds a certain (rated) value (state/imply) 3
melts/breaks 3
circuit is broken 2

A Wheatstone bridge circuit is used to measure the resistance of an unknown resistor R.
The bridge ABCD is balanced when X = 2.2 kΩ, Y = 1.0 kΩ and Z = 440 Ω.

(iv) What test would you use to determine that the bridge is balanced?

connect galvanometer (G) / millivoltmeter (mV) across points AC 3
no deflection in G (when balanced) 3

(v) What is the resistance of the unknown resistor R?

$\frac{R_1}{R_2} = \frac{R_3}{R_4}$ 3

$\frac{2200}{1000} = \frac{R}{440}$ / $R = 968\ \Omega$ 3

(vi) When the unknown resistor R is covered by a piece of black paper, the bridge goes out of balance. What type of resistor is it?

light dependent resistor / l.d.r. / photoresistor / CdS cell 3

Give a use for this type of resistor.

used in light meters / (to control) street lights / security alarms / (control) traffic lights / used in re-charging circuits, etc.

any *one* valid answer 3

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

(*a*) (i) What is a positron?

an electron with + charge / electron antiparticle / $_{+1}^{0}e$ 6

(ii) When a positron and an electron meet two photons are produced.
Write an equation to represent this interaction

$_{-1}^{0}e + {}_{+1}^{0}e \rightarrow \gamma + \gamma$ / $e^{+} + e^{-} \rightarrow 2\,\gamma$ 6

(iii) Why are photons produced in this interaction?

mass converted into energy 3

Explain why two photons are produced.

to conserve momentum 3

Calculate the minimum frequency *f* of the photons produced.

mass of electron = $9.1093826 \times 10^{-31}$ kg 3

$E = m c^2$ 3

$E = (9.1093826 \times 10^{-31})(3 \times 10^{8})^2$ / $E = 8.198444 \times 10^{-14}$ J 3

$E = hf$ / $f = \frac{E}{h}$ / $f = \frac{8.198444 \times 10^{-14}}{6.6260693 \times 10^{-34}}$ 3

$f = 1.237 \times 10^{20}$ Hz **(–1 for omission of or incorrect units)** 3
(–1 for factor of 2 error in answer)

Explain why the photons produced usually have a greater *f* than your calculated minimum *f* value.

(in addition to rest mass) the colliding particles have kinetic energy 3

(iv) Why must two positrons travel at high speeds so as to collide with each other?

to overcome force of repulsion 6

How are charged particles given high speeds?

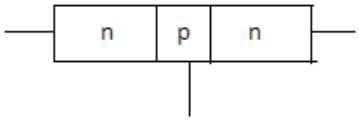
particle accelerators / linear accelerator / cyclotron /synchrotron/magnetic fields/electric fields 6

(v) Explain why two positrons cannot annihilate each other in a collision.

(in conflict with) conservation of charge or equivalent statement 8

('zero charge after interaction' …. award 4 marks)

(*b*) Draw a labelled diagram to show the basic structure of a bipolar transistor.



labelled diagram showing npn (or pnp) layers 3

pin connections to each layer 3

Indicate the difference in the composition of the parts of the transistor that you have drawn.

middle layer: base is thin and lightly doped / +holes are majority carriers 6

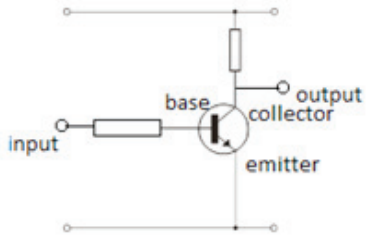
outer layers: emitter and collector are thicker / e^{-} are majority carriers 6

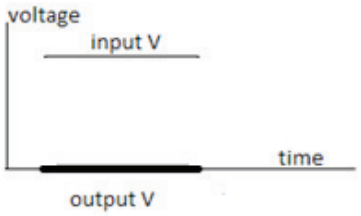
(i) **Complete the circuit diagram for the voltage inverter. Label each part of the circuit.**
Indicate the terminals used for the input and output voltages.

draw the base (protective) resistor 3

label *e,b,c* 3×3

show input and output voltages 3





I/P	O/P
0	1
1	0

(ii) Draw a sketch of an input *V* and its corresponding output *V*, using the same axes and scale.

labelled axes 3

V_{in} shown high and V_{out} indicated low (digital or analogue signal) 3+3

(iii) Draw the symbol of a NOT gate.

correct symbol 3

Draw the truth table for a NOT gate.

input correctly presented 3

output correctly presented 3

(iv) Give another application of a transistor.

any valid answer, e.g. switching, amplification, etc. 5

Question 11

Read the following passage and answer the accompanying questions.

Windmills have been used for thousands of years to grind grain but the first attempts to use wind turbines to generate electricity were not made until the late 1800s. Viable large scale wind turbines were not produced until the 1980s. At the moment about 12% of Ireland's electricity needs are met by wind energy and it is planned to increase this to 33% by 2020. Wind is a source of renewable energy and is now one of the most cost-effective methods of electricity generation.

The power P of the wind can be calculated from $P = \rho A v^3$ where ρ is the density of the air, A is the area the wind acts on and v is the speed of the wind. In theory it is possible to extract 58% of this energy in a wind turbine. Much of the loss occurs as the wind is slowed down rather than stopped as it passes the turbine.

The rotating blades of the turbine transfer their energy to an a.c. generator, which produces electricity by electromagnetic induction. The resulting alternating supply has to be changed to match the 230 V, 50 Hz that is used for electrical supply in Ireland.

Many people are concerned about the noise associated with wind turbines. Better blade construction has led to reduced noise. At about 150 m from a turbine, typical sound intensity levels are 45 dB. This reduces to 42 dB at about 200 m away. These values compare favourably with values of around 60 dB in a busy office.

(Adapted from: Renewable Energy, Edited by Godfrey Boyle, Oxford University Press in association with The Open University.)

(*a*) What is the effect on the power of the wind if the wind speed is doubled?

power increased by a factor of 8 — 7

(*b*) Why is it not possible to extract all of the energy in the wind striking a wind turbine blade?

wind is slowed down — 4

rather than stopped — 3

(*c*) What is electromagnetic induction?

(when) a conductor/wire cuts *magnetic* flux — 4

an emf /voltage is induced — 3

(–1 if 'magnetic' not specified)

(*d*) How is the output voltage of a wind turbine changed to 230 V a.c.?

transformer — 7

(*e*) Estimate the factor by which the sound intensity changes when you move from a position which is about 200 m away to a position which is about 150 m away from a typical wind turbine.

increase (in level) = 3 (dB) — (4)

(sound intensity is) doubled / (increased) by a factor of 2 **(–1 if '$\frac{1}{2}$' given as answer)** — 7

(*f*) What is the tip speed (the linear velocity of the outer end) of a blade of radius 30 m when it completes a revolution every 3 seconds?

$T = \frac{2\pi R}{v}$ — 4

$v = \frac{2\pi(30)}{3}$ / 20π / 62.8(3) m s^{-1} **(–1 for omission of or incorrect units)** — 3

(*g*) Small scale wind turbines are sometimes used to charge batteries. The a.c. output voltage has to be converted to a d.c. voltage. How is this achieved?

diode / rectifier — 7

(*h*) Name one other renewable source of energy.

any valid answer, e.g. geothermal, solar, etc. — 7

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

(a) **An Olympic hammer thrower swings a mass of 7.26 kg at the end of a light inextensible wire in a circular motion. In the final complete swing, the hammer moves at a constant speed and takes 0.8 s to complete a circle of radius 2.0 m.**

(i) **What is the angular velocity of the hammer during its final swing?**

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

$\omega = \frac{2\pi}{0.8}$ / 7.8(54) s^{-1} **(–1 for omission of or incorrect units)** 3

(ii) **Even though the hammer moves at a constant speed, it accelerates. Explain.**

direction changes (continuously) 4

Calculate

(iii) **the acceleration of the hammer during its final swing**

$a = \omega^2 r$ 3

$= (7.854)^2(2)$ 3

acceleration = 123.37 m s^{-2} , towards the centre (of orbit) / inwards **(–1 if no direction given)** 3

(–1 for omission of or incorrect units)

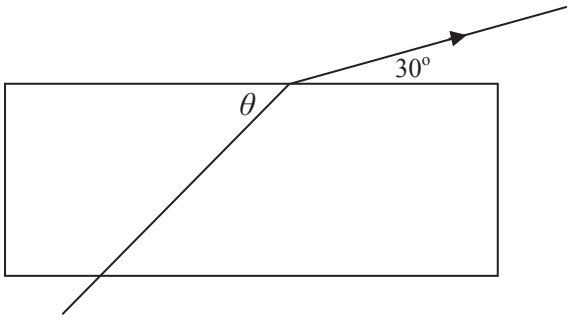
(iv) **the kinetic energy of the hammer as it is released.**

K.E $= \frac{1}{2} m v^2$ 3

$= \frac{1}{2} m(\omega r)^2$ / $\frac{1}{2}(7.26)(15.71)^2$ 3

K.E = 896 J **(–1 for omission of or incorrect units)** 3

(*b*)



(i) **If the refractive index of the glass is 1.5, calculate the value of θ.**

$n_g = \frac{\sin i}{\sin r}$ 3

correct value for i (= 60°) 3

correct value for r (= 35.26°) 3

answer: θ = 54.7(4)°3

(ii) **What would be the value of the angle θ so that the ray of light emerges parallel to the side of the glass block?**

reference to critical angle, i_c / $n_g = \frac{1}{\sin i_c}$ 3

$i_c = 41.81°$ 3

$\theta = 48.2°$ 3

(iii) **Calculate the speed of light as it passes through the glass.**

$n_g = \frac{c_a}{c_g}$ 4

$c_g = \frac{2.9979 \times 10^8}{1.5}$ / 2×10^8 m s^{-1} **(–1 for omission of or incorrect units)** 3

(*c*) The graph shows the variation in temperature θ of 150 g of crushed ice when it was supplied with energy ΔE at a constant rate.

(i) Explain the shape of the graph.

temperature of ice increased (from $\approx -3^{o}$ to 0^{o}C as energy is added) 3

ice temperature stays at 0^{o}C while ice is melting / changing state 3

reference to latent heat 3

(once melted) ice melt /water temperature increases (to 1^{o}C) 3

(ii) Describe how energy could have been supplied at a constant rate.

(heating) coil/element 3

joulemeter / ammeter + rheostat 3

(water bath … 6 marks; hotplate …3 marks)

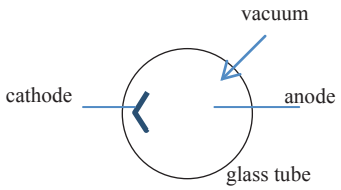
(iii) Using the graph, estimate the specific latent heat of fusion of ice.

energy (E) required to melt 0.15 kg of ice = (59 – 10) / 49 (kJ) 3

$E = m\,L$ 3

$L = \frac{49 \times 10^{3}}{0.150}$ / $3.26(7) \times 10^{5}$ J kg^{-1} **(–1 for omission of or incorrect units)** 4

(*d*) (i) Draw a diagram to show the structure of a photocell.



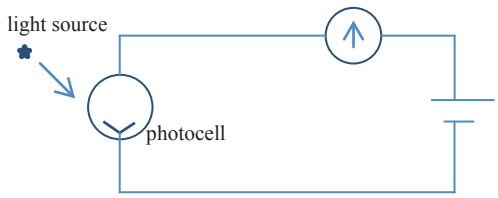
(glass) tube/bulb 3

vacuum (labelled) 3

two electrodes 3

label at least one electrode 3

(ii) Describe an experiment to demonstrate how the current through a photocell can be increased.



apparatus: photocell, meter, light source, (power supply) 3

arrangement: as shown **(–1 if incorrect polarity)** 3

procedure: bring light source closer (to photocell) 3

observation: current in circuit increases 3

(iii) Give an application of the photoelectric effect.

controlling the flame in central heating boilers / automatic doors / fire alarms / photocells / photocopiers / light meters / photomultiplier tubes, etc. any correct *one* 4