GCE AS

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PHYSICS

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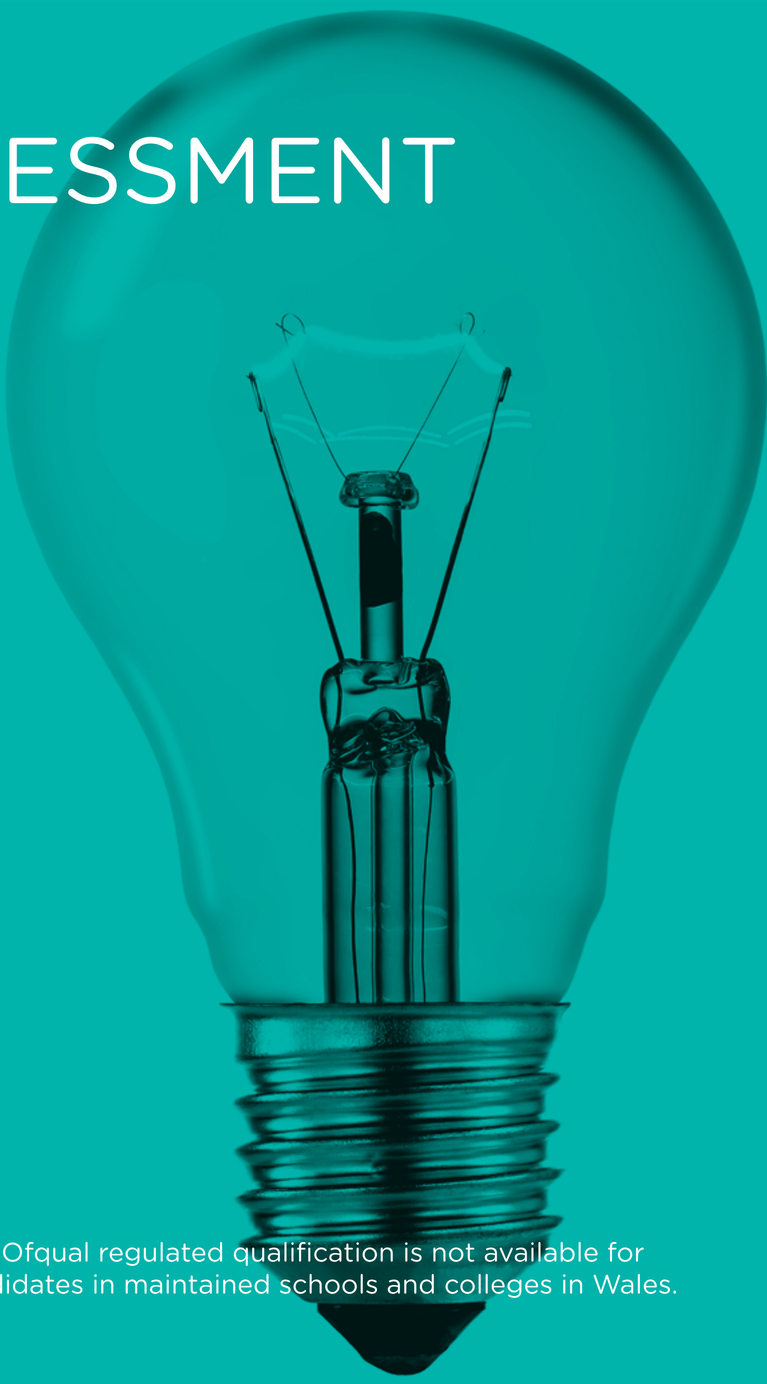
SPECIMEN ASSESSMENT MATERIALS

Teaching from 2015



wjec cbac

For teaching from 2015
For award from 2016

GCE AS PHYSICS

SPECIMEN ASSESSMENT MATERIALS

Contents

Candidate Name	Centre Number					Candidate Number				

AS PHYSICS

COMPONENT 1

Motion, Energy and Matter

SPECIMEN PAPER

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	10	
2.	15	
3.	10	
4.	10	
5.	10	
6.	10	
7.	10	
Total	75	

ADDITIONAL MATERIALS

In addition to this examination paper,
you will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

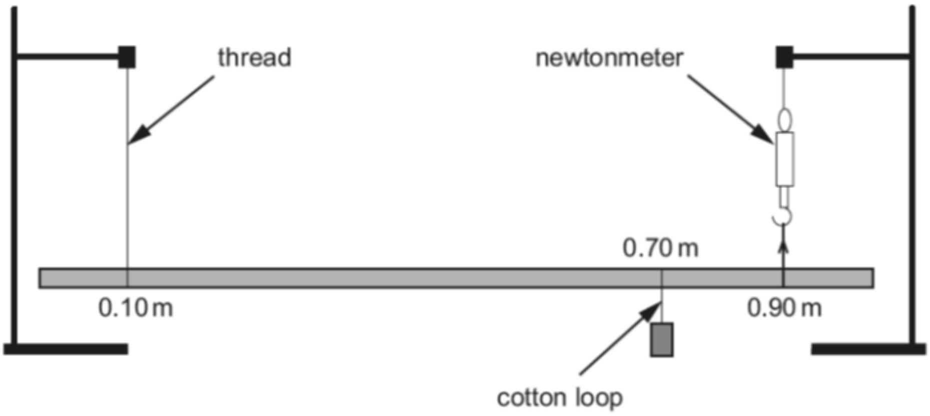
Use black ink or black ball-point pen.
Answer **all** questions.
Write your name, centre number and candidate number in the spaces at the top of this page.
Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.
The assessment of the quality of extended response (QER) will take place in question 5*(a).*
No certificate will be awarded to a candidate detected in any unfair practice during the examination.

*Answer **all** questions.*

1. A student carried out an experiment to investigate the principle of moments. The equipment was set up as shown, with the uniform metre ruler suspended at the 0.10 m mark, by a thread at one end, and by a newtonmeter on the 0.90 m mark at the other end. A 250 g mass was then looped around the ruler on the 0.70 m mark.



(a) When the weight was added the height of the newtonmeter was readjusted until the ruler was horizontal. Explain how this was done. [1]

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(b) Draw an arrow, **labelled W**, on the diagram to represent the weight of the ruler acting through the centre of gravity. [1]

(c) State the principle of moments. [2]

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(d) (i) The reading on the newtonmeter was found to be 2.8 N. Determine a value for the weight of the ruler. [3]

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(ii) Calculate the tension in the thread supporting the ruler at the 0.10 m point. [1]

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(iii) The newtonmeter is replaced by a thin wire whose resistance changes as it is stretched. Explain how this wire combined with an ohmmeter could be used to measure the force. [2]

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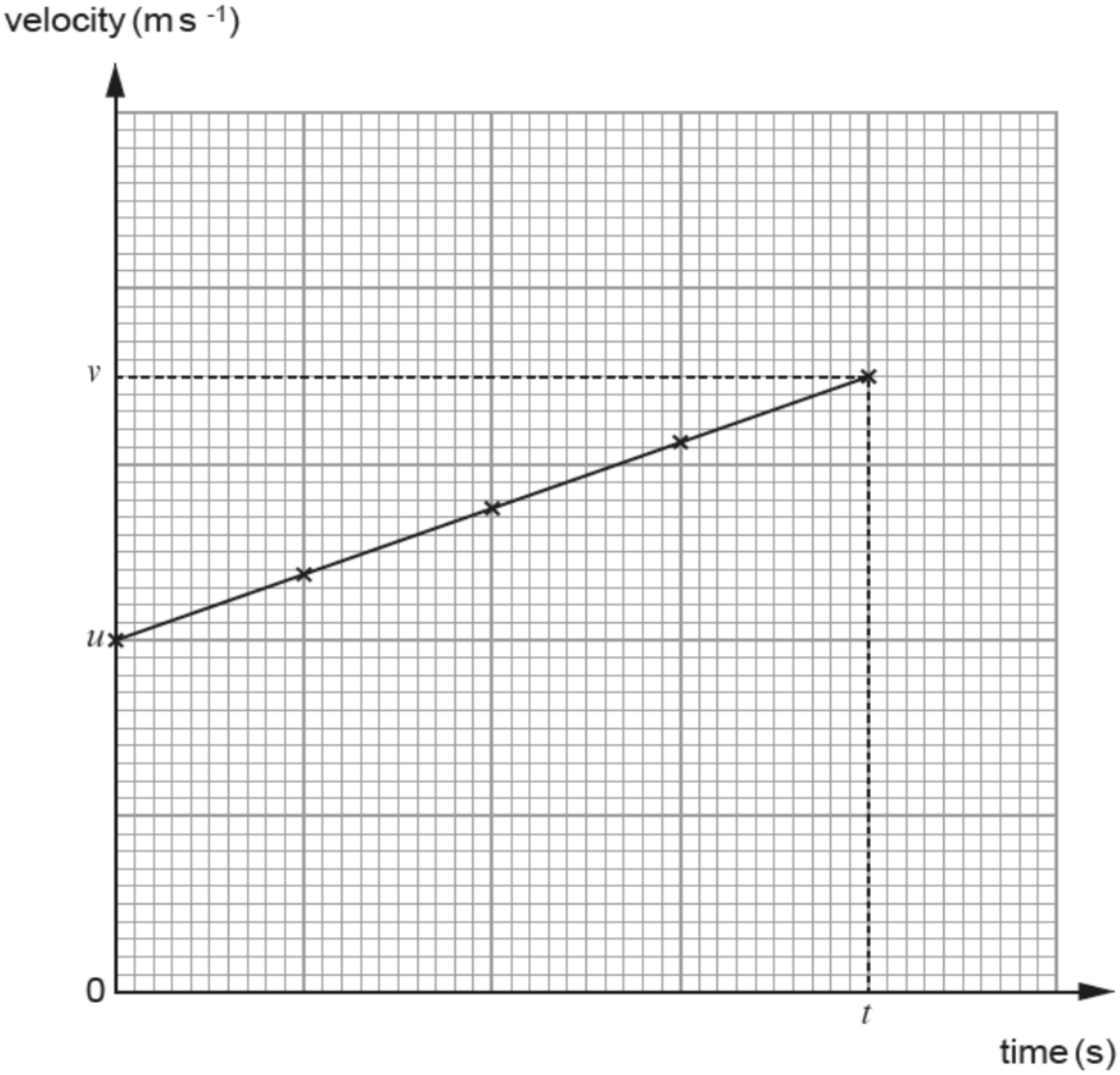
2. *(a)* A velocity-time graph is given for a toy car which is accelerating in a straight line in a laboratory.



(i) Using the symbols given on the graph, write down an expression for the area under the graph and state what it represents. [2]

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(ii) In practice, distance and time can be measured accurately with a video recorder and metre ruler. Explain how velocity (speed) can be measured accurately. [2]

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(b) A stone is kicked horizontally from the top edge of a cliff. Measured data for the flight of the stone are provided in the table.

Time of flight (s)	Distance from foot of cliff to point of impact (m)	Height of cliff (m)	Vertical velocity on impact ($m\,s^{-1}$)	Initial horizontal velocity ($m\,s^{-1}$)
5.00	10.00			

(i) Complete the table by filling in the gaps. Ignore air resistance. [6]

(Space is provided for your calculations.)

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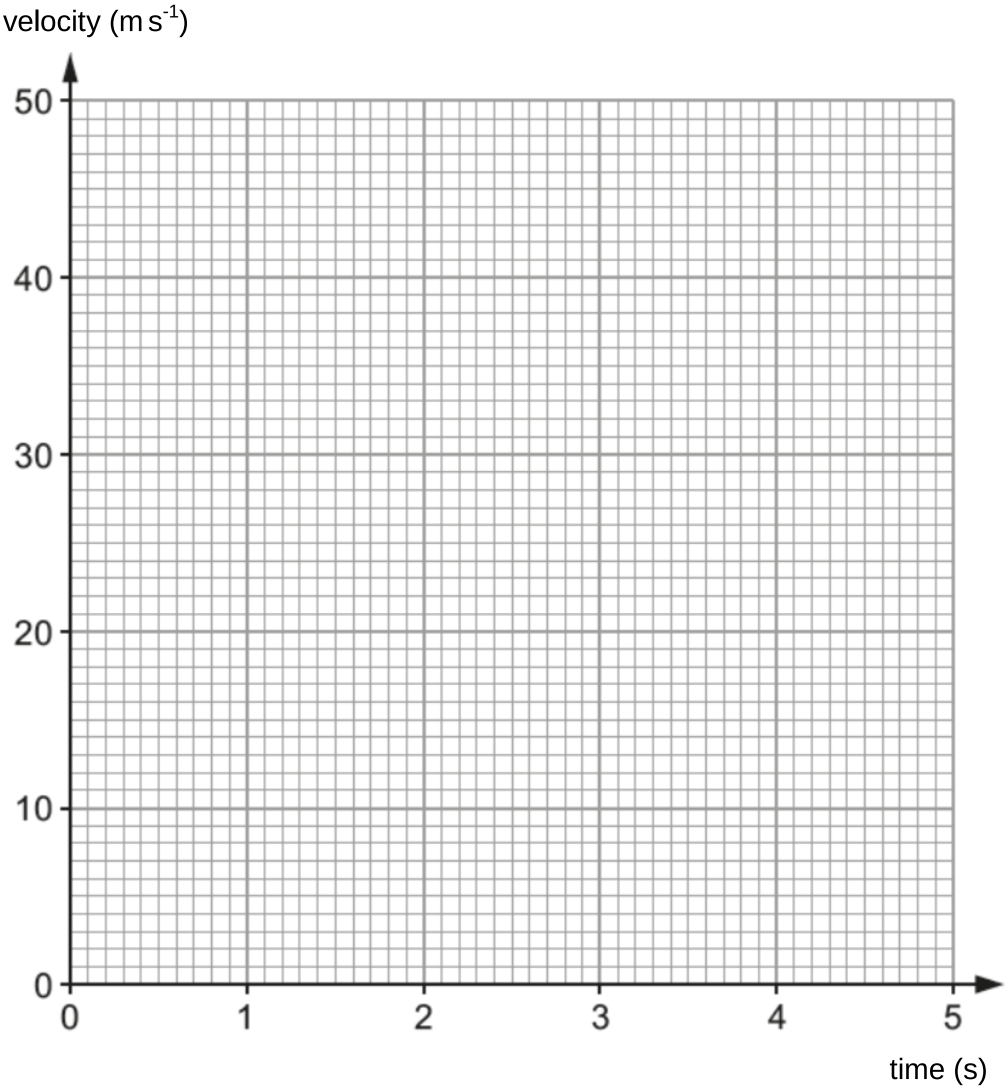
(ii) Plot, on the grid below, lines to represent **both** the vertical **and** horizontal velocities of the stone for the time of flight. [3]



(c) Discuss the effect that air resistance would have on the motion of the stone. [2]

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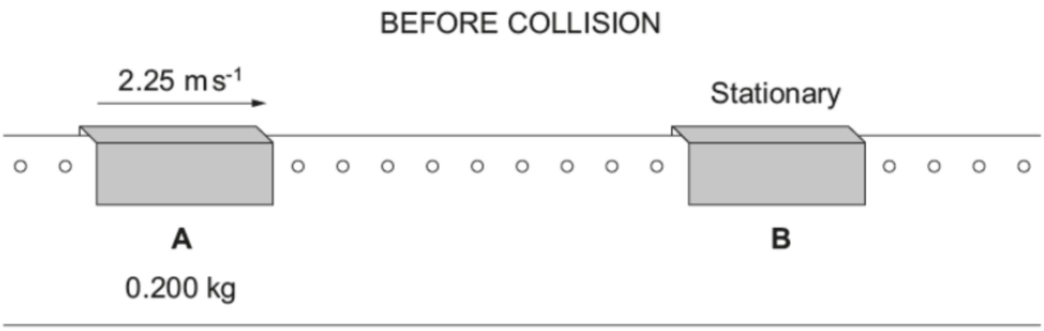
3. In a laboratory experiment two gliders **A** and **B** lie on a linear air track (friction free). Glider **A**, of mass 0.200 kg, is initially moving with a velocity of 2.25 m s^{-1} to the right. Glider **B** is initially stationary.



(a) (i) The *principle of conservation of momentum* states that the momentum of a system remains constant provided that no external resultant force acts. State how friction and the effects of gravity are eliminated in the air track set-up. [2]

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(ii) When the two gliders collide they stick together and move with a velocity of 1.20 m s^{-1} to the right. Use the principle of conservation of momentum to find the mass of glider **B**. [2]

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(iii) Show clearly that the collision is *inelastic* and account for the loss in kinetic energy. [3]

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(b) A student claims that a law of physics is contradicted if the Glider A remains stationary after the collision even if conservation of momentum applies. Determine whether or not this statement is true. [3]

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4. *(a)* State the principle of conservation of energy. [1]

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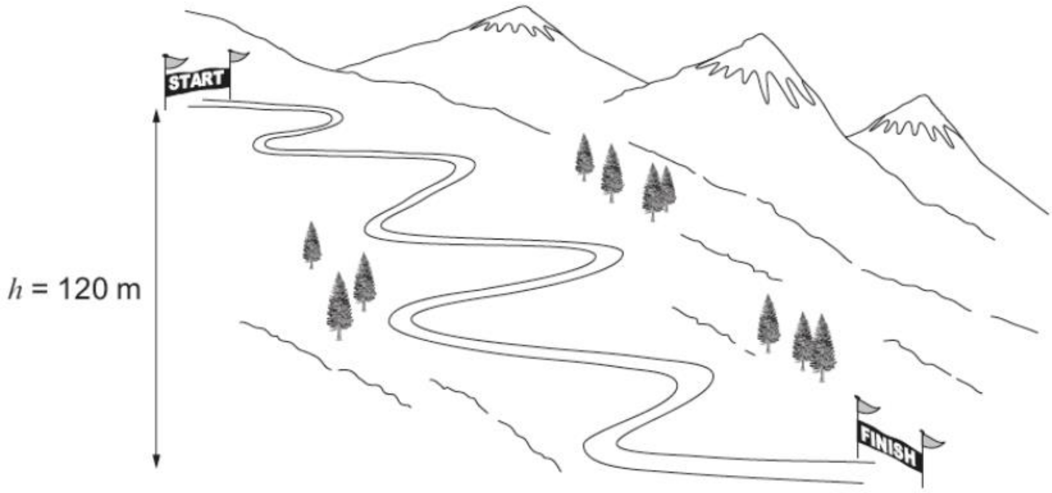
(b) A bobsleigh run in Norway has a curving track of overall length 1.4 km from start to finish. During a run, the bobsleigh drops through a vertical height, *h*, of 120 m.



(i) Assuming no resistive forces, show that the maximum possible speed, v, of a bobsleigh at the finish line is given by: [2]

$$v = \sqrt{2gh}$$

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(ii) Hence calculate the maximum possible speed of a bobsleigh at the finishing line. [1]

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(c) The mass of the bobsleigh and riders is 280 kg. Determine the mean resistive force experienced by the bobsleigh from start to finish **and** give an example of a resistive force acting on the bobsleigh. Assume the speed of the bobsleigh is 20% of its maximum possible speed. [6]

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5. (a) Explain in detail how you would carry out an experiment to measure the Young modulus of a metal in the form of a long wire. [6 QER]

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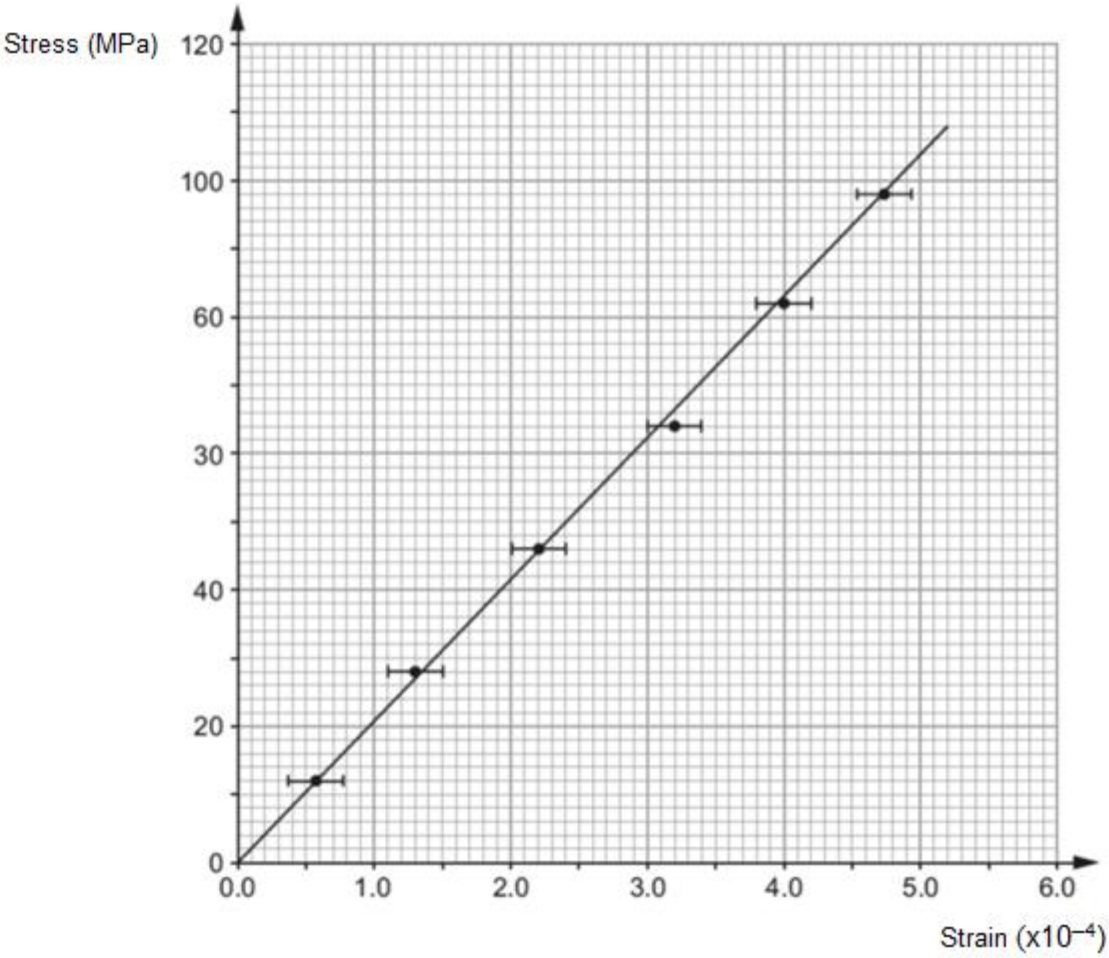
(b) A graph of stress against strain is drawn for a metal.



(i) Use the graph to determine the Young modulus of the metal. [2]

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(ii) A student repeats this experiment with a wire of thickness 10 mm instead of 0.1 mm. Evaluate the associated benefits and risks of this additional experiment. [2]

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6. *(a)* A table of astronomical data includes the following about a star in the *Cassiopeiae* system:

Radius = 7.22×10^{8} m, Temperature = 5 970 K, Luminosity = 4.74×10^{26} W.

(i) Determine whether the data above is consistent with the star radiating as a black body. Show your working clearly, and give your conclusion. [3]

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(ii) The star is 1.84×10^{17} m from the Earth. Calculate the intensity (energy per second per m^2) of electromagnetic radiation reaching the Earth from the star. [2]

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(iii) Calculate the wavelength of the star's peak spectral intensity. [1]

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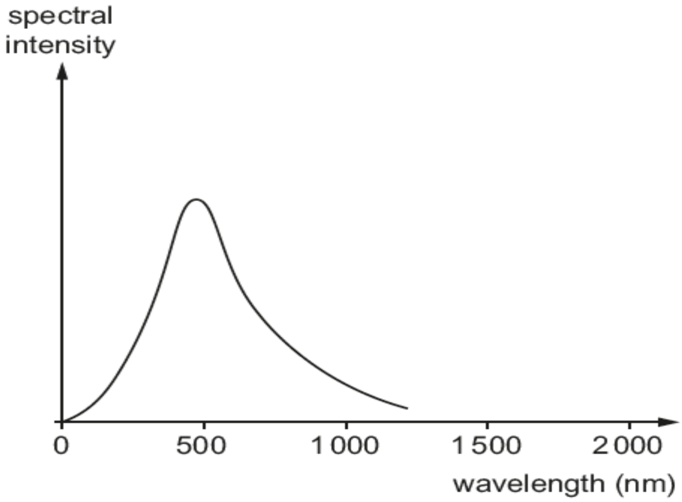
(iv) The light from this star can be detected with a large telescope. This light can then be passed through a diffraction grating to produce the spectrum shown. Explain using the relevant equation why a spectrum is produced at the order n = 1. [2]



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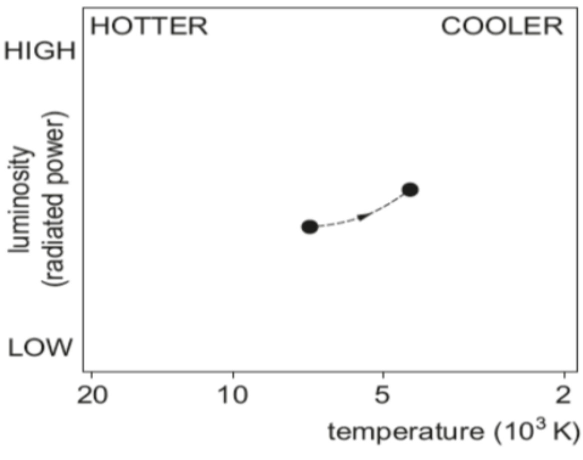
(b) Astronomers assign to each star a position on a chart, according to the star's luminosity and temperature. During one stage in the life of *Alpha Centauri A*, its position on the chart will move as shown by the dotted line.
Use Stefan's law to show clearly what happens to the size of the star during this stage. [No calculations are required.] [2]



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7. *(a)* Put ticks in the boxes in the table to show which of the particles listed can take part in the interactions named. [3]

	strong interaction	weak interaction	electromagnetic interaction
neutrino (ν_e)			
electron (e^-)			
u quark (u)			

(b) The π^- meson has quark make-up $d\bar{u}$ and the Δ^- baryon has quark make-up ddd.

(i) Show that the magnitudes of the charges of the π^- and Δ^- particles are the same. [1]

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(ii) The Δ– baryon has a very short lifetime (about 6×10^{-24} s), almost always decaying into a neutron and a π^-, as shown:

$$\Delta^- \rightarrow n + \pi^-$$

Show clearly whether or not up quark number and down quark number are separately conserved in this decay. [2]

up quark number

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down quark number

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(iii) Is the interaction in *(b)*(ii) a weak interaction? Justify your answer, using two pieces of evidence. [2]

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(c) The Δ^{++} baryon has a charge equal to that of two protons.

(i) Write down the quark make-up which the Δ^{++} baryon must have. [1]

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(ii) Δ^{++} baryon decays into a proton and a pion (π meson) by a similar mechanism to that for the Δ^{-} baryon in *(b)*. Determine the quark make-up of the pion. [1]

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Candidate Name	Centre Number	Candidate Number

AS PHYSICS

COMPONENT 2

Electricity and light

SPECIMEN PAPER

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	5	
2.	13	
3.	10	
4.	14	
5.	10	
6.	15	
7.	8	
Total	75	

ADDITIONAL MATERIALS

In addition to this examination paper,
you will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.
Answer **all** questions.
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Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.
The assessment of the quality of extended response (QER) will take place in question 6*(b).*
No certificate will be awarded to a candidate detected in any unfair practice during the examination.

*Answer **all** questions*

1. The current (I) in a metal conductor of cross-sectional area (A) is given by the equation:

$$I = nAve$$

(a) A wire of cross-sectional area 1.20 mm^2 and length 5.00 m carries a current of 2.00 A. Calculate the time it takes for a free electron in the wire to travel from one end of the wire to the other given that the wire has 8×10^{28} free electrons per m^3. [3]

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(b) The same current (2.00 A) is now passed through a thinner wire of the same length and material. State and explain what effect this change would have on the time for an electron to travel from one end to the other. [2]

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2. (a) X and Y are two lamps.

(i) Lamp X is labelled 12 V, 24 W. Calculate the current in the lamp when it operates at its rated voltage. [1]

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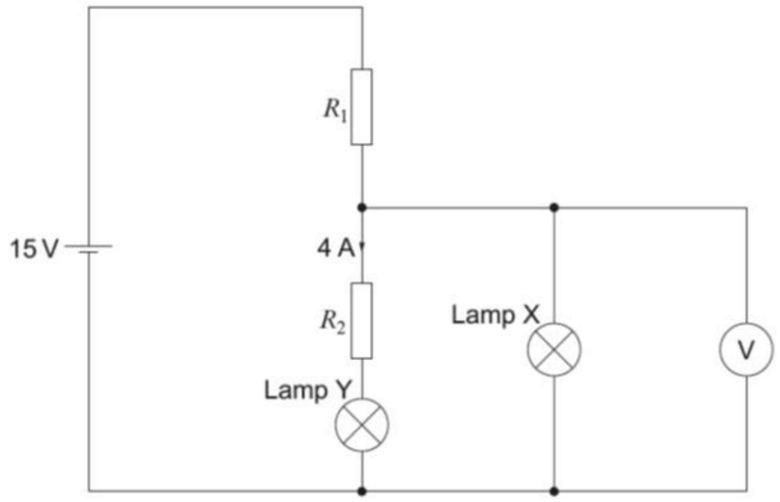
Lamp Y is labelled 6 V, 4 A. In the following circuit, the values of R_1 and R_2 are chosen so that both the lamps operate at their rated voltages.



(ii) Calculate R_1 and R_2. [6]

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(iii) The supply potential difference is now increased so it is greater than 15 V. Without further calculations, state and explain how, if at all, R_1 and R_2 should be changed if both lamps are to remain at their rated voltages. [3]

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(b) Lamp X (12 V, 24 W) is now powered using hydroelectricity. Water turns a turbine and a generator provides electrical energy to the lamp. If the water drops from rest from a height of 1.10 m, calculate the mass of water per second required to provide the power to the bulb. [3]

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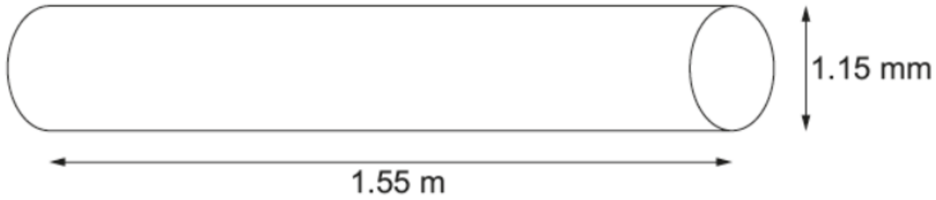
3. The metal wire shown has a resistance of 2.27 Ω.



(a) Calculate the resistivity of the material of the wire. [3]

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(b) Explain why the resistance of the wire increases as its temperature rises. [3]

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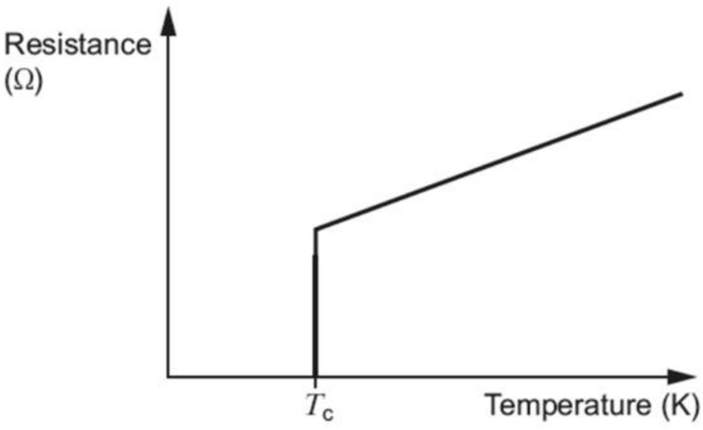
(c) The metal of the wire is cooled to a very low temperature using liquid helium and the following results obtained.



(i) What is the name of the quantity represented by T_C? [1]

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(ii) What is the resistivity of the metal at temperatures below T_C? [1]

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(iii) What potential difference is required to maintain a current in the metal when its temperature is below T_C? [1]

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(iv) Liquid helium is relatively expensive per litre. How can high temperature superconductors be cooled more cheaply? [1]

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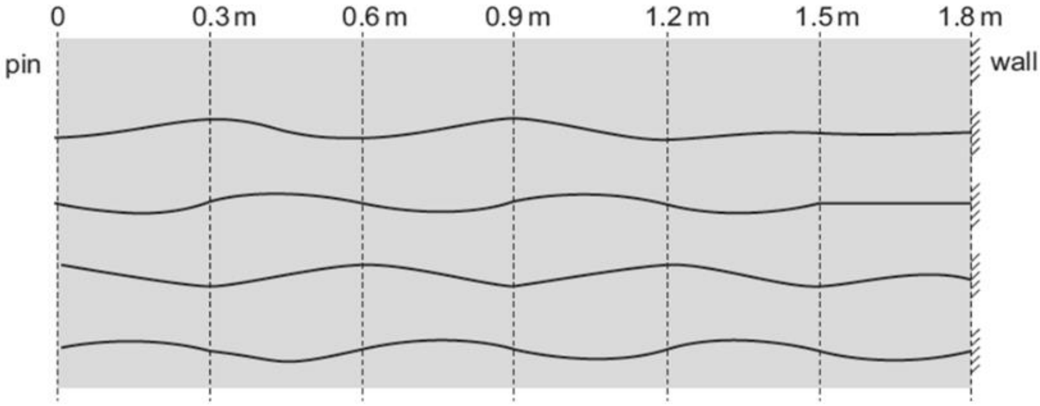
4. *(a)* A piece of string 1.8 m long is attached at one end to the pin of a vibration generator and, at the other end, to a rigid wall. The diagrams show the string at intervals of 0.0030 s, starting from shortly after the string has been connected to the signal generator (so the wave has not yet reached the wall).



Calculate:

(i) the speed of the waves; [2]

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(ii) the frequency. [3]

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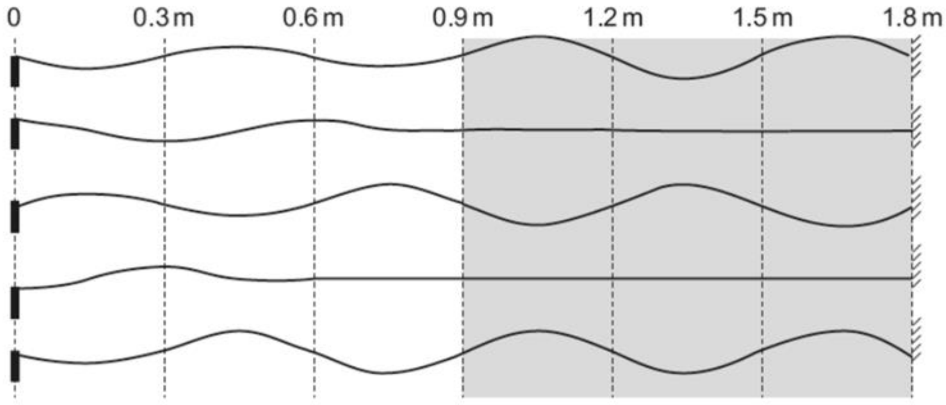
(b) The diagrams below show the set-up of part *(a)* after a stationary wave has started to develop in the string. **Refer only to the shaded area where the stationary wave has started to develop.**



(i) Describe how the amplitude of the stationary wave varies with distance along the string. [2]

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(ii) Explain whether or not the same description applies to the amplitude of the progressive wave in part *(a)*. [1]

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(iii) Explain in terms of interference how the stationary wave is formed. [2]

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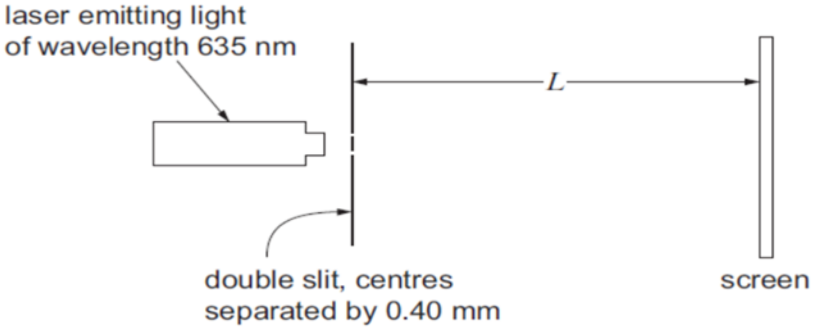
(c) A student attempts to demonstrate the interference of light using the set-up shown.



(i) At first the student places the screen a distance L from the slits of 0.080 m. Calculate the separation of the bright fringes on the screen. [2]

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(ii) Explain why this would not provide a clear demonstration of interference fringes, and by estimating relevant quantities suggest a suitable value for L. [2]

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5. *(a)* Complete in **words** the following version of Einstein's photoelectric equation. [2]

{Maximum KE of emitted electron} = {……………………………..} – {work function of surface}

(b) When violet light falls on a sheet of barium metal held in an insulating stand, the barium acquires a charge.

(i) Explain clearly which sign of charge would be acquired. [3]

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(ii) Explain, in terms of photons, why this effect does not occur if red light is shone on to the same surface. [2]

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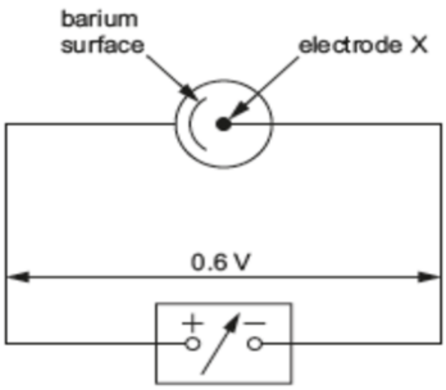
(c) The work function of barium is 4.0×10^{-19} J. Violet light of frequency 7.0×10^{14} Hz is shone on to a barium surface. Determine whether or not electrons would be able to reach the electrode **X** in the circuit below. [3]



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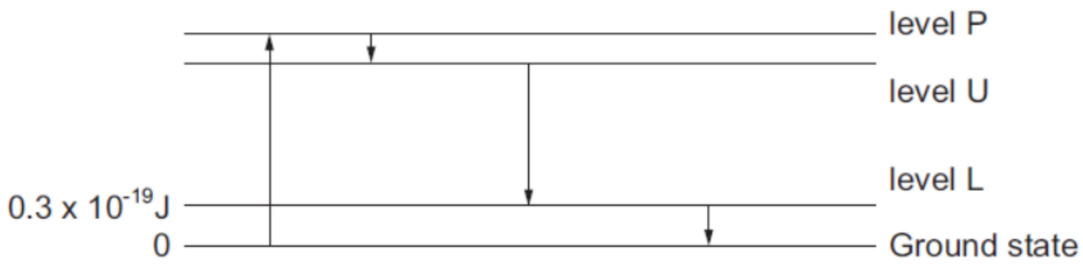
6. *(a)* A simplified energy level diagram is shown for a 4-level laser system. The arrows show the sequence of transitions which electrons make between leaving the ground state and returning to it.



(i) Label the transitions associated with (I) *pumping* and (II) *stimulated emission*. [2]

(ii) The wavelength of the output radiation from the laser is 1.05×10^{-6} m. Calculate the energy **above the ground state** of level U. [2]

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(b) Explain in detail how light amplification takes place for the above laser system. [6 QER]

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(c) (i) The force exerted by a beam of light is given by:

$$\text{force} = \frac{\text{power}}{\text{speed of light}}$$

Explain briefly why a laser of power 1.3×10^{15} W would experience a large recoil. [2]

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(ii) High power lasers can be used as weapons. A scientist developing such a system is assured that it will only be used for medical use. However, the company later sells her laser system for military applications. Discuss whether or not the scientist was treated ethically. [3]

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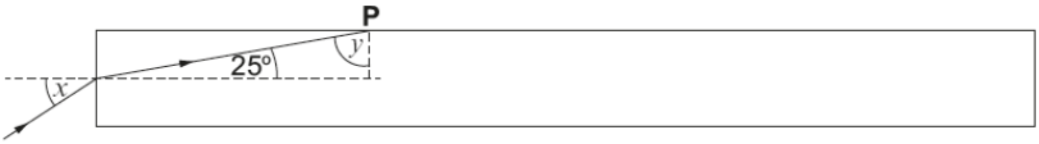
7. *(a)* A student directs a narrow beam of light on to one end of a glass block, as shown.



(i) Referring to the diagram, calculate the angle of incidence, x.
[Refractive index of air = 1.00; refractive index of the glass = 1.52.][2]

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(ii) Calculate the angle y. [1]

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(iii) Determine whether or not any light refracts into the air at point **P**. [2]

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(b) (i) Explain how multimode *dispersion* arises in an optical fibre. [2]

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(ii) What is the main difference in the dimensions of a monomode fibre compared with a multimode fibre? [1]

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WJEC Eduqas AS in PHYSICS

Data Booklet

A clean copy of this booklet should be issued to candidates for their use during each AS Physics examination.

Centres are asked to issue this booklet to candidates at the start of the AS Physics course to enable them to become familiar with its contents and layout.

Values

Fundamental electronic charge	e	=	$1{\cdot}60 \times 10^{-19}$ C
Mass of an electron	m_e	=	$9{\cdot}11 \times 10^{-31}$ kg
Acceleration due to gravity at sea level	g	=	$9{\cdot}81$ m s^{-2}
Gravitational field strength at sea level	g	=	$9{\cdot}81$ N kg^{-1}
Planck constant	h	=	$6{\cdot}63 \times 10^{-34}$ J s
Speed of light in vacuo	c	=	$3{\cdot}00 \times 10^{8}$ m s^{-1}
Stefan constant	σ	=	$5{\cdot}67 \times 10^{-8}$ W m^{-2} K^{-4}
Wien constant	W	=	$2{\cdot}90 \times 10^{-3}$ m K

$\rho = \dfrac{m}{V}$	$I = \dfrac{\Delta Q}{\Delta t}$
$v = u + at$	$I = nAve$
$x = \frac{1}{2}(u+v)t$	$R = \dfrac{V}{I}$
$x = ut + \frac{1}{2}at^2$	$P = IV = I^2R = \dfrac{V^2}{R}$
$v^2 = u^2 + 2ax$	$R = \dfrac{\rho l}{A}$
$\sum F = ma$	$V = E - Ir$
$p = mv$	$\dfrac{V}{V_{\text{total}}}\left[or \dfrac{V_{\text{OUT}}}{V_{\text{IN}}}\right] = \dfrac{R}{R_{\text{total}}}$
$W = Fx\cos\theta$	$T = \dfrac{1}{f}$
$\Delta E = mg\Delta h$	$c = f\lambda$
$E = \frac{1}{2}kx^2$	$\lambda = \dfrac{a\Delta y}{D}$
$E = \frac{1}{2}mv^2$	$d\sin\theta = n\lambda$
$Fx = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$	$n = \dfrac{c}{v}$
$P = \dfrac{W}{t} = \dfrac{\Delta E}{t}$	$n_1v_1 = n_2v_2$
efficiency = $\dfrac{\text{useful energy transfer}}{\text{total energy input}}$ × 100%	$n_1\sin\theta_1 = n_2\sin\theta_2$
$F = kx$	$n_1\sin\theta_C = n_2$
$\sigma = \dfrac{F}{A}$	$E_{k\,\max} = hf - \phi$
$\varepsilon = \dfrac{\Delta l}{l}$	$p = \dfrac{h}{\lambda}$
$E = \dfrac{\sigma}{\varepsilon}$	
$W = \frac{1}{2}Fx$	
$\lambda_{\max} = WT^{-1}$	
$P = A\sigma T^4$	

	leptons		quarks	
particle (symbol)	electron (e^-)	electron neutrino (ν_e)	up (u)	down (d)
charge (e)	-1	0	$+\frac{2}{3}$	$-\frac{1}{3}$
lepton number	1	1	0	0

Mathematical Information

SI multipliers

Multiple	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c

Multiple	Prefix	Symbol
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exa	E
10^{21}	zetta	Z

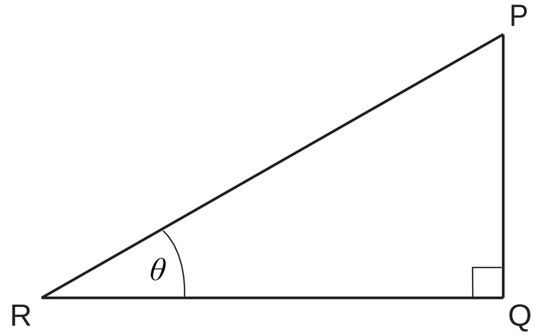
Areas and Volumes

Area of a circle = $\pi r^2 = \dfrac{\pi d^2}{4}$

Area of a triangle = $\frac{1}{2}$ base × height

Solid	Surface area	Volume
rectangular block	$2\,(lh + hb + lb)$	lbh
cylinder	$2\pi\, r\,(r + h)$	$\pi\, r^2\, h$
sphere	$4\,\pi\, r^2$	$\frac{4}{3}\pi\, r^3$

Trigonometry



$$\sin\theta = \frac{PQ}{PR}\,,\quad \cos\theta = \frac{QR}{PR}\,,\quad \tan\theta = \frac{PQ}{QR}\,,\quad \frac{\sin\theta}{\cos\theta} = \tan\theta$$

$$PR^2 = PQ^2 + QR^2$$

COMPONENT 1 – MOTION, ENERGY AND MATTER

MARK SCHEME

GENERAL INSTRUCTIONS

Recording of marks

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One tick must equate to one mark (except for the extended response question).

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Question totals should be entered onto the grid on the front cover and these should be added to give the script total for each candidate.

Marking rules

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Extended response question

A level of response mark scheme is used. Before applying the mark scheme please read through the whole answer from start to finish. Firstly, decide which level descriptor matches best with the candidate's response: remember that you should be considering the overall quality of the response. Then decide which mark to award within the level. Award the higher mark in the level if there is a good match with both the content statements and the communication statement.

Marking abbreviations

The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

cao	=	correct answer only
ecf	=	error carried forward
bod	=	benefit of doubt

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
1	*(a)*		Height from bench to ruler same at each end / accept use of spirit level / set square	1			1		1
	(b)		Arrow drawn through middle of the ruler labelled W	1			1		1
	(c)		When a system is in equilibrium (1) $\sum$ anticlockwise moments about a point = $\sum$ clockwise moments about the same point / resultant moment = 0 (1)	1 1			2		
	(d)	(i)	Weight of 250 g mass = 2.45 [N] (1) Application of the principle of moments e.g. $2.8 \times 0.8 = (0.6 \times 2.45) + (W \times 0.4)$ (1) Weight = 1.92[5] [N] (1)		1 1 1		3	3	3
		(ii)	1.92[5] + 2.45 = 2.8 + T T = 1.57[5] [N]		1		1	1	1
		(iii)	Resistance increases with length (or increases with decrease in cross-sectional area) (1) Extension is directly proportional to the force and therefore change of resistance (1)		1	1	2		2
			Question 1 total	**4**	**5**	**1**	**10**	**4**	**8**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	*(a)*	(i)	$ut + ½ (v - u)t$ / area of trapezium i.e. $½ (u + v)t$ (1) Displacement [in time t] (1)	 1	1		2	2	
		(ii)	Use of light gates (1) Measure time for a fixed distance (1)	1 1			2		2
	(b)	(i)	**Height of cliff:** Use of $x = ut + ½ at^2$ (1) ut = 0 **and** a = 9.8 [m s^{-2}] (1) x = 122.5 [m] (1) **Vertical velocity:** Use of $v = u + at$ (1) v = 49 [m s^{-1}] (1) **Initial horizontal velocity:** u = 2 [m s^{-1}]	1 1	1 1 1 1		6	4	
		(ii)	Straight diagonal line (1) Starting at (0,0) finishing at (5,49) (1) Horizontal line starting at (0,2) (1)		1 1 1		3	3	
	(c)		Increase time of flight (1) Reduce final velocity (1)			1 1	2		
			Question 2 total	**5**	**8**	**2**	**15**	**9**	**2**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
3	*(a)*	(i)	**Gravity:** Level the air track by using a spirit level for example (1) **Friction:** Floating on air so no contact (1)	1 1			2		2
		(ii)	Use of momentum before = momentum after (1) m = 0.175 [kg] (1)	1	1		2	2	2
		(iii)	Total kinetic energy before = 0.51 [J] (1) Total kinetic energy after = 0.27 [J] (1) Lost as heat (1)		1 1 1		3	2	3
	(b)		$v = \frac{(2.25 \text{x} 0.2)}{0.175}$ = 2.57 [m s^{-1}] (1) KE = ½ × 0.175 × 2.57^2 = 0.58 [J] (1) Too much KE, since 0.58 > 0.51 hence the statement seems to be true (1)			1 1 1	3	2	3
			Question 3 total	**3**	**4**	**3**	**10**	**6**	**10**

Question			Marking details	Marks available				Maths	Prac
				AO1	AO2	AO3	Total		
4	*(a)*		Energy cannot be created or destroyed, only converted to other forms	1			1		
	(b)	(i)	$\frac{1}{2}mv^2 = mgh$ shown (1) (no mark for $E_k = E_p$ only) Clear manipulation (1)	1	1		2	2	
		(ii)	v = 48.5 [m s^{-1}]		1		1	1	
	(c)		Actual v = [48.5 – 20% × 48.5] = 38.8 [m s^{-1}] (1) (**ecf**) Actual E_k = 210 762 [J] (1) **Either** (½ × 280 × (48.5)^2 – 210 762) **or** (280 × 9.8 × 120 – 210 762) (**ecf** on 48.5 or 210 762) [= 118 500 J] (1) =F × 1 400 (1) F = 85 [N] (1) Air resistance / friction between bobsleigh and ice (1)	1	1 1 1 1 1		6	5	
			Question 4 total	**3**	**7**	**0**	**10**	**8**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	*(a)*		**Method** M0 – Diagram of valid set-up. M1 – Add weights. M2 – Measure extension (no need to mention subtracting original length). M3 – Measure thickness of wire with micrometer / digital callipers. M4 – [Equal] weights added **or** (range) and intervals of measurements stated. M5 – Parallax avoided by eye being perpendicular to scale **or** wire close to the ruler. M6 – Thickness measured at various locations. M7 – Extra accuracy in measuring extension e.g. travelling microscope, two wires and Vernier scale etc. **Results** R0 – Plot graph of force-extension or stress-strain. R1 – Calculate the gradient. R2 – Use only the linear region **or** don't use past the elastic limit / limit of proportionality. **Calculations** C0 – Young modulus = gradient of the force-extension graph $\times \left(\frac{l}{A}\right)$ **or** gradient of the stress-strain graph. C1 – A point is taken and values put into the relevant formula to calculate Young modulus e.g. $\left(\frac{Fl}{Ax}\right)$.						.

			5-6 marks All of M0 – M3 and 2 from M4 – M7 are present. All of R0 - R2 are present. Either C0 or C1 is present. There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured. **3-4 marks** All of M0 – M3 are present. R0 is present. C1 is present. There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure. **1-2 marks** Expect any 2 from M0 – M3. Either R0 or C1 is present. There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure. **0 marks** No attempt made or no response worthy of credit.	6			6	1	6
	(b)	(i)	Clear attempt to find gradient or values of stress/strain from graph (ignore errors in powers of 10) (1) E = 208 GPa (accept 204 – 212 GPa) (1) **UNIT mark**			1 1	2	2	2
		(ii)	Benefit – Young modulus or breaking stress obtained over a greater range (1) Risk – Far greater energy and risk of injury (1)			1 1	2		2
			Question 5 total	**6**	**0**	**4**	**10**	**3**	**10**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
6	*(a)*	(i)	$A = 4\pi(7.22 \times 10^8$ [m]$)^2$ = [6.55×10^{18} [m^2]] (1) $P = 5.67 \times 10^{-8} \times$ area attempt $\times 5\,970^4$ (1) [W] $P = 4.72 \times 10^{26}$ [W] **and** suitable comment (allow consistency **ecf on slips)** (1) [One mark to be lost for slips e.g. powers of 10, factors of 2, 4, π] Accept other alternatives e.g. finding P from A and T or finding A from P and T			1 1 1	3	3	
		(ii)	$I = \frac{\text{power}}{4\pi(1.8\text{x}10^{17})^2}$ (1) $I = 1.16 \times 10^{-9}$ W m^{-2} **UNIT** mark (1) [penalty of 1 mark for slips of 10^n, 4, π etc no penalty if same slip as in (i)]	1	1		2	2	
		(iii)	$\lambda_{max} = \frac{2.9\text{x}10^{-3}}{5970} = 4.86\text{x}10^{-7}$ [m] (1)		1		1	1	
		(iv)	$n\lambda = d\sin\theta$ used (1) Hence $\sin\theta$ (or θ) depends on the wavelength or $\lambda \times \sin\theta$ or $\lambda \times \theta$ for small angles (1)	1	1		2		2
	(b)		P goes up and T goes down and then A goes up (1) Because $A = \frac{P}{\sigma T^4}$ or any convincing explanation (1)		1 1		2	1	
			Question 6 total	**2**	**5**	**3**	**10**	**7**	**2**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
7	*(a)*		Neutrino: weak only (1) [No mark if additional tick(s)] Electron: weak and e-m only (1) u quark: strong, weak, e-m (1)	1 1 1			3		
	(b)	(i)	$\left(-\frac{1}{3}\right)+\left(-\frac{2}{3}\right)=\left(-\frac{1}{3}\right)+\left(-\frac{1}{3}\right)+\left(-\frac{1}{3}\right)$ **or** equivalent		1		1		
		(ii)	u: 0 $\rightarrow$ 1 + (-1) **or** equivalent (1) d: 3 $\rightarrow$ 2 + 1 **or** equivalent (1)		1 1		2		
		(iii)	Not a weak interaction stated and then qualified by: no change of quark flavour (1) no neutrino involvement (1)			2	2		
	(c)	(i)	uuu		1		1		
		(ii)	$u\bar{d}$		1		1		
			Question 7 total	**3**	**5**	**2**	**10**	**0**	**0**

COMPONENT 1: MOTION, ENERGY AND MATTER

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	4	5	1	10	4	8
2	5	8	2	15	9	2
3	3	4	3	10	6	10
4	3	7	0	10	8	0
5	6	0	4	10	3	10
6	2	5	3	10	7	2
7	3	5	2	10	0	0
TOTAL	**26**	**34**	**15**	**75**	**37**	**32**

COMPONENT 2 – ELECTRICITY AND LIGHT

MARK SCHEME

GENERAL INSTRUCTIONS

Recording of marks

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Question		Marking details	Marks available				Maths	Prac
			AO1	AO2	AO3	Total		
1	*(a)*	$v = \dfrac{I}{nAe}$ or correct substitution (1) v = 1.30 × 10^{-4} [m s^{-1}] (-1 for slips in powers of 10) (1) $t = \dfrac{5}{1.30\text{x}10^{-4}}$ = 3.85 × 10^{4} s (1) **UNIT mark**		1 1 1		3	3	
	(b)	CSA decreased (accept diameter) but n and e constant (1) v increased **and** t decreased (1)			1 1	2	1	
		Question 1 total	**0**	**3**	**2**	**5**	**4**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	*(a)*	(i)	2 [A]		1		1		
		(ii)	Voltmeter reading = 12 [V] (1) pd across R_2 = 6 [V] (1) $R_2 = \frac{6}{4}$ = 1.5 [Ω] (1) pd across R_1= 3 [V] (1) current in R_1= 6 [A] (1) $R_1 = \frac{3}{6}$ = 0.5 [Ω] (1)		1 1 1 1 1 1		6	2	
		(iii)	Currents must stay the same or pds across lamps stay the same (1) pd across R_1 must increase (1) R_1 increases but R_2 stays the same (1)			1 1 1	3		3
	(b)		Use of mgh to find the gravitational potential energy (1) $\frac{mgh}{t} = 24$ (1) $\frac{m}{t} = \frac{24}{9.81\text{x}1.1}$ = 2.2 [kg s^{-1}] (1)	1	1 1		3	3	
			Question 2 total	**1**	**9**	**3**	**13**	**5**	**3**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
3	*(a)*		$\rho = \frac{RA}{l}$ used (1) $A = \pi r^2$ used **or** $A = \frac{\pi d^2}{4}$ (1) Answer = 1.52 × 10^{-6} Ω m (1) **UNIT mark**	1 1	1		3	3	
	(b)		More lattice (or ion or atom) vibrations **or** electrons move faster (1) Therefore collisions with electrons occur more often **or** less time between collisions (1) So the drift velocity decreases **or** electrons take longer to travel given distance (1)	1 1 1			3		
	(c)	(i)	(Superconducting) transition temperature **or** critical temperature	1			1		
		(ii)	0 or negligible or infinitesimal or equivalent	1			1		
		(iii)	0 or negligible or infinitesimal or equivalent		1		1		
		(iv)	By using liquid nitrogen	1			1		
			Question 3 total	**8**	**2**	**0**	**10**	**3**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4	*(a)*	(i)	Divide a distance by corresponding time **or** implied (1) v = 50 [m s^{-1}] (1)		1 1		2	1	
		(ii)	λ = 0.6 [m] **or** T = 0.012 [s] (1) $\frac{v}{\lambda}$ **or** $\frac{1}{T}$ **computed** (1) f = 83 [Hz] **ecf** on v (1)	1	1 1		3	3	
	(b)	(i)	Amplitude goes up and down regularly (1) Must imply periodic variation. Nodes occur at any 2 from 0.9 [m], 1.2 [m], 1.5 [m], 1.8 [m] **or** antinodes equivalent given (1)	1	1		2		
		(ii)	No, for progressive wave amplitude doesn't vary with distance **or** falls steadily		1		1		
		(iii)	Wall reflects waves (1) Waves from pin interfere with reflected waves **or** waves travelling in opposite directions interfere (1)	1 1			2		2
	(c)	(i)	Use of double slit interference equation (1) Fringe separation = 0.13 [mm] (1)	1	1		2	1	
		(ii)	Fringes too close together to see (1) Suitable choice of fringe separation e.g. 2 mm backed up by a calculation e.g. $L = \frac{2\text{x}10^{-3}\text{x}0.4\text{x}10^{-3}}{635\text{x}10^{-9}} = 1.25$ [m] (1) Accept 1 m $\leq L \leq$ 5 m			2	2		2
			Question 4 total	**5**	**7**	**2**	**14**	**5**	**4**

Question			Marking details	Marks available				Maths	Prac
				AO1	AO2	AO3	Total		
5	*(a)*		Energy (1) of photon (1) **or** Planck constant (1) × frequency (1)	2			2		
	(b)	(i)	Electrons are emitted from barium (1) Barium acquires positive charge (1) Explanation of sign e.g. barium neutral **or** electrons are negative **or** +ive ions no longer balanced by –ive electrons (1)	1	1 1		3		
		(ii)	Photon energy is less than work function of barium (1) **Or** photon frequency is less than threshold frequency (or equivalent statements) So no electrons are emitted from the barium (1)			1 1	2		
	(c)		Use of photoelectric equation to determine $E_{k\,\text{max}} = 6.5 \times 10^{-20}$ [J] (1) Determining $V = 0.41$ [V] from $E_{k\,\text{max}}$ (1) Correct conclusion – NO: electrons will not reach X (1)			1 1 1	3	2	3
			Question 5 total	**3**	**2**	**5**	**10**	**2**	**3**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
6	*(a)*	(i)	Ground state to level P labelled I **or** pumping (1) Level U to Level L labelled II **or** stimulated emission (1)	1 1			2		
		(ii)	$E = \frac{hc}{\lambda}$ = 1.9 × 10^{-19} [J] (1) Energy of level U = 2.2 × 10^{-19} [J] (1)		1 1		2	2	
	(b)		**Energy levels** E0 – More electrons in higher energy levels than lower energy levels. E1 – Population inversion mentioned. E2 – Population inversion between U and L. E3 – L is initially (nearly) empty. E4 – Transition from P to U is instantaneous. E5 – U is a metastable state **or** long lived. E6 – Transition from L to the ground state is instantaneous. **Stimulated emission** S1 – Incident photon causes an electron to drop. S2 – Photon emitted when an electron drops. S3 - -Stimulated emission mentioned. S4 – After stimulated emission there are 2 photons instead of 1 photon. S5 – Incident photon of correct energy **or** frequency **or** wavelength is required. S6 – Intensity or number (can increase exponentially). **5-6 marks** All of E0 – E3 and 1 from E4 – E6 are present. All of S1 - S6 are present. There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.	3	3		6		

			3-4 marks 2 or 3 from E0 – E3 are present. 3 from S1 – S6 are present. There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure. **1-2 marks** 1 from E0 – E3 is present. 1 or 2 from S1 – S6 are present. There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure. **0 marks** No attempt made or no response worthy of credit.						
	(c)	(i)	Equation used i.e. $\frac{1.3\text{x}10^{15}}{3\text{x}10^{8}}$ = [4.3 × 10^6 N] (1) Recoil explained using Newton's 3rd Law i.e. equal and opposite large force on beam by reflecting surface (1)	1	1		2		
		(ii)	Consideration of the ethical issues involved from the perspective of the scientist (1) Consideration of the lack of ethics of the company (1) Conclusion that is consistent with the argument. (1)		1 1	1	3		
			Question 6 total	**6**	**8**	**1**	**15**	**2**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
7	*(a)*	(i)	[1.00] $\sin x = 1.52 \sin 25°$ **or** equivalent **or** implied (1) $x = 40°$ (1)		1 1		2	2	
		(ii)	65°		1		1	1	
		(iii)	1.52 $\sin C$ = 1.00 **or** equivalent **or** 1.52 $\sin$ 65° > 1 (1) C = 41° [so 65° > C] so no refraction **or** no y for which $\sin y$ = 1.52 $\sin$ 65°, so no refraction (1)			1 1	2	2	
	(b)	(i)	Light [pulses] at [many] different angles to axis **or** by straighter and more zigzag routes **or** equivalent (1) Leading to a spreading out in time of a pulse. **Accept** overlap of pulses, muddling of pulses (1)	1 1			2		
		(ii)	The core is thinner	1			1		
			Question 7 total	**3**	**3**	**2**	**8**	**5**	**0**

COMPONENT 2: ELECTRICITY AND LIGHT

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	0	3	2	5	4	0
2	1	9	3	13	5	3
3	8	2	0	10	3	0
4	5	7	2	14	5	4
5	3	2	5	10	2	3
6	6	8	1	15	2	0
7	3	3	2	8	5	0
TOTAL	**26**	**34**	**15**	**75**	**26**	**10**