WJEC
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MS4
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GCE MARKING SCHEME

PHYSICS (NEW)
AS/Advanced

SUMMER 2009

INTRODUCTION

The marking schemes which follow were those used by WJEC for the Summer 2009 examination in GCE PHYSICS (NEW). They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

Notes on the interpretation of these marking schemes

The marking schemes, whilst reasonably complete do not give **all** the answers which were credited by the examiners. It is hoped that the schemes are self-explanatory, though they will need to be read alongside the question papers. The following clarifications may be of use:

Statements in brackets [ ] are exemplification, alternatives **or** statements which, whilst desirable in an answer were not required on this occasion for full marks. [accept….] indicates that, whilst not a good answer, it was accepted on this occasion.

The numbers in parentheses ( ) are the marks, usually 1, for each response.

e.c.f. stands for *error carried forward,* and indicates that the results of a previous (incorrect) calculation will be treated as correct for the current section. i.e. the mistake will only be penalised once. The principle of error carried forward is generally applied, even when not explicitly stated. It may also be applied *within* a calculation where a mistake is deemed to be an arithmetic slip and not an error of principle. Examples of this are powers of 10, or a factor of 4 slip when applying πr^2.

The expression [or by impl.] indicates that the mark is credited when subsequent credit-worthy working or answer demonstrates that this idea/equation has been used.

In general the physics of the answer needs to be correct but specific expressions or methods are often not required. The expression [or equiv.] emphasises that the particular idea, could be expressed in several different ways.

Incorrect or absent units are not always penalised; units are present in the mark scheme for completeness. Where ((**unit**)) appears it indicates that the unit is required for the mark to be awarded but attracts no separate mark. A (1) following the unit, in addition to a (1) following the numerical part of the answer, indicates that the unit itself attracts a mark.

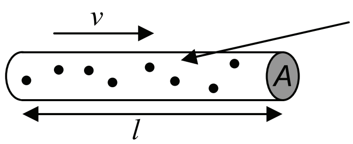
<u>Example</u>: 25 GPa (1) ((**unit**)) indicates that the unit (or correct alternative. e.g. $2{\cdot}5 \times 10^{10}$ N m^{-2}) is a requirement for the mark;

25 (1) GPa (1) indicates that the numerical part of the answer [$2{\cdot}5 \times 10^{10}$] and the unit Pa each attract a mark. In this case, an answer of 25 GN would be awarded the first mark but not the second, it being considered that the SI multiplier is numerical.

Unless otherwise stated, no penalties for excessive significant figures are applied in these papers. Significant figures are usually assessed only in the practical units.
N.B. This Mark Scheme is not a set of Model Answers.

Question			Marking details	Marks Available
1	*(a)*		Rate of change [accept: increase] of velocity [**not** speed]. accept: $\frac{v-u}{t}$ or $\frac{\Delta v}{t}$ or $\frac{\Delta v}{\Delta t}$ (not $\frac{v}{t}$)	1
	(b)	(i)	Both ΣF calculated correctly (20 N and 4 N) (1) Use of $a = \frac{\Sigma F}{m}$ (1) Accelerations = 10 m s^{-2} and 2 m s^{-2} (e.c.f.) (1) [Accept answers based upon calculating resultant acceleration]	3
		(ii)	Diagram with forces shown in opposition (1) and horizontal (1) [B.o.d. on plan-view forces unless clearly incorrect]	2
	(c)		Statement / Must be true / Could be true / Cannot be true: xxxxxxxxxxx – Cannot be true ✓ xxxxxxxxxx – Could be true ✓ xxxxxxxxx – Could be true ✓ xxxxxxxxxx – Cannot be true ✓	4
				[10]
2.	*(a)*		Same p.d. in both branches (1) 2 × resistance in upper branch (or converse) (1) } Correct qualitative ½ current in upper branch (or converse) (1) } answer → 1 mark Currents add up to 0.12 A (1)	4
	(b)	(i)	4.8 V	1
		(ii)	9.6 V	1
	(c)	(i)	Correct use of $R = \frac{V}{I}$ (1) [or by implication] = 120 Ω (1) [e.g. $\frac{4.8}{0.04}$ ✓, $\frac{9.6}{0.08}$ (✓ b.o.d.) or $\frac{9.6}{0.4}$ ✓ **not** $\frac{9.6}{1.2}$ ×]	2
		(ii)	$\frac{1}{R} = \frac{1}{R_A} + \frac{1}{R_B}$ [or equiv.] **and** use of correct values of R_A and R_B. [or by impl.](1) R = 80 Ω (1) **or** $R = \frac{9.6}{0.12}$ (1) =80 Ω (1)	2
				[10]

Question			Marking details	Marks Available
3	*(a)*	(i)	2.4 V	1
		(ii)	$\frac{V}{V_{\text{TOTAL}}} = \frac{R}{R_{\text{TOTAL}}}$ or $V_{\text{OUT}} = \frac{R_1}{R_1 + R_2} V_{\text{IN}}$, selected [or by impl.] Substitution, e.g. $3.6 = \frac{225}{225 + R_2} 6.0$ (1) [or by impl.] Manipulation (1); R_2 = 150 Ω (1) **Or** – from 1st principles: $\frac{3.6}{225}$(1) = 0.016 A (1) ; $\frac{2.4}{0.016}$(1) = 150 Ω (1) [or $\frac{6.0}{0.016} = 375\,\Omega$ then 375 – 225 = 150 Ω]	4
	(b)	(i)	R_2 changed to 1500 Ω	1
		(ii)	Initial current = $\frac{6.0}{375\text{e.c.f.}}$ (1) = 0.016 A (1) Final current = 0.0016 A (1) [**or** accept answer based upon a good qualitative argument] N.B. Calculation of final current → only 2 unless current previously calculated]	3 **[9]**
4.	*(a)*		Collisions between electrons and lattice [or atoms of the conductor or [metal] ions] (1) Kinetic energy of electrons transferred to lattice (1) <u>No collisions</u> (and ∴ no energy transfer) in superconductors) (1) [accept: interactions instead of collisions]	3
	(b)	(i)	–190°C	1
		(ii)	A→B [accept –250 - –190, or “temperatures below –190] [full region required]	1
	(c)		liquid nitrogen [accept: liquid helium]	1 **[6]**

Question			Marking details	Marks Available
5.	*(a)*		Flow of charge	1
	(b)	(i)	 n [free] electrons per unit volume [or electron density] [or in written answer] Diagram (1) Volume of conductor = Al Number of free electrons = nAl Total charge flowing within l = $nAle$ } (1) [Accept without [ ] **if** diagram is clear] $I = \frac{nAle}{t}$ (1) and $v = \frac{l}{t}$ (1)	4
		(ii)	$v = \frac{I}{nAe}$ $= \frac{3.0}{5.0\times10^{28}\times2\times10^{-6}(1)\times1.6\times10^{-19}} = 1.9\times10^{-4}\ \text{m s}^{-1}$ ((**unit**))(1)	2
		(iii)	I. ……the same as II. …….half…..	1 1 **[9]**
6	*(a)*		Units of LHS = N = kg m s^{-2} Units of RHS = (kg m^{-3} . m^2) (+ manip.)(1) × (m^2 s^{-2}) (1) $v^2 = \frac{2.8\times10^4}{1.2\times15\times4.2}$ (1) [or by impl.] v = 19.2 m s^{-1} (1)	3 2
	(b)	(i)	Centre of gravity	1
		(ii)	Bottom of near-side wheel labelled as 'pivot' F_{wind} × 2.1 (1) = 1.0 × 10^5 × 1.4 (1) [or by impl.] ∴ F_{wind} = 67 kN (1) [accept 66 kN ✓b.o.d.]	1 3 **[10]**

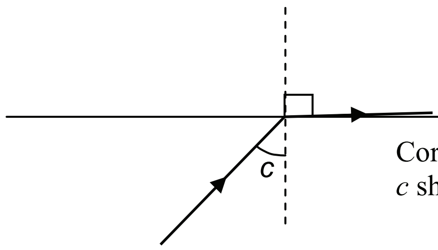
Question			Marking details	Marks Available
7.	*(a)*	(i)	Ball is seen to stay directly in front of the passenger [**or** clearly implied by 2nd statement]. (1) No [horizontal] forces on ball [so horizontal speed is constant, with the same value as the train] (1)	2
		(ii)	Observer sees the ball moving in the same direction as the train [with the same speed]. [Accept: "moving with the train."]	1
	(b)		Passenger sees the ball accelerating [or moving] 'backwards' [or towards the rear of the train]. Observer sees the ball moving in the same direction as the train with decreasing speed. (1) Net [horizontal] force on ball [due to air resistance] towards the back of the train. (1)	3
		(i)	The graph is symmetrical / up time = down time.	1
		(ii)	$x = 11$ m ; $t = 1.5$ s (1) $x = \frac{u+v}{2}t$, **or** $11 = \frac{u}{2} \times 1.5$ (1) **or** $v^2 = u^2 + 2ax$ **or** $0 = u^2 + 2 \times 9.81 \times 11$ (1) **or** $x = ut + \frac{1}{2}at^2$, **or** $11 = 1.5u + \frac{1}{2}\, 9.81 \times 1.5^2$ (1) $\therefore u = 14.7$ m s^{-1} (1) [accept $v = u + at$ with $v = 0$ and $t = 1.5$ s]	3
		(iii)	**Graph**: v axis – 20 to + 20 e.c.f. (1) Intercept on v axis 14.7 m s^{-1} e.c.f. (1) Straight line graph (1) to intercept time axis of 1.5 s (1) Graph continued straight beyond 1.5 s to negative values of v (1)	5 **[15]**

Question			Marking details	Marks Available
8	*(a)*		Energy cannot be created or destroyed (1) …[only] changed from one form into another (1) [Accept: total energy [in the Universe] is constant for 1st mark]	2
	(b)	(i)	Area under graph = energy stored (1) [or by impl.] x = 70 m chosen (1) [or by impl.] Elastic potential energy [= ½ ×1600 × 70] = 56 kJ (1) **Alternative:** calculation of k [22.9 N m^{-1}] or left as, e.g. $\frac{1600}{70}$ ✓ Use of x = 70 m to calculate energy ✓; Energy stored = 56 kJ ✓	3
		(ii)	70 kJ – 56 kJ (e.c.f.) (1) = mgh (1) [**Or** E_p(grav) lost = 60×9.81×96 (1) [= 56 kJ]. ∴ 14 kJ = mgh (1)] ∴ h = 23.8 m (1) **Alternative:** 7.0 × 10^4 J = mgh ✓→ h = 118.92 m ✓ Then subtract 96 m → 22.92 m ✓	3
		(iii)	Tension in 'bungee' = weight of Jumper = 60 × 9.81 [= 589 N] (1) From graph x = 26 [± 1] m (1) [or from k → 25.8 m] ∴ d = 52 m. (1)	3 **[11]**

PH2

Question			Marking details	Marks Available
1	*(a)*	(i)	0.04[0 m]	1
		(ii)	T = 0.20 s [or by impl.] (1) f = 5.0 (1) Hz (1) (e.c.f. on T)	3
	(b)		If peak arriving at 0.050 s at **B** is the peak that passed **A** at 0.00 s [or equiv] (1), $v = \frac{0.30\,\text{m}}{0.050\,\text{s}}$ [free-standing](1) [Accept: **B** could be $\lambda/4$ from **A**, so λ = 1.2 m (1); $v = f\lambda$ = 5.0 × 1.2 m s^{-1}(1).]	2
	(c)	(i)	Distance [along the direction of wave propagation] between two [consecutive] point (1) oscillating in phase (1) ["Distance between two peaks / troughs → 1]	2
		(ii)	λ = 1.2 m (e.c.f. on f)	1
				[9]

Question			Marking details	Marks Available
2	*(a)*	(i)	Wavefronts [or waves] from each slit spread out (1) [accept: waves diffract at each slit] …….and overlap (1) [or superpose or interfere].	2
		(ii)	I. Sources which emit waves, which are at the same point in their cycle at the same time [accept: "emit peaks at the same time"] II. A maximum on central axis **or** microwave source central w.r.t. S_1 and S_2.	1 1
		(iii)	Correct insertion of values into $\lambda = \frac{ay}{D}$ (1) [or by implication] λ = 0.012 m (1)	2
		(iv)	I. Constructive interference at **P** (1) [accept: waves reinforce] So waves are in phase (1) [Accept: phase difference = $2\pi n$ etc]	2
			II. $S_1P - S_2P = n\lambda$ [for $n = 0, \pm1, \pm2….$] (1) [$n = 0$ for central maximum, $n = 1$ for next one out from centre], $n = 2$ at P. (1) So $S_1P - S_2P$ = 0.024 m (1) [Geometric method based upon Pythagoras ✓✓✓ if correct]	3
	(b)		Interpose a grille of parallel metal rods and rotate. (1) The signal strength varies. (1) [Accept rotation of the sensor / ærial]	2
	(c)		Any 2 × (1) of: • the radiation penetrates the potato ✓ • absorbed within the potato, heating interior ✓ • waves transfer energy [or equiv] ✓ • water content heated / water molecules made to vibrate more ✓	2
				[15]

Question			Marking details	Marks Available
3	*(a)*		 Correctly drawn ray (1) *c* shown correctly (1)	2
	(b)		$1.520\sin\theta_A = 1.550\sin\theta_B$ (1) [or by impl.] $\theta_A = 90°$, $\theta_B = c$ (1) [or by impl.] $c = 79\ °$ (1)	3
	(c)	(i)	11 ° [± 1°] e.c.f.	1
		(ii)	Some enters the cladding (1) …. and is lost (1) Some is reflected but lost on subsequent reflections (1).	3
	(d)		Paths at different angles to the axis are of different lengths (1). Data travelling on different paths arrive different times [or by clear implic.](1) so data is muddled / smeared out / data pulses overlap (1)	3 **[12]**
4.	*(a)*	(i)	Photons hit the caesium surface. (1) Electrons knocked out (1) • Electrons cross vacuum to collecting electrode✓ • returned to the caesium via cell and meter✓ • constituting an electric current✓ • aided by [p.d. of] cell ✓ } any 1 ×	3
		(ii)	Larger current (1) because more photons arrive [per second] (1)	2
	(b)	(i)	• Power supply polarity needs reversing ✓ • Voltage needs to be variable ✓ • voltmeter needed ✓ } any 2 ×	2
		(ii)	$E_{k\,max} = 6.6 \times 10^{-34} \times 8.6 \times 10^{14} - 3.1 \times 10^{-19}$ J (1) $= 2.6 \times 10^{-19}$ J (1)	2
		(iii)	$E_k = \frac{1}{2}mv^2$ <u>with</u> $m = 9.1 \times 10^{-31}$ kg (1) Convincing substitution of $v = 7.5 \times 10^5$ m s^{-1} to obtain $E_k = 2.6 \times 10^{-19}$ J **or** vice versa (1)	2
		(iv)	Intensity doesn't affect individual photon energies [or equiv.]	1 **[12]**

Question			Marking details	Marks Available
5	*(a)*	(i)	$\Delta E = \frac{hc}{\lambda}$ [**or** $\Delta E = hf$ **and** $f = \frac{c}{\lambda}$] [**or** by impl.] (1) $\Delta E = 1.9 \times 10^{-19}$ J [or by impl.] (1) $\lambda = 1.0 \times 10^{-6}$ m (1) ((**unit**))	3
		(ii)	infrared	1
		(iii)	[Incident] photon causes emission of a photon (1) + 2 × (1) of: • Incident photon energy needs to be $E_A - E_B$ [or equiv.] ✓ • Emitted photon has same energy (**or** λ or f) as incident photon.✓ • Emitted photon in phase with incident photon. ✓	3
		(iv)	Two photons where there was one before [and the process repeats]	1
	(b)	(i)	More electrons in level A than in level B.	1
		(ii)	If more electrons in B than A, absorption of photons is more likely than stimulated emission.	1
		(iii)	B almost empty [because electrons 'fall' from B to ground state] (1) So not many electrons needed in A to cause population inversion. (1)	2 **[12]**
6.	*(a)*		Weak (1) because neutrinos only feel the weak force [as well as gravity] (1) [**Or** because the weak force alone can cause a change of quark type].	2
	(b)	(i)	Ar has 1 more proton than Cl, but electron also appears [so net charge is conserved]. [Or Ar appears as + ion (and picks up an electron)]	1
		(ii)	ν_e on left is a lepton [**or** has a lepton number of 1]; electron on right is a lepton [**or** ….]	1
	(c)		(i) 20 (ii) 19 [both answers correct]	1
	(d)	(i)	udd	1
		(ii)	In version at top, neutron is lost and proton is gained. (1) [**or** $n + \nu_e \rightarrow p + e^-$] We can regard this as a neutron losing a d [quark] and gaining a u [quark] (1)	2 **[8]**

Question			Marking details	Marks Available
7	*(a)*		[A body with a surface that] absorbs all radiation[accept: 'light'] falling upon it.	1
	(b)	(i)	Area of sphere of radius 8.1×10^{16} m = $4\pi \times (8.1 \times 10^{16})^2$ (1) [= 8.2×10^{34} m^2] Power reaching surface = $1.2 \times 10^{-7} \times 4\pi \times (8.1 \times 10^{16})^2$ W (1) [Or reverse argument from power to intensity, if clear] e.c.f on numerical factors in area [not for use of $2\pi r$]	2
		(ii)	Absorption / scattering [of radiation by interstellar dust / gas]	1
		(iii)	$9.9 \times 10^{27} = 5.67 \times 10^{-8} A \times 9900^4$ [or by impl.] (1) (Data subst. at any stage) Transposition at any stage (1) $r = 1.2 \times 10^9$ m (1) [e.c.f. on A, if πr^2 used]	3
		(iv)	Curve of correct general shape sketched which is • lower throughout (1) • has a maximum at longer λ (1)	2
	(c)		Atoms / ion / [accept molecules]of a star's atmosphere (1) [**or** interstellar space **or** Earth's atmosphere] absorb specific wavelengths (1) [from the continuous spectrum] promoting electrons to higher energy level (1) [**or** re-emitting in all directions]	3
				[12]

GCE AS/A level

1323/01 – D **New AS**

PHYSICS

PH3: PRACTICAL PHYSICS

MARKING SCHEME

Tests 1 and 2

NOT TO BE OPENED UNTIL

P.M. WEDNESDAY, 29 April 2009

CJ*(S09-1323-01D)

GENERAL INSTRUCTIONS FOR MARKERS

1. Mark in red ink. Correct any marking mistakes clearly.

2. To aid moderation, please adopt the principle of "one tick per mark". Generally the tick should be placed as close as possible to the work which attracts the credit.

3. **Marking of tables and graphs**. To aid moderation please indicate with either a column or row of ticks and crosses which of the marking points in the scheme have been awarded (e.g. ✓✓×✓×, if the 1st, 2nd and 4th points have been awarded but not the 3rd and 5th).

4. Write in the marks awarded for each question part in the margin next to the question part and also the total marks awarded for the question in the box at the end of the question.

5. Transfer the total marks for each question to the table on the front page of the question paper.

6. Where two or more people at a centre mark candidates work this should be internally moderated. Changes to marking as a result of internal moderation should be clearly made in a distinctive ink, e.g. green or purple. Ensure that the changed mark is transferred to the front of the question paper and that the C-form mark reflects this change.

7. The principle of *error carried forward* (e.c.f.) generally applies. This means that a candidate's mistake is, where possible, only penalised once. The results of an incorrect calculation are treated as correct in subsequent work. To aid moderation, where a candidate is credited under this principle, markers are asked to annotate "ecf".

8. Unless stated in the question (e.g. using the instruction "show that") it is not a requirement that all working be shown. A correct result alone, with no indication that this arose by chance or multiple mistakes, attracts full credit. Where the use or statement of an equation forms one of the marking points (e.g. in Task A2*(c)*), a correct result allows this mark to be awarded "by implication". In these cases, a cluster of the appropriate number of ticks by the answer suffices for annotation.

9. Excessive significant figures are only penalised where indicated in the marking scheme. The same is true for missing or incorrect units.

TEST 1 – MARK SCHEME

SECTION A

TASK A1 (15 minutes)

Repeat readings are not required for this task.

(a) (i) You are provided with 10 identical microscope slides. Use the equipment available to determine the mean slide thickness as accurately as possible. [2]

Total thickness of <u>ten slides</u> measured (1)

Correct mean value of 1 slide to ±0·2 mm of centre value (1)

(ii) State the resolution of the ruler you used to measure the thickness. [1]

0.1cm (or equivalent) with units (1)

(iii) Using this resolution, determine the percentage uncertainty in your result. [1]

correct calculation (1) $\left[\text{e.c.f.} = \frac{(a)\text{(ii)}}{\text{Thickness of 10 slides}}\right]$

For example if total thickness is 12mm, then

$$\text{Percentage uncertainty} = \frac{1}{12}\ 100 = 8(\cdot 3)\%$$

$$\text{Note:} \quad \frac{\text{resolution}}{\text{mean thickness of 1 slide}} \rightarrow 0$$

(b) Measure the length and width of one of the slides, and again using the resolution as your uncertainty calculate a percentage error for each measurement. [2]

correct length ***and*** *width to within 2mm (1)*

% uncertainties both correctly determined (1)

(c) Calculate the volume of one of the slides. Give this value along with the total percentage uncertainty in your calculation. [2]

volume correct ***with consistent units*** *(1) (e.c.f.)*

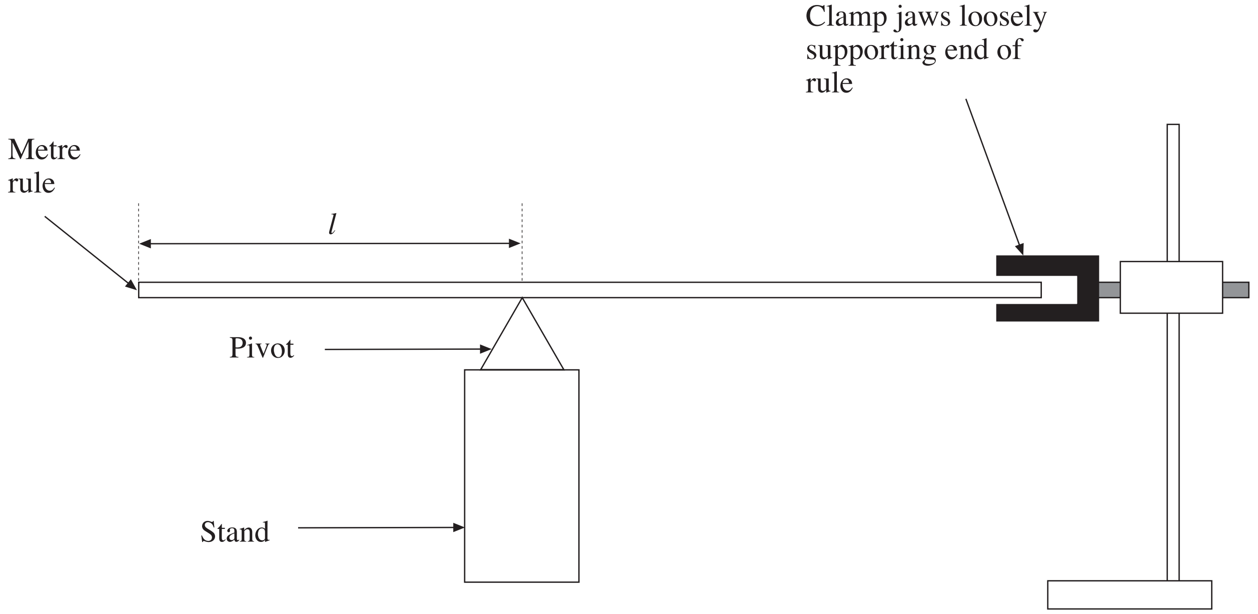
Total % uncertainty correct (1) (e.c.f.)

N.B. There is no significant figure penalty.

TASK A2 (15 minutes)

Repeat readings are not required for this task.

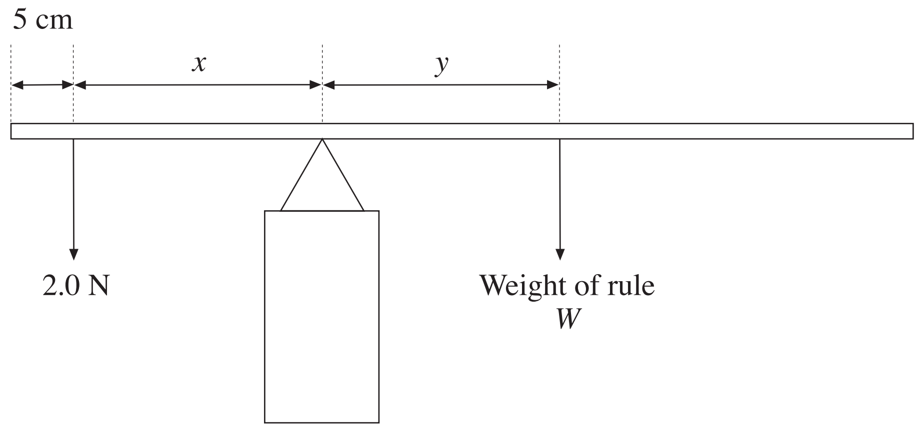
(a) You are provided with the following apparatus.



Adjust the rule until it is just, **or very nearly**, balanced. The balance point is known as the centre of gravity of the rule. This is the point through which the whole of the weight of the rule, W, can be thought to act. Make a note of this length, *l*.

Answer given to 1 d.p. within 0·5cm of the centre value (1)

(b) Hang a weight of 2.0N a distance of 5.0 cm from the left hand end of the rule, as shown, and once again adjust the ruler so that it balances.



(i) Measure the distances *x* and *y*. [1]

x = ... cm y = ... cm

*Both values to 1 d.p. and **within 0.5cm of centre value** (1)*

(ii) The Principle of Moments applied to this situation leads to the following equation:

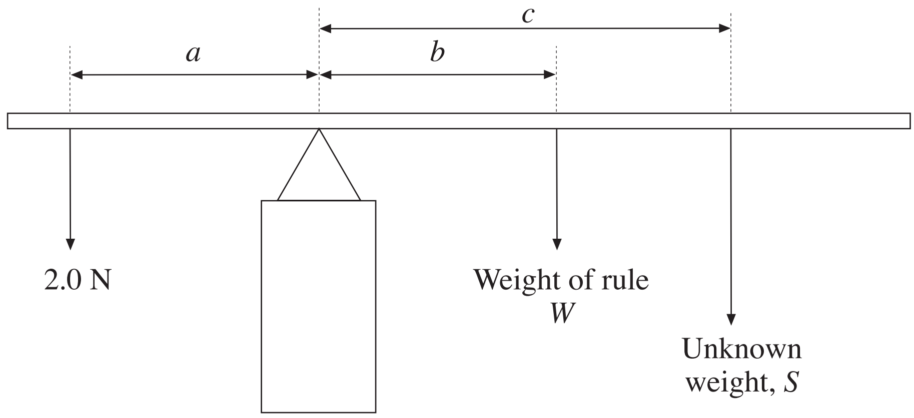
$$2.0x = Wy$$

Use your results in *(b)*(i) to determine a value for *W* (in newtons). [2]

Weight correct to 5% of true value (1)

Units newton / N (1) [Accept: Newton(s)]

(c) Hang the unknown weight, *S*, on the opposite side to the 2.0N weight and once again balance the rule.



Record the values of *a, b* and *c*. [1]

All values recorded to 1 d.p. (1)

Use the above information, and your value for the weight of the rule in *(b)* to calculate the unknown weight. [3]

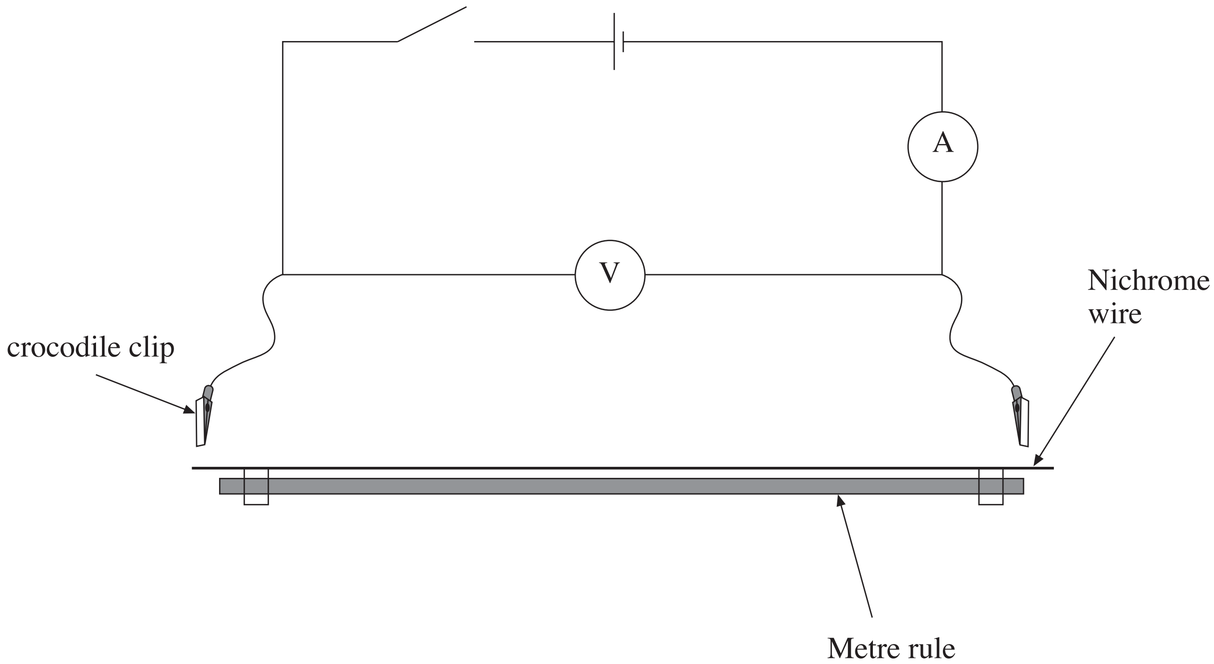
2a = Wb + Sc (1) [or by impl.]

S calculated correctly (1)

*S correct to ± **0.2N of centre value** (1)*

TASK A3 (15 minutes)

You are going to carry out an investigation to determine the resistivity, ρ of nichrome wire. The following circuit has been set up for you.



(a) (i) Attach the crocodile clips, one to each end and determine a value for the resistance of the nichrome wire. [2]

$$R = \frac{V}{I}$$

Voltage and current given to 2 d.p. (1)

Resistance calculated correctly with units (1)

(ii) Your value for the resistance of the wire is slightly greater than the actual value. Explain why. [1]

Less
Because of lead resistance
*[**or** contact resistance] - answer **and** explanation required. (1)*

(b) Determine the diameter of the wire and use this value to calculate the cross sectional area of the wire in **metres^2**. [3]

Thickness given to the resolution of the instrument (1)

Radius calculated / πr^2 / $\frac{\pi d^2}{4}$ *used (1) [or by impl.]*

Area given in metres^2 to no more than 3 significant figures (1) *(c)* Use the equation,

$$R = \frac{\rho l}{A}$$

to determine the resistivity, ρ , of the wire. Remember to include appropriate units with your answer. [2]

ρ *calculated correctly (1) e.c.f.*

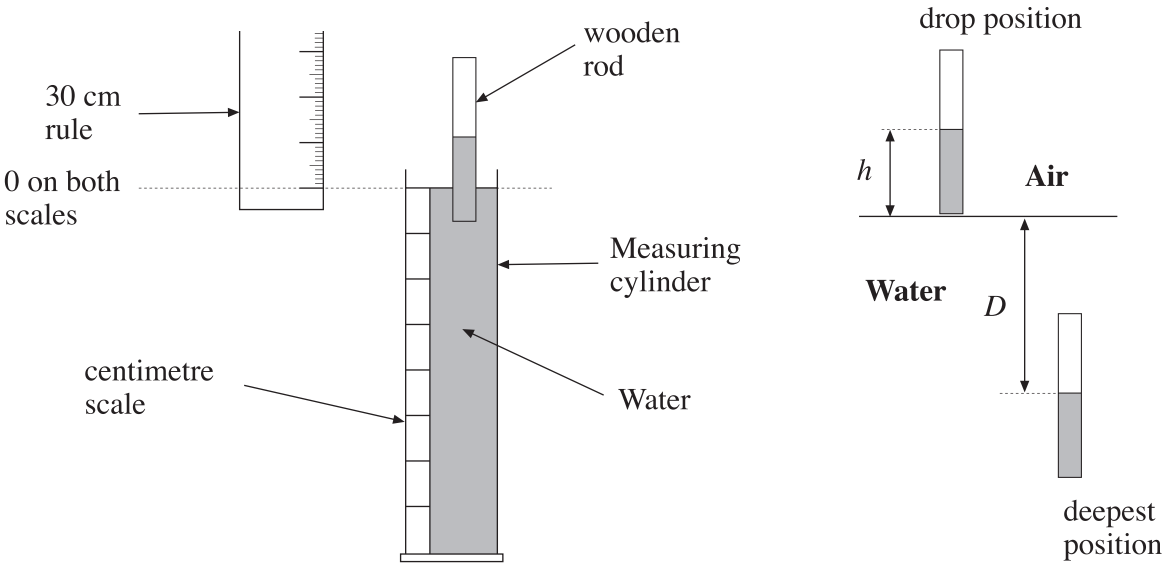
Units Ω*m (1)*

[N.B. Data Book value = $1{\cdot}08 \times 10^{-6}$ Ωm]

SECTION B

TASK B4 (45 minutes)

You are going to investigate how the height, h, from which a wooden rod is dropped affects the depth, D, it penetrates into a measuring cylinder of water. The diagrams show the apparatus and how h and D are defined.



(a) (i) Release the wooden rod from a position where the middle of the rod (top of black area) is 2.0cm above the water surface (i.e. h = 2.0 cm).

Measure the maximum depth by which the middle of the rod penetrates the water. This is the penetration depth D. Measure D three times in total and calculate the mean. [2]

Three readings taken all expressed to the nearest cm (1)

Mean calculated correctly with units accept answer to max of 1 d.p.[i.e. ±1mm] (1)

(ii) Using the equations given on page 3 determine the estimated uncertainty and percentage uncertainty of your results. [2]

Uncertainty correct (1)

Percentage uncertainty correct (1)

(b) (i) Repeat the experiment in part *(a)* for values of *h* of 4.0 cm, 6.0 cm, 8.0 cm, 10.0 cm and 12.0 cm.

Present your results in a clear table. Include your result for part *(a)* (i). [6]

*Titles and **clear** table (1)*

Units for all columns (1)

Repeat readings (1)

Averages calculated correctly (1)

***All** 6 rows of results sequential [i.e. logical order] (1) [either ascending or descending]*

No results (including averages) quoted to better than 1mm accuracy (1)

(ii) Which of your mean values for D has the greatest uncertainty? Calculate this uncertainty, and explain why you think it is the most uncertain. [3]

Correct reading(s) identified [i.e. with greatest spread](1)

Uncertainty calculated correctly (1) [e.c.f.]

Explanation: Readings chosen had the largest spread of results (1)
[only accessible if correct readings identified]

(c) Plot a graph of depth of penetration, *D* (on the y-axis) against height, *h*, above the surface of the water (on the *x*-axis). [6]

*Titles on both axes **and** axes correctly orientated (1)*

Correct units on both axes (1) [e.c.f.]
[N.B. Absence of units in both table and graph is penalised twice]

Sensible scales (over half page used, not multiples of 3) (1)

All points plotted correctly (2) -1 for each incorrect point up to 2 marks

Line / curve of best fit (1)

(d) Using your graph explain carefully, whether *D* is directly proportional to *h*. [2]

Straight line / not straight line [as appropriate from candidate's graph] (1)

Graph passes through origin / doesn't pass through origin [as appropriate] (1)

Comment needed [Yes/No] on whether directly proportional. If no comment max mark 1.

(e) Describe **two** ways in which you could change the **design** of the experiment in order to improve its accuracy. [2]

Release mechanism (1)

Video (1)

Use of an assistant (1) any 2

***NOT** more results / repeats / light gates / datalogger / computer*
["Results" and "repeats" are not design features]

(f) The height the wooden rod is released above the water is one factor that will affect its depth of penetration. Give one other factor that will affect the depth, explaining carefully how you think the depth will change. [1]

Examples:

Sharpened point / tapered – deeper

Heavier wooden rod – deeper

Any sensible suggestion (1)

TEST 2 – MARK SCHEME

SECTION A

TASK A1

As **TEST 1** except *(a)*(iii): e.c.f. = $\dfrac{(a)\text{(ii)}}{\text{Thickness of 20 slides}}$

TASK A2

As **TEST 1**

TASK A3

As **TEST 1**

[N.B. Data Book resistivity of constantan = $4{\cdot}9 \times 10^{-7}\ \Omega\text{m}$]

TASK B4

As **TEST 1**

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