

Markscheme

May 2018

Physics

Standard level

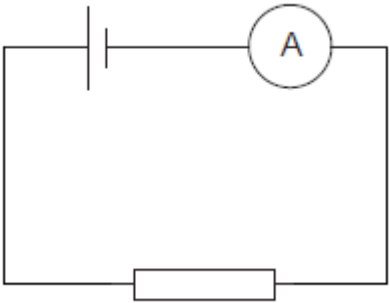
Paper 3

18 pages

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Section A

Question			Answers	Notes	Total
1.	a		smooth line, not kinked, passing through <u>all</u> the error bars ✓		1
1.	b	i	0.84 ± 0.03 «S» ✓	Accept any value from the range: 0.81 to 0.87. Accept uncertainty 0.03 OR 0.025.	1
1.	b	ii	$K = \sqrt{0.005} \times 0.84 = 0.059$ ✓ $\left\langle \frac{\Delta K}{K} = \frac{\Delta P}{P} \right\rangle$ $\Delta K = \frac{0.03}{0.84} \times 0.0594 = 0.002$ ✓ $\left\langle K = (0.059 \pm 0.002) \right\rangle$ uncertainty given to 1sf ✓	Allow ECF [3 max] if 10T is used. Award [3] for BCA.	3
1.	b	iii	$sT^{\frac{1}{2}}$ ✓	Accept $s\sqrt{T}$ or in words.	1
1.	c		straight AND ascending line ✓ through origin ✓		2
1.	d		$K = \sqrt{\text{slope}}$ ✓		1

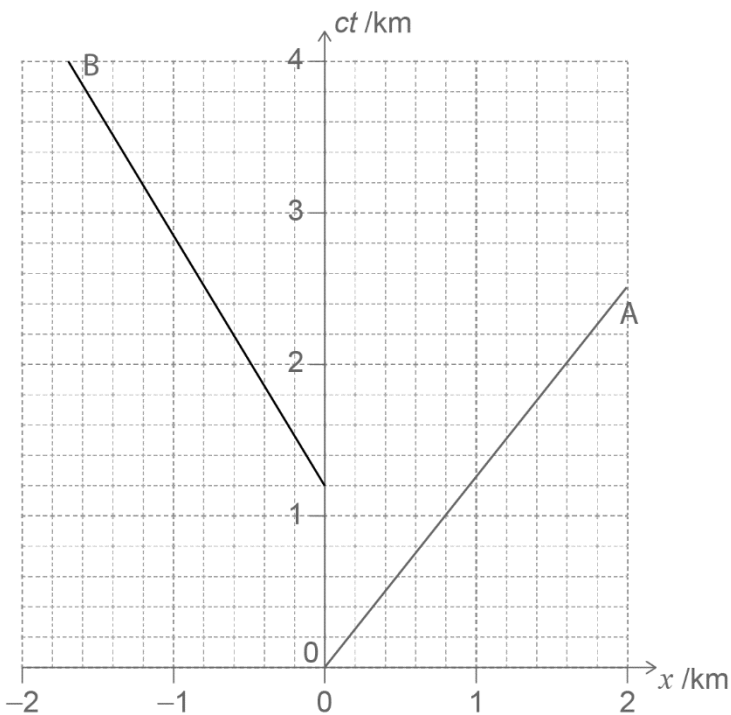
2.	a		 ammeter and resistor in series ✓		1
2.	b		resistance of resistor would increase / be greater than $10\ \Omega$ ✓ $R + r$ «from $\varepsilon = I(R + r)$» would be overestimated / lower current ✓ ✓ therefore calculated r would be larger than real ✓	<i>Award MP3 only if at least one previous mark has been awarded.</i>	3
2.	c		variable resistor would allow for multiple readings to be made ✓ gradient of V-I graph could be found «to give r » ✓	<i>Award [1 max] for taking average of multiple.</i>	2

Section B

Option A — Relativity

3.	a		magnetic field ✓		1
3.	b	i	«according to Y» the positive charges are moving «to the right» ✓ d decreases ✓	<i>For MP1, movement of positive charges must be mentioned explicitly.</i>	2
3.	b	ii	positive charges are moving, so there is a magnetic field ✓ the density of positive charges is higher than that of negative charges, so there is an electric field ✓	<i>The reason must be given for each point to be awarded.</i>	2

4.	a	i	$\llcorner \frac{10^4}{0.995 \times 3 \times 10^8} = \gg 34 \llcorner \mu\text{s} \gg \checkmark$	<i>Do not accept $10^4/c = 33 \mu\text{s}$.</i>	1
4.	a	ii	time is much longer than 10 times the average life time «so only a small proportion would not decay» $\checkmark$		1
4.	b	i	$\gamma = 10 \checkmark$ $\Delta t_0 = \llcorner \frac{\Delta t}{\gamma} = \frac{34}{10} = \gg 3.4 \llcorner \mu\text{s} \gg \checkmark$		2
4.	b	ii	the value found in (b)(i) is of similar magnitude to average life time $\checkmark$ significant number of muons are observed on the ground $\checkmark$ «therefore this supports the special theory»		2

5.	a	straight line with negative gradient with vertical intercept at $ct = 1.2$ «km» ✓ through $(-0.6, 2.2)$ ie gradient = -1.67 ✓ 	<i>Tolerance: Allow gradient from interval -2.0 to -1.4, (at $ct = 2.2$, x from interval 0.5 to 0.7).</i> <i>If line has positive gradient from interval 1.4 to 2.0 and intercepts at $ct = 1.2$ km then allow [1 max].</i>	2
5.	b	line for the flash of light from A correctly drawn ✓ line for the flash of light of B correctly drawn ✓ correct reading taken for time of intersection of flash of light and path of B, $ct = 2.4$ «km» ✓	Accept values in the range: 2.2 to 2.6.	3

(continued...)

(Question 5 continued)

5.	b				
5.	c		the two events take place in the same point in space at the same time ✓ <u>so</u> all observers will observe the two events to be simultaneous / <u>so</u> zero difference ✓	<i>Award the second MP only if the first MP is awarded.</i>	2
5.	d		$u' = \frac{-0.6 - 0.8}{1 - (-0.6) \times 0.8} \checkmark$ $= \llcorner \rightarrow 0.95 \llcorner c \gg \checkmark$		2

Option B — Engineering physics

6.	a		$\Gamma \llcorner = Fr = 50 \times 2 \llcorner = 100 \llcorner \text{Nm} \llcorner \checkmark$ $\alpha \llcorner = \frac{\Gamma}{I} = \frac{100}{450} \llcorner = 0.22 \llcorner \text{rads}^{-2} \llcorner \checkmark$	Final value to at least 2 sig figs, OR clear working with substitution required for mark.	2
6.	b	i	$\llcorner \omega_t^2 - \omega_0^2 = 2\alpha\Delta\theta \llcorner$ $\llcorner \omega_t^2 - 0 = 2 \times 0.22 \times 2\pi \llcorner$ $\omega_t = 1.7 \llcorner \text{rads}^{-1} \llcorner \checkmark$	Accept BCA, values in the range: 1.57 to 1.70.	1
6.	b	ii	$\llcorner L = I\omega = 450 \times 1.66 \llcorner$ $= 750 \llcorner \text{kgm}^2\text{rads}^{-1} \llcorner \checkmark$	Accept BCA, values in the range: 710 to 780.	1
6.	c		$\llcorner I = 450 + mr^2 \llcorner$ $I \llcorner = 450 + 30 \times 2^2 \llcorner = 570 \llcorner \text{kgm}^2 \llcorner \checkmark$ $\llcorner L = 570 \times \omega = 747 \llcorner$ $\omega = 1.3 \llcorner \text{rads}^{-1} \llcorner \checkmark$	Watch for ECF from (a) and (b). Accept BCA, values in the range: 1.25 to 1.35.	2

(continued...)

(Question 6 continued)

6.	d	i	moment of inertia will decrease ✓ angular momentum will be constant «as the system is isolated» ✓ «so the angular speed will increase»		2
6.	d	ii	$\omega_t = 1.66$ from bi AND $W = \Delta E_k$ ✓ $W = \frac{1}{2} \times 450 \times 1.66^2 - \frac{1}{2} \times 570 \times 1.31^2 = 131$ «J» ✓	ECF from 8bi Accept BCA, value depends on the answers in previous questions.	2

7.	a		« $p_1 V_1^{\frac{5}{3}} = p_2 V_2^{\frac{5}{3}}$ » $1.1 \times 10^5 \times 5^{\frac{5}{3}} = p_2 \times 2^{\frac{5}{3}}$ ✓ p_2 « $= \frac{1.1 \times 10^5 \times 5^{\frac{5}{3}}}{2.5^{\frac{5}{3}}}$ » = 5.066×10^5 «Pa» ✓	Volume may be in litres or m^3 . Value to at least 2 sig figs, OR clear working with substitution required for mark.	2
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(continued...)

(Question 7 continued)

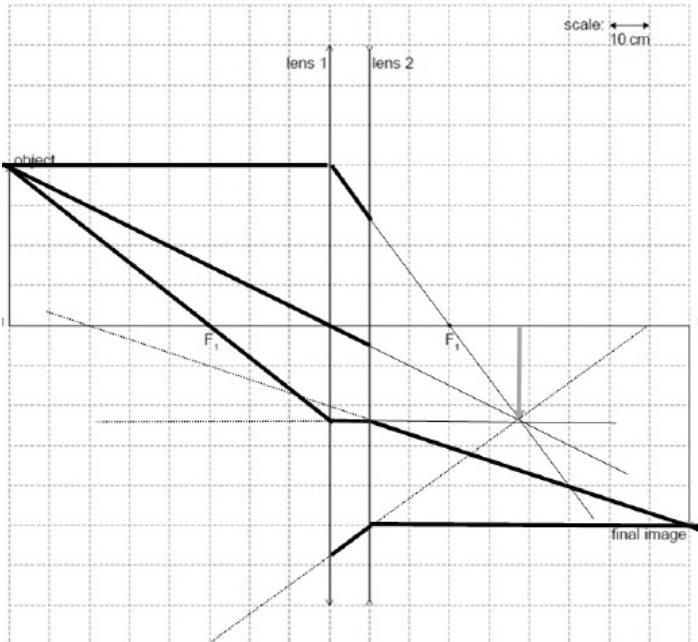
7.	b	i	$\ll W = p\Delta V \gg$ $\ll = 5.07 \times 10^5 \times (5 \times 10^{-3} - 2 \times 10^{-3}) \gg$ $= 1.52 \times 10^3 \ll \text{J} \gg \checkmark$	Award [0] if POT mistake.	1
7.	b	ii	$\Delta U = \frac{3}{2} p\Delta V = \frac{3}{2} 5.07 \times 10^5 \times 3 \times 10^{-3} = 2.28 \times 10^3 \ll \text{J} \gg \checkmark$	Accept alternative solution via T_c .	1
7.	b	iii	$Q \ll = (1.5 + 2.28) \times 10^3 \Rightarrow 3.80 \times 10^3 \ll \text{J} \gg \checkmark$	Watch for ECF from (b)(i) and (b)(ii).	1
7.	c	i	for isothermal process, $PV = \text{constant}$ / ideal gas laws mentioned $\checkmark$ since $V_C > V_B$, P_C must be smaller than $P_B \checkmark$		2
7.	c	ii	the area enclosed in the graph would be smaller $\checkmark$ <u>so</u> the net work done would decrease $\checkmark$	Award MP2 only if MP1 is awarded.	2
7.	d		to reduce energy loss; increase engine performance; improve mpg etc $\checkmark$	Allow any sensible answer.	1

Option C — Imaging

8.	a	i	image is real «as projected on a screen» ✓		1
8.	a	ii	$\left\langle -\frac{18}{u} = -0.40 \right\rangle$ $u = 45 \text{ ✓}$ $\frac{1}{45} + \frac{1}{18} = \frac{1}{f}$ OR $f = 13 \text{ «cm» ✓}$ $P = \frac{1}{f} = \left\langle \frac{1}{13} \right\rangle = 0.078 \text{ «cm}^{-1}\text{» ✓}$	Accept answer 7.7«D».	3
8.	a	iii	refractive index depends on wavelength ✓ light of different wavelengths have different focal points / refract differently ✓ there will be coloured fringes around the image / image will be blurred ✓		3
8.	b		any 2 correct rays to find image from lens 1 ✓ ray to locate F ₂ ✓ focal length = « – » 70 «cm» ✓	Accept values in the range: 65cm to 75cm. Accept correct MP3 from accepted range also if working is incorrect or unclear, award [1].	3

(continued...)

(Question 8 continued)

8.	b	 The diagram shows two lenses, lens 1 and lens 2, on a horizontal principal axis. Lens 1 is a converging lens with focal points F_1 and F_2 at 10 cm from the lens. An object is placed 15 cm to the left of lens 1. A virtual image is formed 30 cm to the left of lens 1. This virtual image acts as the object for lens 2, which is a diverging lens with focal points F_3 and F_4 at 10 cm from the lens. The final image is formed 10 cm to the right of lens 2. The scale bar indicates 10 cm.		
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9.	a		$\text{« sinc} = \frac{1.34}{1.56} \text{ »}$ $c = 59.2 \text{ «}^\circ \text{ » } \checkmark$	Accept values in the range: 59.0 to 59.5. Accept answer 1.0 rad.	1
9.	b		optic fibres are not susceptible to earthing problems $\checkmark$ optic fibres are very thin and so do not require the physical space of electrical cables $\checkmark$ optic fibres offer greater security as the lines cannot be tapped $\checkmark$ optic fibres are not affected by external electric/magnetic fields/interference $\checkmark$ optic fibres have lower attenuation than electrical conductors / require less energy $\checkmark$ the bandwidth of an optic fibre is large and so it can carry many communications at once/in a shorter time interval /faster data transfer $\checkmark$		2 max
9.	c	i	a signal that is wider and lower, not necessarily rectangular, but not a larger area $\checkmark$		1
9.	c	ii	attenuation = $-1.24 \times 3.4 \text{ «} = -4.216 \text{ dB} \text{ » } \checkmark$ $-4.216 = 10 \log \frac{I}{15} \checkmark$ $I = 5.68 \text{ «mW} \text{ » } \checkmark$	Need negative attenuation for MP1, may be shown in MP2. For mp3 answer must be less than 15mW (even with ECF) to earn mark Allow [3] for BCA.	3

(continued...)

(Question 9 continued)

9.	c	iii	refractive index near the edge of the core is less than at the centre ✓ speed of rays which are reflected from the cladding are greater than the speed of rays which travel along the centre of the core ✓ the time difference for the rays that reflect from the cladding layer compared to those that travel along the centre of the core is less OR the signal will remain more compact/be less spread out /dispersion is lower✓ bit rate of the system may be greater ✓		3 max
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Option D — Astrophysics

10.	a	i	a galaxy is much larger in size than a solar system ✓ a galaxy contains more than one star system / solar system ✓ a galaxy is more luminous ✓	Any other valid statement.	1 max
10.	a	ii	a comet is a small icy body whereas a planet is mostly made of rock or gas ✓ a comet is often accompanied by a tail/coma whereas a planet is not ✓ comets (generally) have larger orbits than planets ✓ a planet must have cleared other objects out of the way in its orbital neighbourhood ✓		1 max
11.	a	i	the wavelengths of the dips correspond to the wavelength in the emission spectrum ✓ the absorption lines in the spectrum of star X suggest it contains predominantly hydrogen OR main sequence stars are rich in hydrogen ✓		2
11.	a	ii	peak wavelength: 290 ± 10 «nm» ✓ $T = \frac{2.9 \times 10^{-3}}{290 \times 10^{-9}} = \text{«}10\,000 \pm 400 \text{ K}\text{»} \checkmark$	Substitution in equation must be seen. Allow ECF from MP1.	2

(continued...)

(Question 11 continued)

11.	b	i	$35 \pm 5L_s \checkmark$		1
11.	b	ii	$\frac{L_x}{L_s} = \frac{R_x^2 \times T_x^4}{R_s^2 \times T_s^4}$ OR $R_x = \sqrt{\frac{L_x T_s^4}{L_s T_x^4}} \times R_s \checkmark$ $R_x = \sqrt{\frac{35 \times 6000^4}{10000^4}} \times R_s \text{ (mark for correct substitution) } \checkmark$ $R_x = 2.1R_s \checkmark$	Allow ECF from (b)(i). Accept values in the range: 2.0 to $2.3R_s$. Allow T_s in the range: 5500 K to 6500 K.	3
11.	b	iii	$M_x = (35)^{\frac{1}{3.5}} M_s \checkmark$ $M_x = 2.8M_s \checkmark$	Allow ECF from (b)(i). Do not accept $M_x = (35)^{\frac{1}{3.5}}$ for first marking point. Accept values in the range: 2.6 to $2.9M_s$.	2
11.	c		the star «core» collapses until the «inward and outward» forces / pressures are balanced $\checkmark$ the outward force / pressure is due to electron degeneracy pressure «not radiation pressure» $\checkmark$		2

12.	a		experiments and collecting data are extremely costly ✓ data from many projects around the world can be collated ✓	OWTTE	1 max
12.	b		$v = \llcorner zc = 0.19 \times 3 \times 10^8 \Rightarrow 5.7 \times 10^7 \llcorner \text{ms}^{-1} \gg \checkmark$ $d = \llcorner \frac{v}{H_0} = \frac{5.7 \times 10^4}{70} \gg = 810 \text{Mpc OR } 8.1 \times 10^8 \text{ pc} \gg \checkmark$	Correct units must be present for MP2 to be awarded. Award [2] for BCA.	2
12.	c		ALTERNATIVE 1 $\frac{R_{\text{now}}}{R_{\text{then}}} = 1 + z = 1.19 \checkmark$ so (assuming constant expansion rate) $\frac{t_{\text{now}}}{t} = 1.19 \checkmark$ $t = \frac{14}{1.19} = 11.7 \text{By} = 12 \llcorner \text{By (billion years)} \gg \checkmark$ ALTERNATIVE 2 light has travelled a distance: $(810 \times 10^6 \times 3.26 =) 2.6 \times 10^9 \text{ly} \checkmark$ so light was emitted: 2.6 billion years ago ✓ so the universe was 11.4 billion years old ✓	MP1 can be awarded if MP2 clearly seen. Accept $2.5 \times 10^{25} \text{ m}$ for mp1. MP1 can be awarded if MP2 clearly seen.	3