Markscheme

May 2018

Physics

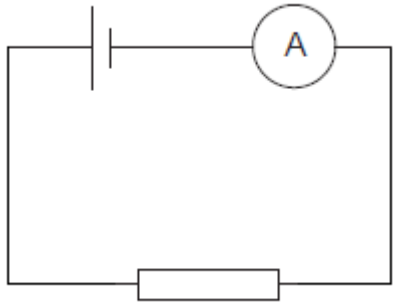
Standard level

Paper 3

18 pages

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	$K = \sqrt{0.005} \times 0.84 = 0.059$ ✓ **«** $\frac{\Delta K}{K} = \frac{\Delta P}{P}$ **»** $\Delta K = \frac{0.03}{0.84} \times 0.0594 = 0.002$ ✓ **«** $K = (0.059 \pm 0.002)$ **»** 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

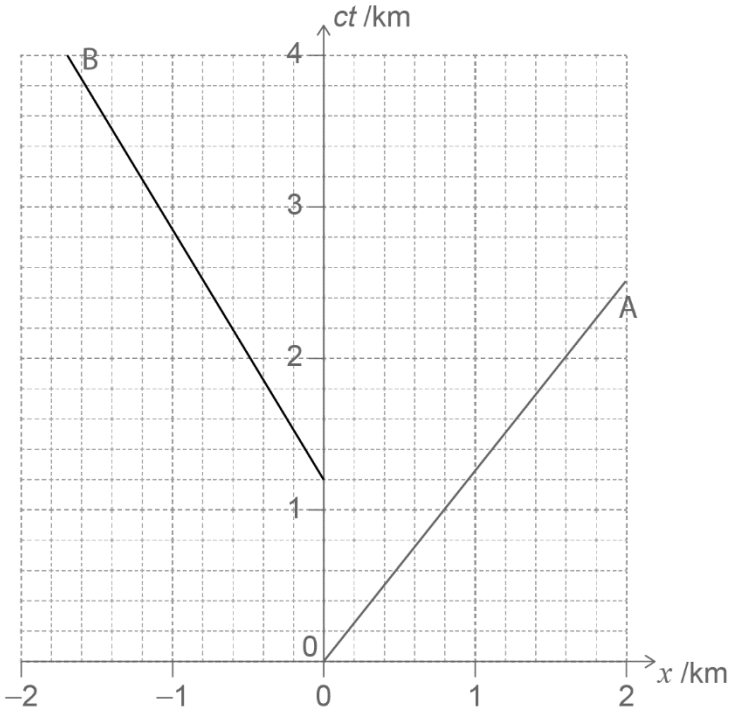
2.	**a**		 ammeter and resistor in series ✓		**1**
2.	**b**		resistance of resistor would increase / be greater than $10\,\Omega$ ✓ $R + r$ «from $\varepsilon = I(R + r)$» would be overestimated / lower current ✓ ✓ therefore calculated r would be larger than real ✓	*Award MP3 only if at least one previous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

Section B

Option A — Relativity

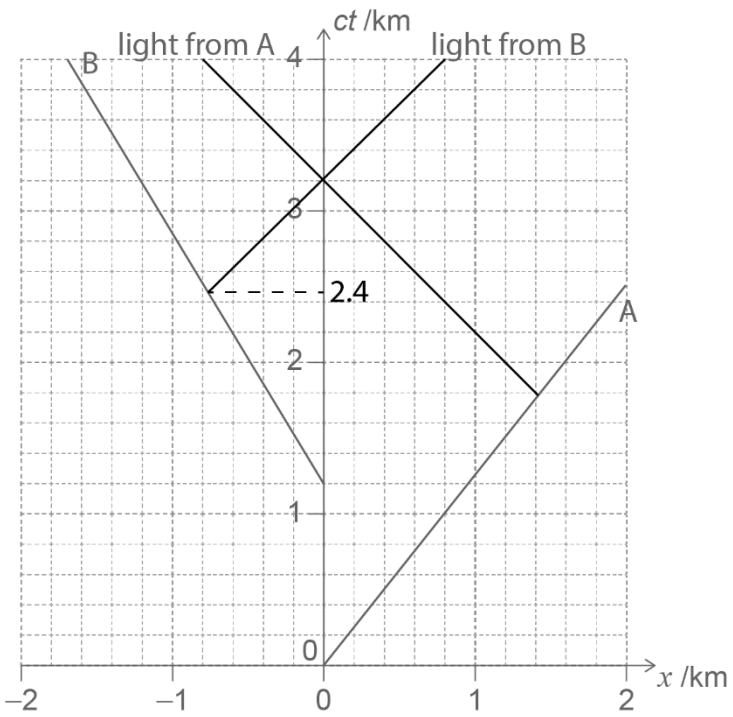
3.	**a**		magnetic field ✓		**1**
3.	**b**	**i**	**«**according to Y**»** the positive charges are moving **«**to the right**»** ✓ *d* decreases ✓	*For MP1, movement of positive charges must be mentioned explicitly.*	**2**
3.	**b**	**ii**	positive charges are moving, so there is a magnetic field ✓ the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

4.	**a**	**i**	**«** $\frac{10^4}{0.995 \times 3 \times 10^8} =$ **»** 34 **«** μs **»** ✓	*Do not accept* $10^4/c = 33\ \mu s$ **.**	**1**
4.	**a**	**ii**	time is much longer than 10 times the average life time **«**so only a small proportion would not decay**»** ✓		**1**
4.	**b**	**i**	$\gamma = 10$ ✓ $\Delta t_0 =$ **«** $\frac{\Delta t}{\gamma} = \frac{34}{10} =$ **»** 3.4 **«** μs **»** ✓		**2**
4.	**b**	**ii**	the value found in (b)(i) is of similar magnitude to average life time ✓ significant number of muons are observed on the ground ✓ **«**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 ✓  	*Tolerance: Allow gradient from interval –2.0 to –1.4, (at ct = 2.2, x from interval 0.5 to 0.7).* *If line has positive gradient from interval 1.4 to 2.0 and intercepts at ct = 1.2 km then allow **[1 max]**.*	**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 ✓ so all observers will observe the two events to be simultaneous / so zero difference ✓	*Award the second MP only if the first MP is awarded.*	**2**
5.	**d**		$u' = \frac{-0.6 - 0.8}{1-(-0.6)\times 0.8}$ ✓ $= $ **«–»**0.95 **«*c*»** ✓		**2**

Option B — Engineering physics

6.	**a**		Γ «$= Fr = 50 \times 2$» $= 100$ «Nm» ✓ α «$= \frac{\Gamma}{I} = \frac{100}{450}$» $= 0.22$ «rad s^{-2}» ✓	*Final value to at least 2 sig figs, **OR** clear working with substitution required for mark.*	**2**
6.	**b**	**i**	«$\omega_t^2 - \omega_0^2 = 2\alpha\Delta\theta$» «$\omega_t^2 - 0 = 2 \times 0.22 \times 2\pi$» $\omega_t = 1.7$ «rad s^{-1}» ✓	*Accept BCA, values in the range: 1.57 to 1.70.*	**1**
6.	**b**	**ii**	«$L = I\omega = 450 \times 1.66$» $= 750$ «$\text{kgm}^2\text{rad s}^{-1}$» ✓	*Accept BCA, values in the range: 710 to 780.*	**1**
6.	**c**		«$I = 450 + mr^2$» I «$= 450 + 30 \times 2^2$» $= 570$ «kgm^2» ✓ «$L = 570 \times \omega = 747$» $\omega = 1.3$ «rad s^{-1}» ✓	*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 **«** $= \frac{1.1 \times 10^5 \times 5^{\frac{5}{3}}}{2.5^{\frac{5}{3}}}$ **»** $= 5.066 \times 10^5$ **«**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**

(continued…)

(Question 7 continued)

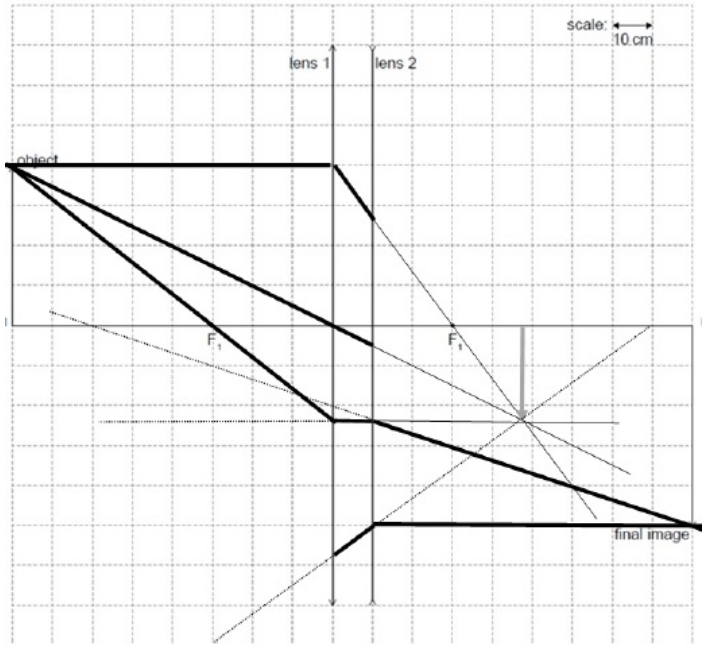
7.	**b**	**i**	**«** $W = p\Delta V$ **»** **«** $= 5.07\times10^{5}\times(5\times10^{-3}-2\times10^{-3})$ **»** $= 1.52\times10^{3}$ **«J»** ✓	*Award **[0]** if POT mistake.*	**1**
7.	**b**	**ii**	$\Delta U = \frac{3}{2}p\Delta V = \frac{3}{2}5.07\times10^{5}\times3\times10^{-3} = 2.28\times10^{3}$ **«J»** ✓	*Accept alternative solution via T_C.*	**1**
7.	**b**	**iii**	Q**«**$= (1.5+2.28)\times10^{3}=$**»**$3.80\times10^{3}$ **«J»** ✓	*Watch for ECF from (b)(i) and (b)(ii).*	**1**
7.	**c**	**i**	for isothermal process, $PV =$ constant / ideal gas laws mentioned ✓ since $V_C > V_B$, P_C must be smaller than P_B ✓		**2**
7.	**c**	**ii**	the area enclosed in the graph would be smaller ✓ <u>so</u> the net work done would decrease ✓	*Award MP2 only if MP1 is awarded.*	**2**
7.	**d**		to reduce energy loss; increase engine performance; improve mpg *etc* ✓	*Allow any sensible answer.*	**1**

Option C — Imaging

8.	**a**	**i**	image is real **«**as projected on a screen**»** ✓		**1**
8.	**a**	**ii**	**«** $-\frac{18}{u} = -0.40$ **»** $u = 45$ ✓ $\frac{1}{45} + \frac{1}{18} = \frac{1}{f}$ ***OR*** $f = 13$ **«**cm**»** ✓ $P = \frac{1}{f} = \text{«}\frac{1}{13}\text{»} = 0.078$ **«** cm^{-1} **»** ✓	*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**				

9.	**a**		« $\sin c = \frac{1.34}{1.56}$ » $c = 59.2$«°» ✓	*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 ✓ optic fibres are very thin and so do not require the physical space of electrical cables ✓ optic fibres offer greater security as the lines cannot be tapped✓ optic fibres are not affected by external electric/magnetic fields/interference ✓ optic fibres have lower attenuation than electrical conductors / require less energy✓ 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 ✓		**2 max**
9.	**c**	**i**	a signal that is wider and lower, not necessarily rectangular, but not a larger area ✓		**1**
9.	**c**	**ii**	attenuation $= -1.24 \times 3.4$ « $= -4.216\,\text{dB}$» ✓ $-4.216 = 10\log\frac{I}{15}$ ✓ $I = 5.68$«mW» ✓	*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**

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**»** ✓ $T = \frac{2.9 \times 10^{-3}}{290 \times 10^{-9}} =$ **«**$10\,000 \pm 400$ K**»** ✓	*Substitution in equation must be seen.* *Allow ECF from MP1.*	**2**

(continued…)

(Question 11 continued)

11.	**b**	**i**	$35 \pm 5L_s$ ✓		**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*** $R_X = \sqrt{\frac{L_X T_s^4}{L_s T_X^4}} \times R_s$ ✓ $R_X = \sqrt{\frac{35 \times 6000^4}{10000^4}} \times R_s$ (mark for correct substitution) ✓ $R_X = 2.1R_s$ ✓	*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**	$M_X = (35)^{\frac{1}{3.5}} M_s$ ✓ $M_X = 2.8M_s$ ✓	*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 ✓ the outward force / pressure is due to electron degeneracy pressure «not radiation pressure» ✓		**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**		$v = «zc = 0.19 \times 3 \times 10^8 =» 5.7 \times 10^7$ «ms^{-1}» ✓ $d = «\frac{v}{H_0} = \frac{5.7 \times 10^4}{70}» = 810$ Mpc ***OR*** 8.1×10^8 pc ✓	*Correct units must be present for MP2 to be awarded.* *Award **[2]** for BCA.*	**2**
12.	**c**		***ALTERNATIVE 1*** $\frac{R_{\text{now}}}{R_{\text{then}}} = 1 + z = 1.19$ ✓ so (assuming constant expansion rate) $\frac{t_{\text{now}}}{t} = 1.19$ ✓ $t = \frac{14}{1.19} = 11.7$ By $= 12$ «By (billion years)» ✓ ***ALTERNATIVE 2*** light has travelled a distance: $(810 \times 10^6 \times 3.26 =) 2.6 \times 10^9$ ly ✓ 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 2.5×10^{25} m for mp1.* *MP1 can be awarded if MP2 clearly seen.*	**3**