

# Markscheme

November 2017

Physics

Standard level

Paper 3

19 pages

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**Section A**

Question			Answers	Notes	Total
1.	a		single smooth curve passing through all data points ✓		1
1.	b	i	tangent drawn at 80 °C ✓	<i>Do not accept tangent unless "ruler" straight. Tangent line must be touching the curve drawn for MP1 to be awarded.</i>	3
		gradient values separated by minimum of 20 °C ✓			
		$9.0 \times 10^{-4}$ «kJ kg <sup>-1</sup> K <sup>-2</sup> » ✓	<i>Accept values between <math>7.0 \times 10^{-4}</math> and <math>10 \times 10^{-4}</math>. Accept working in J, giving 0.7 to 1.0</i>		
1.	b	ii	kJ kg <sup>-1</sup> K <sup>-2</sup> ✓	<i>Accept J instead of kJ Accept °C<sup>-2</sup> instead of K<sup>-2</sup> Accept °C<sup>-1</sup> K<sup>-1</sup> instead of K<sup>-2</sup> Accept C for °C</i>	1
1.	c	i	«0.1 × 4.198 × 10 =» 4.198 «kJ» <b>or</b> 4198 «J» ✓	<i>Accept values between 4.19 and 4.21</i>	1
1.	c	ii	percentage uncertainty in $\Delta T = 10\%$ ✓	<i>Allow fractional uncertainties in MP1 and MP2</i>	3
		«2% + 5% + 10% =» 17% ✓			
		absolute uncertainty = «0.17 × 4.198 =» 0.7 «kJ» therefore 2 sig figs <b>OR</b> absolute uncertainty to more than 1 sig fig and consistent final answer ✓			

Question		Answers	Notes	Total
2.	a	« $\varepsilon = IR + Ir$ »	<i>No mark for stating data booklet equation</i>	2
		$\frac{1}{I} = \frac{R}{\varepsilon} + \frac{r}{\varepsilon} \checkmark$ identifies equation with $y = mx + c \checkmark$ «hence $m = \frac{1}{\varepsilon}$ »	<i>Do not accept working where <math>r</math> is ignored or <math>\varepsilon = IR</math> is used</i>  OWTTE	
2.	b	«-» $r \checkmark$	<i>Allow answer in words</i>	

3.	a	«to reduce» random errors $\checkmark$	OWTTE	1 max
		to reduce absolute uncertainty $\checkmark$ to improve precision $\checkmark$	<i>Do not accept just “to find an average” or just “reduce error”</i> <i>Ignore any mention to accuracy</i>	
3.	b	as the literature value is within the range «9.7 – 11.1» $\checkmark$	OWTTE	2
		hence it is accurate $\checkmark$	<i>MP2 must be correctly justified</i>	

**Section B**

**Option A — Relativity**

Question		Answers	Notes	Total
4.		light is an EM wave ✓		2
		speed of light is independent of the source/observer ✓		

5.	a	a co-ordinate system in which measurements «of distance and time» can be made ✓	<i>Ignore any mention to inertial reference frame.</i>	1
5.	b	closing speed = $c$ ✓ 2 «s» ✓		2
5.	c	$u$ and $v$ are velocities with respect to the same frame of reference/Earth <b>AND</b> $u'$ the relative velocity ✓	<i>Accept 0.4c and 0.6c for <math>u</math> and <math>v</math></i>	1
5.	d	$\frac{-0.4 - 0.6}{1 + 0.24}$ ✓ «-» $0.81c$ ✓		2
5.	e	i	$\gamma = 1.25$ ✓ so the time is $t = 1.6$ «s» ✓	2
5.	e	ii	gamma is smaller for B ✓ so time is greater than for A ✓	2

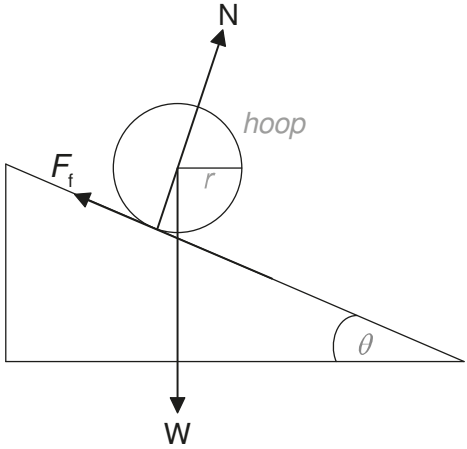
Question		Answers	Notes	Total
6.	a	the length of an object in its rest frame <b>OR</b> the length of an object measured when at rest relative to the observer ✓		1
6.	b	world lines for front and back of tunnel parallel to $ct$ axis ✓ world lines for front and back of train ✓ which are parallel to $ct'$ axis ✓		3
6.	c	realizes that $\gamma = 1.25$ ✓ $0.6c$ ✓		2

(continued...)

(Question 6 continued)

Question		Answers	Notes	Total
6.	d	<p><b>ALTERNATIVE 1</b></p> <p>indicates the two simultaneous events for <math>t</math> frame ✓</p> <p>marks on the diagram the different times «for both spacetime points» on the <math>ct'</math> axis «shown as <math>\Delta t'</math> on each diagram» ✓</p> <p><b>ALTERNATIVE 2: (no diagram reference)</b></p> <p>the two events occur at different points in space ✓</p> <p>statement that the two events are not simultaneous in the <math>t'</math> frame ✓</p>	<p>The diagram is a spacetime plot with a vertical axis labeled <math>ct</math> and a horizontal axis labeled <math>x</math>. A second set of axes, <math>ct'</math> and <math>x'</math>, is shown, with <math>ct'</math> tilted to the right and <math>x'</math> tilted to the left. Two events are represented by black dots on the <math>ct</math> axis. Dashed lines connect these dots to the <math>ct'</math> axis, and the vertical distance between these intersection points is labeled <math>\Delta t'</math>. Vertical lines are also drawn from the dots to the <math>x</math> axis, showing they are at different spatial locations.</p>	2

Option B — Engineering physics

Question		Answers	Notes	Total
7.	a	weight, normal reaction and friction in correct direction ✓ correct points of application for at least two correct forces ✓	<p><i>Labelled on diagram.</i></p>  <p><i>Allow different wording and symbols</i> <i>Ignore relative lengths</i></p>	<b>2</b>

(continued...)



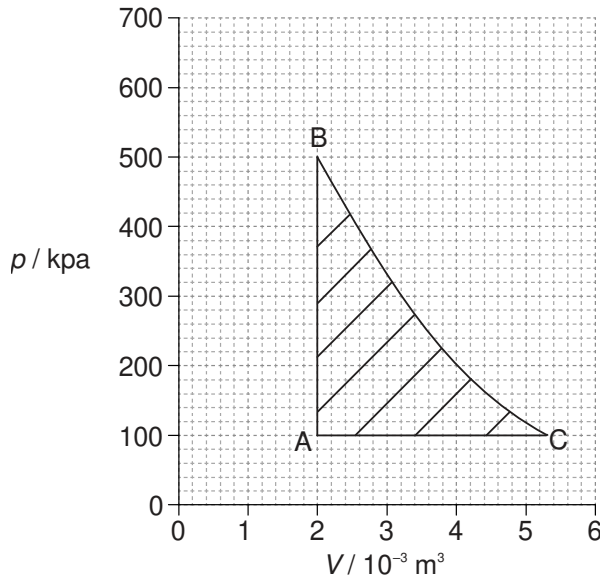
(Question 7 continued)

Question		Answers	Notes	Total
7.	b	<p><b>ALTERNATIVE 1</b></p> $ma = mg \sin \theta - F_f \checkmark$ $I\alpha = F_f \times r$ <p><b>OR</b></p> $mr\alpha = F_f \checkmark$ $\alpha = \frac{a}{r} \checkmark$ $ma = mg \sin \theta - mr \frac{a}{r} \rightarrow 2a = g \sin \theta \checkmark$ <p><b>ALTERNATIVE 2</b></p> $mgh = \frac{1}{2} I\omega^2 + \frac{1}{2} mv^2 \checkmark$ <p>substituting <math>\omega = \frac{v}{r}</math> «giving <math>v = \sqrt{gh}</math>» <math>\checkmark</math></p> <p>correct use of a kinematic equation <math>\checkmark</math></p> <p>use of trigonometry to relate displacement and height «<math>s = h \sin \theta</math>» <math>\checkmark</math></p>	<p>Can be in any order</p> <p>No mark for re-writing given answer</p> <p>Accept answers using the parallel axis theorem (with <math>I = 2mr^2</math>) only if clear and explicit mention that the only torque is from the weight</p> <p>Answer given look for correct working</p> <p>For alternative 2, MP3 and MP4 can only be awarded if the previous marking points are present</p>	4
7.	c	1.68 «ms <sup>-2</sup> » $\checkmark$		1

(continued...)

(Question 7 continued)

Question		Answers	Notes	Total
7.	d	<p><b>ALTERNATIVE 1</b></p> <p><math>N = mg \cos \theta</math> ✓</p> <p><math>F_f \leq \mu mg \cos \theta</math> ✓</p> <p><b>ALTERNATIVE 2</b></p> <p><math>F_f = ma</math> «from 7(b)» ✓</p> <p>so <math>F_f = \frac{mg \sin \theta}{2}</math> ✓</p>		2
7.	e	<p><math>F_f = \mu mg \cos \theta</math> ✓</p> <p><math>\frac{mg \sin \theta}{2} = mg \sin \theta - \mu mg \cos \theta</math></p> <p><b>OR</b></p> <p><math>mg \frac{\sin \theta}{2} = \mu mg \cos \theta</math> ✓</p> <p>algebraic manipulation to reach <math>\tan \theta = 2\mu</math> ✓</p>		3

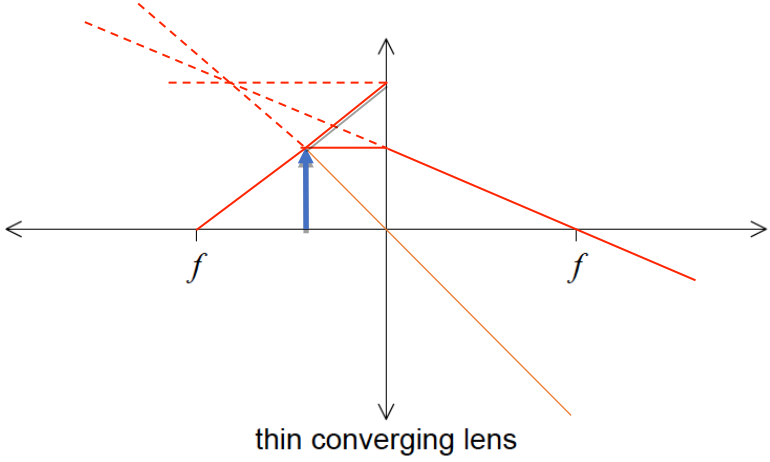
Question		Answers	Notes	Total
8.	a	$500\,000 \times (2 \times 10^{-3})^{\frac{5}{3}} = 100\,000 \times V_{\text{calc}}^{\frac{5}{3}} \checkmark$ $V = 5.25 \times 10^{-3} \text{ «m}^3 \text{»} \checkmark$		2
8.	b	correct vertical and horizontal lines $\checkmark$ curve between B and C $\checkmark$	Allow tolerance $\pm 1$ square for A, B and C Allow ECF for MP2 Points do not need to be labelled for marking points to be awarded 	2
8.	c	use of $PV = nRT$ <b>OR</b> use of $\frac{P}{T} = \text{constant} \checkmark$ $T = \text{«}5 \times 290 \text{»} = 1450 \text{ «K»} \checkmark$		2

(continued...)

(Question 8 continued)

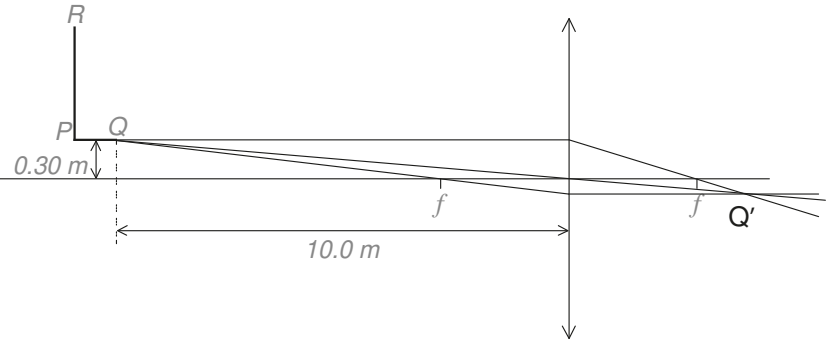
Question		Answers	Notes	Total
8.	d	area enclosed ✓ work is done by the gas during expansion <b>OR</b> work is done on the gas during compression ✓ the area under the expansion is greater than the area under the compression ✓		2 max

Option C — Imaging

Question			Answers	Notes	Total
9.	a	i	with object placed between lens and focus ✓ two rays correctly drawn ✓  <p style="text-align: center;">thin converging lens</p>	<i>Backwards extrapolation of refracted rays can be dashes or solid lines</i> <i>Do not penalize extrapolated rays which would meet beyond the edge of page</i> <i>Image need not be shown</i>	2
9.	a	ii	«just less than» the focal length <i>or f</i> ✓		1
9.	b	i	$\frac{1}{10} + \frac{1}{v} = \frac{1}{2}$ ✓ $v = 2.5$ «m» ✓		2
9.	b	ii	real, smaller, inverted ✓	<i>All three required — OWTTE</i>	1

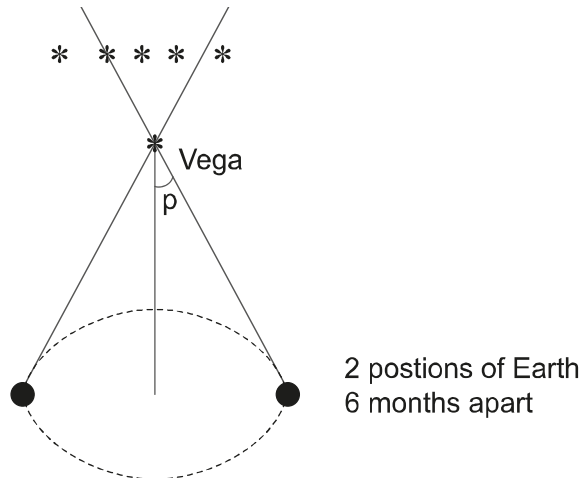
(continued...)

(Question 9 continued)

Question			Answers	Notes	Total
9.	c	i	two correct rays coming from Q ✓  locating Q' below the main axis <b>AND</b> beyond $f$ to the right of lens <b>AND</b> at intercept of rays ✓	Allow any <b>two</b> of the three conventional rays.  	2
9.	c	ii	$\frac{h}{h'} = \frac{-x}{x'}$ <b>OR</b> 2.5 <b>or</b> $10 \times 0.3$ «m» ✓  «→» 0.075 «m» ✓		2
9.	c	iii	towards Q ✓	Accept move to the left	1
9.	c	iv	spherical aberration ✓  top of the shape «R» is far from axis so no paraxial rays ✓	For MP2 accept rays far from the centre converge at different points	2

Question		Answers	Notes	Total
10.	a	plane mirror to the left of principal focus tilted anti-clockwise ✓ two rays which would go through the principal focus ✓ two rays cross between mirror and eyepiece <b>AND</b> passing through the eyepiece ✓	eg: 	3
10.	b	$\frac{2 \times 1737}{363300} = \frac{0.0120}{f} \quad \checkmark$ $f = 1.25 \text{ «m»} \quad \checkmark$		2
10.	c	$M = \frac{1.25}{0.05} = 25 \quad \checkmark$		1
10.	d	parabolic/convex mirror instead of flat mirror ✓ eyepiece/image axis same as mirror ✓		1 max

Option D — Astrophysics

Question			Answers	Notes	Total
11.	a	i	«nuclear» fusion ✓	<i>Do not accept “burning”</i>	1
11.	a	ii	brightness depends on luminosity and distance/ $b = \frac{L}{4\pi d^2}$ ✓  Vega is much further away but has a larger luminosity ✓	<i>Accept answer in terms of Jupiter for MP2</i>	2
11.	b	i	a group of stars forming a pattern on the sky <b>AND</b> not necessarily close in distance to each other ✓	<i>OWTTE</i>	1
11.	b	ii	the star’s position is observed at two times, six months apart, relative to distant stars ✓ parallax angle is half the angle of shift ✓  	<i>Answers may be given in diagram form, so allow the marking points if clearly drawn</i>	2

(continued...)



(Question 11 continued)

Question			Answers	Notes	Total
11.	b	iii	$\frac{1}{0.13} = 7.7 \text{ «pc» } \checkmark$ so $d = 7.7 \times 3.26 = 25.1 \text{ «ly» } \checkmark$		2

12.	a		two stars orbiting a common centre «of mass» $\checkmark$	<i>Do not accept "stars which orbit each other"</i>	1
12.	b		$\ll \lambda \times T = 2.9 \times 10^{-3} \gg$ $T = \frac{2.9 \times 10^{-3}}{115 \times 10^{-9}} = 25217 \text{ «K» } \checkmark$		1
12.	c		use of the mass-luminosity relationship <b>or</b> $\left(\frac{M_{\text{Sirius}}}{M_{\text{Sun}}}\right)^{3.5} = 1 \checkmark$ if Sirius B is on the main sequence then $\left(\frac{L_{\text{SiriusB}}}{L_{\text{Sun}}}\right) = 1 \text{ «which it is not» } \checkmark$	<i>Conclusion is given, justification must be stated</i>  <i>Allow reverse argument beginning with luminosity</i>	2

(continued...)

(Question 12 continued)

Question			Answers	Notes	Total
12.	d	i	$\left(\frac{L_{\text{SiriusB}}}{L_{\text{Sun}}}\right) = 0.025 \checkmark$ $r_{\text{Sirius}} = \llcorner \sqrt{0.025 \times \left(\frac{5800}{25000}\right)^4} \Rightarrow 0.0085 r_{\text{Sun}} \checkmark$		2
12.	d	ii	white dwarf ✓		1
12.	e	i	Sirius A on the main sequence above and to the left of the Sun <b>AND</b> Sirius B on white dwarf area as shown ✓	<p><i>Both positions must be labelled</i></p> <p><i>Allow the position anywhere within the limits shown.</i></p>	1

(continued...)

(Question 12 continued)

Question			Answers	Notes	Total
12.	e	ii	arrow goes up and right and then loops to white dwarf area ✓		1

13.	a		galaxies are moving away <b>OR</b> space «between galaxies» is expanding ✓	<i>Do not accept just red-shift</i>	1
13.	b		« $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ » ✓ $\frac{1.04}{115} = \frac{v}{c}$ ✓ 0.009c ✓	<i>Accept <math>2.7 \times 10^6</math> «m s<sup>-1</sup>»</i> <i>Award [0] if 116 is used for <math>\lambda</math>.</i>	2