
PHYSICS

9702/21

Paper 2 AS Level Structured Questions

May/June 2018

MARK SCHEME

Maximum Mark: 60

Published

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Question	Answer	Marks
1(a)	a scalar has magnitude (only)	B1
	a vector has magnitude and direction	B1
1(b)	power: scalar temperature: scalar momentum: vector <i>(two correct 1 mark, all three correct 2 marks)</i>	B2
1(c)(i)	arrow labelled R in a direction from 5° to 20° north of west	B1
1(c)(ii)	$v^2 = 28^2 + 95^2 - (2 \times 28 \times 95 \times \cos 115^\circ)$ or $v^2 = [(95 + 28 \cos 65^\circ)^2 + (28 \sin 65^\circ)^2]$	C1
	$v = 110 \text{ ms}^{-1}$ (109.8 ms ⁻¹)	A1
	or (scale diagram method)	
	triangle of velocities drawn	(C1)
	$v = 110 \text{ ms}^{-1}$ (allow 108–112 ms ⁻¹)	(A1)

Question	Answer	Marks
2(a)	a body continues at (rest or) constant velocity unless acted upon by a resultant force	B1
2(b)(i)1.	from 0–2 s, distance = $\frac{1}{2} \times 2 \times 6.8$ (= 6.8 m) and from 2–3 s, distance = $\frac{1}{2} \times 1 \times 3.4$ (= 1.7 m)	C1
	magnitude of displacement = 5.1 m	A1
	direction of displacement is down(wards)	B1
2(b)(i)2.	$(\Delta E) = mg\Delta h$ or $(E) = mgh$ or $(E) = Wh$	C1
	$(\Delta)E = 15 \times 5.1$ $= (-) 77 \text{ J}$	A1
2(b)(ii)	$a = (v - u) / t$ or $a = \text{gradient}$ or $a = dv/dt$	C1
	$a = 3.4 \text{ ms}^{-2}$	A1
2(b)(iii)	$T - W = ma$ or $T - mg = ma$	C1
	$T = 15 + (15/9.81) \times 3.4 = 20 \text{ N or } 20.2 \text{ N}$	A1
2(b)(iv)	$E = F / A\epsilon$ or $E = \sigma / \epsilon$ and $\sigma = F / A$	C1
	$\epsilon = 20 / (2.8 \times 10^{-5} \times 1.7 \times 10^{11})$	C1
	$= 4.2 \times 10^{-6}$	A1
2(b)(v)	block is in equilibrium/has no resultant force	B1
	block could be stationary (or have constant velocity/speed) (so no, not possible to deduce)	B1

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Question	Answer	Marks
3(a)	mass is the property (of a body/object) resisting changes in motion or mass is the quantity of matter (in a body)	B1
3(b)(i)	force on A (by B) equal <u>and opposite</u> to force on B (by A) or both A and B exert equal and opposite forces on each other	B1
	force is rate of change of momentum <u>and</u> time (of contact) is same	B1
3(b)(ii)	$p = mv$ or $3M \times 0.40$ or $M \times 0.25$ or $3M \times 0.2$ or Mv	C1
	$(3M \times 0.40) - (M \times 0.25) = (3M \times 0.2) + Mv$	C1
	$v = (3 \times 0.40) - 0.25 - (3 \times 0.2)$ $= 0.35 \text{ ms}^{-1}$	A1
3(b)(iii)	1. relative speed of approach $= 0.40 + 0.25$ $= 0.65 \text{ ms}^{-1}$	A1
	2. relative speed of separation $= 0.35 - 0.20$ $= 0.15 \text{ ms}^{-1}$	A1
3(b)(iv)	(relative) speed of separation not equal to/less than (relative) speed of approach or answers (to (b)(iii) are) not equal and so inelastic collision	B1

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Question	Answer	Marks
4(a)(i)	time for one oscillation/one vibration/one cycle or time between adjacent wavefronts/points in phase or shortest time between two wavefronts/points in phase	B1
4(a)(ii)	distance moved by wavefront/energy during one cycle/oscillation/period (of source) or minimum distance between two wavefronts or distance between two adjacent wavefronts or minimum distance between two points having the same displacement and moving in the same direction	B1
4(b)(i)	$v = \lambda / T$ or $v = f\lambda$ <u>and</u> $f = 1 / T$	C1
	$\lambda = 20 \times 0.60$ $= 12 \text{ cm}$	A1
4(b)(ii)	phase difference $= 360^\circ \times (0.20/0.60)$ or $360^\circ \times (0.40/0.60)$ $= 120^\circ$ or 240°	A1
4(b)(iii)	$I \propto A^2$	C1
	$I_Q / I_P = A_Q^2 / A_P^2$ $= 2.0^2 / 3.0^2$ $= 0.44$	A1
4(b)(iv)	displacement $= 1.00 - 3.00$ $= -2.00 \text{ mm}$	A1

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Question	Answer	Marks
5(a)(i)	waves spread at (each) slit/gap	B1
5(a)(ii)	constant phase difference (between (each of) the waves)	B1
5(b)(i)	$n\lambda = d\sin\theta$	B1
	$d\sin\theta$ is the same and $3\lambda_1 = 4\lambda_2$ so $\lambda_2 / \lambda_1 = 0.75$	A1
5(b)(ii)	$\lambda_2 / \lambda_1 = 0.75$ and $\lambda_1 - \lambda_2 = 170$ $\lambda_1 = 680\text{ nm}$	A1

Question	Answer	Marks
6(a)	joule/coulomb	B1
6(b)(i)	lamps have same p.d./lamps have p.d. of 2.7 V	B1
	current = 0.15 + 0.090 = 0.24 A	A1
6(b)(ii)	$R = (4.5 - 2.7) / 0.24$ or $R_P = 18(\Omega)$ and $R_Q = 30(\Omega)$ $1/R_T = 1/18 + 1/30$ and so $R_T = 11.25$ $4.5 = 0.24 \times (R + 11.25)$	C1
	$R = 7.5\Omega$	A1

Question	Answer	Marks
6(b)(iii)	$R = \rho l / A$	C1
	$R_P / R_Q = [(2.7/0.15)/(2.7/0.09)] (= 0.60)$	C1
	ratio = 0.60×2^2 = 2.4	A1
6(b)(iv)	less p.d. across resistor/greater p.d. across <u>P</u>	B1
	greater current through <u>P</u> and so resistance (of P) increases	B1

Question	Answer	Marks
7(a)	arrow pointing vertically down the page	B1
7(b)	$E = \frac{1}{2}mv^2$	C1
	$E = 460 \times 1.60 \times 10^{-19} (= 7.36 \times 10^{-17} \text{ (J)})$	C1
	$v = [(2 \times 460 \times 1.60 \times 10^{-19})/(9.11 \times 10^{-31})]^{1/2}$ = $1.3 \times 10^7 \text{ ms}^{-1}$	A1
7(c)	β^- particles have range of/different/various speeds/velocities/momenta/energies	M1
	so they follow different paths	A1

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1(a)	rate of change of momentum	B1
1(b)	kgms^{-2}	A1
1(c)	units for Q : As and for r : m	C1
	units for $\varepsilon = (\text{As} \times \text{As})/(\text{kgms}^{-2} \times \text{m}^2)$ $= \text{A}^2\text{kg}^{-1}\text{m}^{-3}\text{s}^4$	A1

Question	Answer	Marks
2(a)	<u>sum/total</u> momentum (of a system of bodies) is constant or <u>sum/total</u> momentum before = <u>sum/total</u> momentum after	M1
	for an isolated system or no (resultant) external force	A1
2(b)(i)	$(p =) mv$ or $(3.0M \times 7.0)$ or $(2.0M \times 6.0)$ or $(1.5M \times 8.0)$	C1
	$3.0M \times 7.0 = 2.0M \times 6.0 \sin \theta + 1.5M \times 8.0 \sin \theta$	C1
	$\theta = 61^\circ$	A1
	or (vector triangle method)	
	momentum vector triangle drawn	(C1)
	$\theta = 61^\circ$ (2 marks for $\pm 1^\circ$, 1 mark for $\pm 2^\circ$)	(A2)
	or (use of cosine rule)	
	$p = mv$ or $(3.0M \times 7.0)$ or $(2.0M \times 6.0)$ or $(1.5M \times 8.0)$	(C1)
	$(21M)^2 = (12M)^2 + (12M)^2 - (2 \times 12M \times 12M \times \cos 2\theta)$	(C1)
	$\theta = 61^\circ$	(A1)
2(b)(ii)	$(E =) \frac{1}{2}mv^2$	C1
	ratio = $(\frac{1}{2} \times 2.0M \times 6.0^2) / (\frac{1}{2} \times 1.5M \times 8.0^2)$ = 0.75	A1

Question	Answer	Marks
3(a)	time = 12s	A1
3(b)	distance (up slope) = $\frac{1}{2} \times 12 \times 18$ (= 108)	C1
	distance (down slope) = $\frac{1}{2} \times 12 \times 6$ (= 36)	C1
	displacement from A = 108 – 36 = 72m	A1
3(c)	$v = u + at$ or $a = \text{gradient}$ or $a = \Delta v / (\Delta)t$	C1
	$a = 6 / 12 = 0.50 \text{ (ms}^{-2}\text{)}$ (other points from the line may be used)	A1
	or	
	$v^2 = u^2 + 2as$ and $u = 0$ or $v^2 = 2as$	(C1)
	$a = 6.0^2 / (2 \times 36) = 0.50 \text{ (ms}^{-2}\text{)}$	(A1)
	or	
	$s = ut + \frac{1}{2}at^2$ and $u = 0$ or $s = \frac{1}{2}at^2$	(C1)
	$a = 2 \times 36 / 12^2 = 0.50 \text{ (ms}^{-2}\text{)}$	(A1)
	or	
	$s = vt - \frac{1}{2}at^2$	(C1)
	$a = 2 \times (6 \times 12 - 36) / 12^2 = 0.50 \text{ (ms}^{-2}\text{)}$	(A1)

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Question	Answer	Marks
3(d)(i)	$F = 70 \times 0.50 (= 35)$	C1
	frictional force = $80 - 35$ = 45 N	A1
3(d)(ii)	$\sin \theta = 80 / (70 \times 9.81)$	C1
	$\theta = 6.7^\circ$	A1
3(e)(i)	$f_0 = (900 \times 340) / (340 + 12)$	C1
	= 870 Hz	A1
3(e)(ii)	speed/velocity (of sledge) decreases and (so) frequency increases	B1

Question	Answer	Marks
4(a)(i)	distance moved by wavefront/energy during one cycle/oscillation/period (of source) or <u>minimum</u> distance between two wavefronts or distance between two <u>adjacent</u> wavefronts	B1
4(a)(ii)	(position where) maximum amplitude	B1
4(b)(i)	$\lambda = 4 \times 0.045$ (= 0.18 (m) or 18 (cm))	C1
	$v = f\lambda$	C1
	$f = 340/0.18$ = 1900 Hz	A1
4(b)(ii)	distance = $\lambda/2$ (= 0.09 (m) or 9 (cm))	C1
	time = $0.09 / 0.0075$ = 12 s	A1
	or	
	$t = 4.5/0.75$ and $t = 13.5/0.75$	(C1)
	time = $18 - 6$ = 12 s	(A1)

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Question	Answer	Marks
5(a)	$\rho = m/V$	C1
	$= (560/9.81)/(1.2 \times 0.018)$	A1
	$= 2600 \text{ kg m}^{-3}$	
5(b)	$(\Delta)p = 940 \times 9.81 \times 1.2$	C1
	(upthrust =) $940 \times 9.81 \times 1.2 \times 0.018 = 200 \text{ N}$	A1
5(c)(i)	tension = $560 - 200$ $= 360 \text{ N}$	A1
5(c)(ii)	$P = Fv$	C1
	$= 360 \times 0.020$	A1
	$= 7.2 \text{ W}$	
5(d)(i)	upthrust decreases	B1
	tension (in wire) increases	M1
	power (output of motor) increases	A1
5(d)(ii)	there is work done (on the cylinder) by the upthrust or GPE of oil decreases (as it fills the space left by cylinder and so total energy is conserved)	B1

Question	Answer	Marks
6(a)(i)	<u>sum of</u> current(s) into junction = <u>sum of</u> current(s) out of junction or (algebraic) sum of current(s) at a junction is zero	B1
6(a)(ii)	charge	B1
6(b)(i)1.	$E = I^2 R t$ or $E = V I t$ or $E = (V^2 / R) t$	C1
	$E = 2.5^2 \times 2.0 \times 5.0 \times 60$ or $5.0 \times 2.5 \times 5.0 \times 60$ or $(5.0^2 / 2.0) \times 5.0 \times 60$ $= 3800 \text{ J}$	A1
6(b)(i)2.	p.d. = $8.0 - (2.0 \times 2.5)$ $= 3.0 \text{ V}$	A1
6(b)(ii)	$I_X = 3.0 / 15 = 0.20 \text{ (A)}$	C1
	$I_Y = 2.5 - 0.20 = 2.3 \text{ (A)}$	C1
	$R_Y = 3.0 / 2.3$ $= 1.3 \Omega$	A1
	or	
	$R_T = 3.0 / 2.5 = 1.2 (\Omega)$ or $(8.0 / 2.5) - 2.0 = 1.2 (\Omega)$	(C1)
	$1 / 1.2 = 1 / 15 + 1 / R_Y$	(C1)
	$R_Y = 1.3 \Omega$	(A1)

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Question	Answer	Marks
6(b)(iii)1.	Z has larger radius/diameter/(cross-sectional) area	B1
	Z has (material of) smaller resistivity/greater conductivity	B1
6(b)(iii)2.	current/ I (in battery) increases	M1
	($P = EI$ so) power/ P (produced by battery) increases	A1

Question	Answer	Marks
7(a)	circle(s) drawn only around β^- and $\bar{\nu}$ symbols	B1
7(b)	(electron) <u>antineutrino</u>	B1
7(c)	kinetic (energy)	B1
7(d)	Y has one more proton (and one less neutron)/X has one less proton (and one more neutron) or Y has more protons (and fewer neutrons)/X has fewer protons (and more neutrons) or a neutron changes to a proton or the number of protons increases	M1
	(so) not isotopes	A1
7(e)	up down down changes to up up down or udd $\rightarrow$ uud or down changes to up or d $\rightarrow$ u	B1

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1(a)(i)	zero error or wrongly calibrated scale	B1
1(a)(ii)	reading scale from different angles or wrongly interpolating between scale readings/divisions	B1
1(b)(i)	$P = V^2 / R$ or $P = VI$ <u>and</u> $V = IR$	C1
	$P = 5.0^2 / 125$ or 5.0×0.04 or $(0.04)^2 \times 125$ $= 0.20 \text{ W}$	A1
1(b)(ii)	$\%V = 2\%$ or $\Delta V / V = 0.02$	C1
	$\%P = (2 \times 2\%) + 3\%$ or $\%P = (2 \times 0.02 + 0.03) \times 100$ $= 7\%$	A1
1(b)(iii)	absolute uncertainty in $P = (7 / 100) \times 0.20$ $= 0.014$	C1
	power = $0.20 \pm 0.01 \text{ W}$ or $(2.0 \pm 0.1) \times 10^{-1} \text{ W}$	A1

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Question	Answer	Mark
2(a)(i)	(work =) force $\times$ distance moved in the direction of the force	B1
2(b)(i)	$\rho = m/V$	C1
	$= (20/9.81)/(4/3 \times \pi \times 0.16^3)$	A1
	$= 120 \text{ kg m}^{-3}$	
2(b)(ii)	the pressure on the lower surface (of sphere) is greater than the pressure on the upper surface (of sphere)	B1
2(b)(iii)	$a = (170 - 20)/(20/9.81)$	C1
	$= 74 \text{ ms}^{-2}$	A1
2(b)(iv)	$D = 170 - 20 (= 150)$	C1
	$810 \times (0.16^2) \times v^2 = 150$	C1
	$v = 2.7 \text{ ms}^{-1}$	A1
2(b)(v)	$4870 = (4850 \times v)/(v - 6.30)$	C1
	$v = 1530 \text{ ms}^{-1}$	A1

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Question	Answer	Mark
3(a)	$v = u + at$ $v = 9.6 - (9.81 \times 0.37) = 6.0 \text{ ms}^{-1}$	A1
3(b)	$s = \frac{1}{2} \times (9.6 + 6.0) \times 0.37$ or $6.0^2 = 9.6^2 - (2 \times 9.81 \times s)$ or $s = (9.6 \times 0.37) - (\frac{1}{2} \times 9.81 \times 0.37^2)$ or $s = (6.0 \times 0.37) + (\frac{1}{2} \times 9.81 \times 0.37^2)$	C1
	$s = 2.9 \text{ m}$	A1
3(c)(i)	$(\Delta)E = mg(\Delta)h$	C1
	$\Delta E = 0.056 \times 9.81 \times 2.9$ $= 1.6 \text{ J}$	A1
3(c)(ii)	$E = \frac{1}{2}mv^2$	C1
	$\Delta E = \frac{1}{2} \times 0.056 \times (6.0^2 - 3.8^2)$ $= 0.60 \text{ J}$	A1
3(d)	force on ball (by ceiling) <u>equal</u> to force on ceiling (by ball)	M1
	and opposite (in direction)	A1
3(e)	$(p =) mv$ or 0.056×6.0 or 0.056×3.8	C1
	change in momentum $= 0.056 \times (6.0 + 3.8)$ $= 0.55 \text{ N s}$	A1

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Question	Answer	Mark
3(f)	resultant force = $0.55/0.085$ (= 6.47 N)	C1
	force by ceiling = $6.47 - (0.056 \times 9.81)$ = 5.9 N	A1

Question	Answer	Mark
4(a)	(Young modulus =) stress/strain	B1
4(b)(i)	$k = F/\Delta L$ or 1/gradient	C1
	= $90 \times 10^3 / (2 \times 10^{-3})$ (<i>or other point on line</i>) = $4.5 \times 10^7 \text{ Nm}^{-1}$	A1
4(b)(ii)	$E = \frac{1}{2}F\Delta L$ or $E = \frac{1}{2}k(\Delta L)^2$	C1
	= $\frac{1}{2} \times 90 \times 10^3 \times 2 \times 10^{-3}$ or $\frac{1}{2} \times 4.5 \times 10^7 \times (2 \times 10^{-3})^2$	C1
	= 90 J	A1
4(c)	straight line starting from (0, 150) and below original line	M1
	line ends at (90, 147)	A1

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Question	Answer	Marks
5(a)	intensity $\propto$ (amplitude) ²	B1
5(b)(i)	$v = f\lambda$ or $c = f\lambda$	C1
	$f = 3.00 \times 10^8 / 0.060$ $= 5.0 \times 10^9 \text{ Hz}$	A1
5(b)(ii)	(at X path) difference = 3λ	M1
	(at X phase) difference = 0 or 1080°	M1
	so intensity is at a maximum/it is an intensity maximum	A1
5(b)(iii)	1. decrease in the distance between (adjacent intensity) maxima/minima	B1
	2. (intensity) maxima and minima exchange places	B1

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Question	Answer	Mark
6(a)	$R = \rho L / A$	C1
	$3.0 = \rho / [\pi \times (0.48 \times 10^{-3} / 2)^2]$	C1
	$\rho = 5.4 \times 10^{-7} \Omega \text{m}$	A1
6(b)(i)	p.d. = $5.0 - (2.0 \times 1.6)$ = 1.8V	A1
6(b)(ii)1.	current in resistor = $1.8 / 4.5$ (= 0.40 A)	C1
	current in wire = $1.6 - 0.40$ (= 1.2 A)	C1
	$R_X = 1.8 / 1.2$ = 1.5 Ω	A1
	or	
	$R_T = 1.8 / 1.6$ or $(5.0 / 1.6) - 2.0$ (= 1.125 Ω)	(C1)
	$(1 / 1.125) = (1 / 4.5) + (1 / R_X)$	(C1)
	$R_X = 1.5 \Omega$	(A1)
6(b)(ii)2.	length = $1.5 / 3.0$ or $1.5 \times 1.8 \times 10^{-7} / (5.4 \times 10^{-7})$ = 0.50m	A1

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Question	Answer	Mark
7(a)(i)	Q plotted at (82, 210)	A1
7(a)(ii)	R plotted at (83, 210)	A1
7(b)	lepton(s)	B1
7(c)	up down down changes to up up down or udd → uud or down changes to up or d → u	B1