
PHYSICS

9702/21

Paper 2 AS Level Structured Questions

May/June 2017

MARK SCHEME

Maximum Mark: 60

Published

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Question	Answer	Marks
1(a)	(stress =) force / area or $\text{kg m s}^{-2} / \text{m}^2$	B1
	$= \text{kg m}^{-1} \text{s}^{-2}$	A1
1(b)(i)	$0.58 = 2\pi \times [(4 \times 0.500 \times 0.600^3) / (E \times 0.0300 \times 0.00500^3)]^{0.5}$	C1
	$E = [4\pi^2 \times 4 \times 0.500 \times (0.600)^3] / [(0.58)^2 \times 0.0300 \times (0.00500)^3]$ $= 1.35 \times 10^{10} \text{ (Pa)}$	C1
	$= 14 \text{ (13.5) GPa}$	A1
1(b)(ii)1.	(accuracy determined by) the closeness of the value(s)/measurement(s) to the true value	B1
	(precision determined by) the range of the values/measurements	B1
1(b)(ii)2.	l is (cubed so) $3 \times$ (percentage/fractional) uncertainty and T is (squared so) $2 \times$ (percentage / fractional) uncertainty and (so) l contributes more	B1

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Question	Answer	Marks
2(a)	resultant force (in any direction) is zero	B1
	resultant torque/moment (about any point) is zero	B1
2(b)(i)	$a = (v - u) / t$ or gradient or $\Delta v / (\Delta)t$	C1
	e.g. $a = (8.8 - 4.6) / (7.0 - 4.0) = 1.4 \text{ m s}^{-2}$	A1
2(b)(ii)	$s = 4.6 \times 4 + [(8.8 + 4.6) / 2] \times 3$	C1
	$= 18.4 + 20.1$	A1
	$= 39 \text{ (38.5) m}$	
2(b)(iii)	$\Delta E = \frac{1}{2} \times 95 [(8.8)^2 - (4.6)^2]$	C1
	$= 3678 - 1005$	A1
	$= 2700 \text{ (2673) J}$	
2(b)(iv)1.	weight = 95×9.81 (= 932 N)	C1
	vertical tension force = $280 \sin 25^\circ$ or $280 \cos 65^\circ$ (=118.3 N)	C1
	$F = 932 + 118$	A1
	$= 1100 \text{ (1050) N}$	
2(b)(iv)2.	horizontal tension force = $280 \cos 25^\circ$ or $280 \sin 65^\circ$ (= 253.8 N)	C1
	resultant force = 95×1.4 (= 133 N)	C1
	$133 = 253.8 - R$	A1
	$R = 120 \text{ (120.8) N}$	

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Question	Answer	Marks
3(a)	$\rho = m / V$	C1
	$V = \pi d^2 L / 4$ or $\pi r^2 L$	C1
	weight = $2.7 \times 10^3 \times \pi (1.2 \times 10^{-2})^2 \times 5.0 \times 10^{-2} \times 9.81 = 0.60 \text{ N}$	A1
3(b)(i)	the point from where (all) the weight (of a body) seems to act	B1
3(b)(ii)	$W \times 12$	C1
	$(0.25 \times 8) + (0.6 \times 38)$	C1
	$W = (2 + 22.8) / 12$ $= 2.1 \text{ (2.07) N}$	A1
3(c)(i)	pressure changes with depth (in water) or pressure on bottom (of cylinder) different from pressure on top	B1
	pressure on bottom of cylinder <u>greater than</u> pressure on top or force (up) on bottom of cylinder <u>greater than</u> force (down) on top	B1
3(c)(ii)	anticlockwise moment reduced and reducing the weight of X reduces clockwise moment or anticlockwise moment reduced so clockwise moment now greater than (total) anticlockwise moment	B1

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Question	Answer	Marks
4(a)	(two) waves travelling (at same speed) in opposite directions overlap	B1
	waves (are same type and) have same frequency/wavelength	B1
4(b)(i)	$\lambda = 12 / 250 (= 0.048 \text{ m})$	C1
	distance = 1.5×0.048 = 0.072 m	A1
4(b)(ii)	$T = 1 / 250$ = 0.004 (s) or 4 (ms)	C1
	1. curve drawn is mirror image of that in Fig. 4.2 and labelled P	A1
	2. horizontal line drawn between A and B and labelled Q	A1

Question	Answer	Marks
5(a)	observed frequency is different to source frequency when source moves relative to observer	B1
5(b)	$360 = (400 \times 340) / (340 \pm v)$	C1
	$v = 38 (37.8) \text{ m s}^{-1}$	A1
	away (from the observer)	B1

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Question	Answer	Marks
6(a)	volt / ampere	B1
6(b)(i)	$R_T = [1/3.0 + 1/6.0]^{-1} + 4.0 (= 6.0 \Omega)$	C1
	$I = 1.5 / 6.0$	C1
	$= 0.25 \text{ A}$	A1
6(b)(ii)	$V_B = 0.5 \text{ V}$ $I = 0.5 / 3.0$ $= 0.17 (0.167) \text{ A}$	A1
6(b)(iii)	$P = I^2 R$ or VI or V^2 / R	C1
	ratio $= (0.167^2 \times 3.0) / (0.25^2 \times 4.0)$ $= 0.33$	A1
6(c)(i)	vary/change/different radius/diameter/ <u>cross-sectional</u> area (of wire)	B1
6(c)(ii)	$v = I / Ane$ ratio $= \frac{(I_B / A_B)}{(I_C / A_C)}$ or $\frac{I_B}{I_C} \times \frac{A_C}{A_B}$	C1
	$(R \propto 1 / A \text{ so}) \text{ ratio} = \frac{I_B}{I_C} \times \frac{R_B}{R_C} = \frac{0.167}{0.25} \times \frac{3.0}{4.0}$ $= 0.50$	A1
6(d)(i)	0.25 A to 0.13 (0.125) A or halved	A1
6(d)(ii)	no change	A1

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Question	Answer	Marks									
7(a)(i)	(proton is uud so) $(2/3)e + (2/3)e - (1/3)e = e$	B1									
7(a)(ii)	(neutron is udd so) $(2/3)e - (1/3)e - (1/3)e = 0$	B1									
7(b)(i)	<table border="1"> <tr> <td></td><td>β^-</td><td>β^+</td></tr> <tr> <td>nucleon number</td><td>90</td><td>64</td></tr> <tr> <td>proton number</td><td>39</td><td>28</td></tr> </table> <i>all correct</i>		β^-	β^+	nucleon number	90	64	proton number	39	28	B1
	β^-	β^+									
nucleon number	90	64									
proton number	39	28									
7(b)(ii)	weak (nuclear force/interaction)	B1									
7(b)(iii)	β^- decay: electron and (electron) antineutrino β^+ decay: positron and (electron) neutrino <i>all correct</i>	B1									

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Question	Answer	Marks
1(a)	kelvin, mole, ampere, candela <i>any two</i>	B1
1(b)	use of resistivity = RA/l and $V = IR$ (to give $\rho = VA/Il$)	C1
	units of V : (work done / charge) $\text{kg m}^2 \text{s}^{-2} (\text{A s})^{-1}$	C1
	units of resistivity: $(\text{kg m}^2 \text{s}^{-3} \text{A}^{-1} \text{A}^{-1} \text{m})$ $= \text{kg m}^3 \text{s}^{-3} \text{A}^{-2}$	A1
	or	
	use of $R = \rho L/A$ and $P = I^2 R$ (gives $\rho = PA/I^2 L$)	(C1)
	units of P : $\text{kg m}^2 \text{s}^{-3}$	(C1)
	units of resistivity: $(\text{kg m}^2 \text{s}^{-3} \times \text{m}^2) / (\text{A}^2 \times \text{m})$ $= \text{kg m}^3 \text{s}^{-3} \text{A}^{-2}$	(A1)
1(c)(i)	$\rho = (RA/l)$	C1
	$= (0.03 \times 1.5 \times 10^{-6}) / 2.5$ ($= 1.8 \times 10^{-8}$)	C1
	$= 18 \text{ n}\Omega \text{ m}$	A1
1(c)(ii)	1. precision is determined by the range in the measurements/values/readings/data/results	B1
	2. metre rule measures to $\pm 1 \text{ mm}$ and micrometer to $\pm 0.01 \text{ mm}$ (so there is less (percentage) uncertainty/random error)	B1

Question	Answer	Marks
2(a)	rate of change of displacement or change in displacement/time taken	B1
2(b)(i)	$s = ut + \frac{1}{2}at^2$	C1
	$t = [(2 \times 1.25) / 9.81]^{1/2} (= 0.5048 \text{ s})$	C1
	or	
	$v^2 = u^2 + 2as$ $v_{\text{vert}} = (2 \times 9.81 \times 1.25)^{1/2} (= 4.95)$	(C1)
	$t = [2s / (u + v)] = 2 \times 1.25 / 4.95 (= 0.5048 \text{ s})$	(C1)
	$v = d / t = 1.5 / 0.50(48)$ $= 3.0 \text{ (2.97) ms}^{-1}$	A1
2(b)(ii)	vertical velocity = at $= 9.81 \times 0.5048 (= 4.95) \text{ [using } t = 0.50 \text{ gives 4.9]}$	C1
	velocity = $[(v_h)^2 + (v_v)^2]^{1/2}$	C1
	$= [(2.97)^2 + (4.95)^2]^{1/2}$ $= 5.8 \text{ (5.79) [using } t = 0.50 \text{ leads to 5.7]}$	A1
	direction ($= \tan^{-1} 4.95/2.97$) = 59°	A1
2(b)(iii)	kinetic energy = $\frac{1}{2}mv^2$	C1
	$= \frac{1}{2} \times 0.45 \times (5.8)^2$ $= 7.6 \text{ (7.57) J [using } t = 0.50 \text{ leads to 7.3 J]}$	A1

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Question	Answer	Marks
2(b)(iv)	potential energy = mgh	C1
	= $(0.45 \times 9.81 \times 1.25)$	A1
	= 5.5 (5.52) J	
2(c)	there is KE of the ball at the start/leaving table or the ball has an initial/constant horizontal velocity or the ball has velocity at start/leaving table	B1

Question	Answer	Marks
3(a)	$E = \text{stress} / \text{strain}$ or $(F / A) / (e / l)$	C1
	= $[\text{gradient} \times 3.5] / [\pi \times (0.19 \times 10^{-3})^2]$	C1
	e.g. $E = [(40 - 5) / ([11.6 - 3.2] \times 10^{-3})] \times 3.5 / [\pi \times (0.19 \times 10^{-3})^2]$ or $[4170 \times 3.5] / [\pi \times (0.19 \times 10^{-3})^2]$	
	$E (= 1.3 \times 10^{11}) = 0.13 \text{ TPa}$ (allow answers in range 0.120–0.136 TPa)	A1
3(b)	a larger <u>range</u> of F required or <u>range</u> greater than 35 N	B1

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Question	Answer	Marks
4(a)	a body/mass/object continues (at rest or) at constant/uniform velocity unless acted on by a resultant force	B1
4(b)(i)	initial momentum = final momentum $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$	C1
	$0.60 \times 100 - 0.80 \times 200 = -0.40 \times 100 + v \times 200$ $v = (-) 0.3(0) \text{ m s}^{-1}$	A1
4(b)(ii)	<u>kinetic</u> energy is not conserved/is lost (but) <u>total</u> energy is conserved/constant or some of the (initial) <u>kinetic</u> energy is transformed into other forms of energy	B1

Question	Answer	Marks
5(a)	frequency is the number of vibrations/oscillations per unit time or the number of wavefronts passing a point per unit time	B1
5(b)	vibrations/oscillation of the air particles are parallel to the direction of it (the direction of travel of the sound wave)	B1
5(c)(i)	$T = 2(.0) \text{ (ms)}$	C1
	$f = 500 \text{ Hz}$	A1
5(c)(ii)	1. amplitude increases (time) period decreases 2. amplitude decreases (time) period increases <i>any 3 points</i>	B3

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Question	Answer	Marks
6(a)(i)	<u>waves</u> at (each) slit/aperture spread	B1
	(into the geometric shadow) <u>wave(s)</u> overlap/superpose/sum/meet/intersect	B1
6(a)(ii)	there is not a constant phase difference/coherence (for two separate light source(s)) or waves/light from the double slit are coherent/have a constant phase difference	B1
6(b)	$x = \lambda D / a$	C1
	$\lambda = (36 \times 10^{-3} \times 0.48 \times 10^{-3}) / (16 \times 2.4)$	C1
	$= 4.5 \times 10^{-7} \text{ m}$	A1
6(c)(i)	<u>no</u> movement of the water/water is flat/no ripples/disturbance	B1
	the path difference is 2.5λ or the phase difference is 900° or 5π rad	B1
6(c)(ii)	1. surface/water/P vibrates/ripples and as (waves from the two dippers) arrive in phase	B1
	2. surface/water/P vibrates/ripples and as amplitudes/displacements are no longer equal/do not cancel	B1

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Question	Answer	Marks
7(a)	energy transformed from <u>chemical to electrical</u> / unit charge (driven around a complete circuit)	B1
7(b)(i)	the current decreases (as resistance of Y increases)	M1
	lost volts go down (as resistance of Y increases)	M1
	p.d. AB increases (as resistance of Y increases)	A1
7(b)(ii)1.	$1.50 = 0.180 \times (6.00 + 0.200 + R_X)$	C1
	$R_X = 2.1(3) \Omega$	A1
7(b)(ii)2.	p.d. AB = $1.5 - (0.180 \times 0.200)$ or $0.18 \times (2.13 + 6.00)$	C1
	= $1.46(4) \text{ V}$	A1
7(b)(ii)3.	efficiency = (useful) power output / (total) power input or IV / IE	C1
	(= $1.46 / 1.5$) = 0.97 [0.98 if full figures used]	A1

Question	Answer	Marks
8(a)	β^- emission: neutron changes to proton (+ β^- /electron) and β^+ emission: proton changes to neutron (+ β^+ /positron)	B1
	β^- emission: (electron) antineutrino also emitted and β^+ emission: (electron) neutrino also emitted	B1
8(b)	proton: up up down (and zero strange) neutron: up down down (and zero strange)	B1

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Question	Answer	Marks
1(a)(i)	$R = 7(.0) \text{ N}$	B1
1(a)(ii)	$R = 13 \text{ N}$	B1
1(b)(i)	forces resolved: $18 \sin 65^\circ$ (vertical) and $55 + 18 \cos 65^\circ$ (horizontal) or scale drawing: correct triangle drawn for forces	B1
	$F = [(18 \sin 65^\circ)^2 + (55 + 18 \cos 65^\circ)^2]^{1/2} = 65 \text{ (64.7) N}$ or scale drawing: scale given, length of resultant given correctly, $\pm 1 \text{ N}$	A1
1(b)(ii)	angle = $\tan^{-1} [18 \sin 65^\circ / (55 + 18 \cos 65^\circ)] = \tan^{-1} (16.3 / 62.6)$ or scale drawing: correct angle measured/direction correct on diagram below the 55 N force	C1
	angle = 15 (14.6) ° (below the 55 N force) or scale drawing: angle = $15^\circ \pm 1^\circ$	A1
1(c)	(resultant) force = mass $\times$ acceleration	C1
	$80 - 65 = 2.7a$	C1
	$a = 5.6 \text{ m s}^{-2}$ [5.7 if 64.7 N used from (i)]	A1

Question	Answer	Marks
2(a)	(resultant) force is proportional/equal to the rate of change of momentum	B1
2(b)(i)	change in momentum = $m(v_2 - v_1)$ $= 0.84 \times (8.8 - 4.2)$	C1
	$= 3.9 \text{ (3.86) kg m s}^{-1}$	A1
2(b)(ii)	$F = (3.9 / 4.0) = 0.97 \text{ (0.965) N}$	A1
2(c)(i)	change in momentum for A: $0.84 \times (4.7 - 8.8) = -3.4 \text{ (3.44)}$ change in momentum for B: $0.73 \times (4.7 - 0) = 3.4 \text{ (3.43)}$	M1
	change in momentum for B is equal and opposite to A	A1
2(c)(ii)	change in momentum equal (for A and B)	M1
	force is change in momentum / time and time (of collision) is the same hence force on A and B equal and opposite as for Newton's third law	A1
2(c)(iii)	inelastic as relative speed of approach not equal to relative speed of separation	B1

Question	Answer	Marks
3(a)	force per unit (positive) charge	B1
3(b)(i)	$a = (v^2 - u^2) / 2s$ $= [(18 \times 10^6)^2 - (2.5 \times 10^3)^2] / (2 \times 12 \times 10^{-3})$	B1
	$= 1.3 (1.35) \times 10^{16} \text{ m s}^{-2}$	A1
3(b)(ii)	$\text{KE} = \frac{1}{2}mv^2$ or $\frac{1}{2}m(v^2 - u^2)$	C1
	change in KE $= 0.5 \times 9.11 \times 10^{-31} \times [(18 \times 10^6)^2 - (2.5 \times 10^3)^2]$	B1
	$= 1.5 (1.48) \times 10^{-16} \text{ J}$	A1
3(b)(iii)	$E = F / e = ma / e$ or $eV = \Delta\text{KE}$ so $E = \Delta\text{KE} / (e \times d)$	C1
	$E = (9.11 \times 10^{-31} \times 1.35 \times 10^{16}) / 1.60 \times 10^{-19}$ or $E = (1.48 \times 10^{-16}) / (12 \times 10^{-3} \times 1.60 \times 10^{-19})$	C1
	$= 7.7 (7.69) \times 10^4 \text{ V m}^{-1}$	A1
3(c)	charge on α opposite to electron/charge on α is positive	B1
	ΔKE is negative/KE reduced	B1
	charge of α greater/twice that of electron causes larger/twice ΔKE (in magnitude)	B1

Question	Answer	Marks
4(a)	the straight line does not go through the origin/the force is not proportional to extension (so does not obey Hooke's law)	A1
4(b)	elastic potential energy	B1
4(c)	remove the force/masses and the spring returns to its original length if elastic	B1
4(d)	work done is represented by/linked to area under the line ($\times g$)	C1
	work = $\frac{1}{2} (145 + 70) \times 10^{-3} \times 9.81 \times 120 \times 10^{-3}$	C1
	= 0.13 (0.127) J	A1

Question	Answer	Marks
5(a)(i)	waves at the elements/slits	B1
	waves spread (into the geometric shadow)	B1
5(a)(ii)	1. waves (from each element/slit) overlap/meet/superpose	B1
	with a phase difference/path difference of zero	B1
	2. phase difference is 360° /path difference of λ	B1
5(b)(i)	e.g. gradient = $(0.40 - 0.32) / [(500 - 400) \times 10^{-9}]$	C1
	= $8(.0) \times 10^5$	A1
5(b)(ii)	$d \sin \theta = n\lambda$	C1
	$d = n / \text{gradient}$	
	= $2 / 8.0 \times 10^5 = 2.5 \times 10^{-6} \text{ m}$	A1
5(b)(iii)	straight line drawn with lower gradient (about $\frac{1}{2}$) and all points lower	B1

Question	Answer	Marks
6(a)(i)	straight line <u>through the origin</u>	B1
6(a)(ii)	zero current for one direction (–ve V) up to zero or a few tenths of volt (+ve V)	B1
	straight line positive gradient/increasing gradient (+ve V)	B1
6(b)(i)	1. current = 2.8 A	A1
	2. 4(.0) A for each lamp	C1
	current in circuit = 8(.0) A	A1
6(b)(ii)	use of $R = V / I$ with correct values of V from graph for each arrangement	C1
	1. series resistance (= 2.1 + 2.1) = 4.2 or 4.3 Ω or (12 / 2.8) = 4.3 Ω	A1
	2. parallel resistance 1.5 Ω (each lamp 3.0 Ω) or (12 / 8.0) = 1.5 Ω	A1
6(b)(iii)	power = IV or V^2 / R or $I^2 R$	C1
	ratio = $(2.8 \times 6.0) / (4.0 \times 12) = 0.35$	A1

Question	Answer	Marks
7(a)	electron and quark both underlined/clearly indicated and no others	B1
7(b)(i)	value A60 B28 <i>both correct</i>	B1
7(b)(ii)	(electron) antineutrino	B1