
PHYSICS

9702/21

Paper 2 AS Level Structured Questions

October/November 2019

MARK SCHEME

Maximum Mark: 60

Published

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Question	Answer	Marks
1(a)(i)	mass in range 1–20 g	A1
1(a)(ii)	wavelength in range 1×10^{-8} m to 4×10^{-7} m	A1
1(b)(i)	$T = 2\pi \times (200 \times 10^{-3} / 25)^{0.5}$ $= 0.56$ s	A1
1(b)(ii)	percentage uncertainty = $(2\% + 8\%) / 2$ (= 5%) or fractional uncertainty = $(0.02+0.08) / 2$ (= 0.05)	C1
	$\Delta T = 0.56 \times 0.05$ $= 0.028$ (s)	C1
	$T = (0.56 \pm 0.03)$ s	A1

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Question	Answer	Marks
2(a)	the (two) plates are <u>vertical</u> (and separated)	B1
	left plate positively charged and right plate negatively charged/earthed or right plate negatively charged and left plate positively charged/earthed	B1
2(b)	$F = Eq$	C1
	$= 1.3 \times 10^4 \times 3.7 \times 10^{-9}$ $= 4.8 \times 10^{-5} \text{ N}$	A1
2(c)	$F^2 = (4.8 \times 10^{-5})^2 + (5.4 \times 10^{-5})^2$ so $F = 7.2 \times 10^{-5} \text{ N}$ or $F = [(4.8 \times 10^{-5})^2 + (5.4 \times 10^{-5})^2]^{0.5}$ so $F = 7.2 \times 10^{-5} \text{ N}$	A1
2(d)	electric force is constant (because field strength/ E is constant)	B1
	weight is constant (and so resultant force constant)	B1
2(e)(i)	$m = 5.4 \times 10^{-5} / 9.81 (= 5.5 \times 10^{-6})$	C1
	$a = 7.2 \times 10^{-5} / (5.5 \times 10^{-6})$ $= 13 \text{ m s}^{-2}$	A1
2(e)(ii)	$v^2 = u^2 + 2as$ $v^2 = 2 \times 13 \times 0.58$	C1
	$v = 3.9 \text{ m s}^{-1}$	A1

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Question	Answer	Marks
3(a)	$\rho = m / V$	C1
	$V = \pi \times (0.16 / 2)^2 \times 7.6 \times 3.0$ (= 0.458 m ³)	C1
	$m = \pi \times (0.16 / 2)^2 \times 7.6 \times 3.0 \times 1.2 = 0.55$ kg	A1
3(b)(i)	$\Delta p = 0.55 \times 7.6$ $= 4.2$ N s	A1
3(b)(ii)	$F = 4.2 / 3.0$ or $0.55 \times 7.6 / 3.0$ $= 1.4$ N	A1
3(c)(i)	$F = 1.4$ N	A1
3(c)(ii)	Newton's third law (of motion)	B1
3(d)	$2 \times 1.4 = m \times 9.81$	A1
	$m = 0.29$ kg	
3(e)	the density of air is less at high altitude	B1
3(f)	$f_o = f_s v / (v - v_s)$ $= 3000 \times 340 / (340 - 22)$	C1
	$= 3200$ Hz	A1

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Question	Answer	Marks
4(a)	$k = F / x$ or $k = \text{gradient}$	C1
	e.g. $k = 4.0 / 0.050$	A1
	$k = 80 \text{ N m}^{-1}$	
4(b)	$E = \frac{1}{2}Fx$ or $E = \frac{1}{2}kx^2$ or $E = \text{area under graph}$	C1
	$(\Delta)E = (\frac{1}{2} \times 3.2 \times 0.040) - (\frac{1}{2} \times 1.2 \times 0.015) = 0.055 \text{ J}$ or $(\Delta)E = (\frac{1}{2} \times 80 \times 0.040^2) - (\frac{1}{2} \times 80 \times 0.015^2) = 0.055 \text{ J}$ or $(\Delta)E = \frac{1}{2} \times (1.2 + 3.2) \times 0.025 = 0.055 \text{ J}$	A1
4(c)	$(\Delta)E = mg(\Delta)h$	C1
	$= 0.122 \times 9.81 \times (0.120 - 0.095)$ $= 0.030 \text{ J}$	A1
	or	
	$(\Delta)E = W \times (\Delta)h$	(C1)
	$= 1.2 \times 0.025$ $= 0.030 \text{ J}$	(A1)

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Question	Answer	Marks
4(d)(i)	$E = 0.055 - 0.030$ $= 0.025 \text{ J}$	A1
4(d)(ii)	$E = \frac{1}{2}mv^2$	C1
	$v = [(2 \times 0.025) / 0.122]^{0.5}$ $= 0.64 \text{ m s}^{-1}$	A1

Question	Answer	Marks
5(a)(i)	the dippers are connected to the same vibrator/motor	B1
5(a)(ii)	(the overlapping waves have) similar/same amplitude	B1
5(b)	any means of ‘freezing’ the pattern e.g. use a stroboscope/strobe	B1
5(c)	$vT = \lambda$ or $v = f\lambda$ and $f = 1 / T$	C1
	$T = 0.060 / 0.40$ $= 0.15 \text{ s}$	A1
5(d)(i)	path difference = 3.0 cm	A1
5(d)(ii)	phase difference = 180°	A1
5(e)	line drawn joining points where only maxima are observed (i.e. through points where wavefronts intersect) of length at least 4 cm	B1

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Question	Answer	Marks
6(a)	work done / charge or energy (transferred from electrical to other forms) / charge	B1
6(b)	for $V < 0.25 \text{ V}$ resistance is infinite/very high (as current is zero)	B1
	for $V > 0.25 \text{ V}$ resistance decreases (as V increases)	B1
6(c)(i)	$R = V / I$	C1
	$= 0.75 / (15 \times 10^{-3})$	C1
	$= 50 \, \Omega$	A1

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Question	Answer	Marks
6(c)(ii)	1. $V_Y = 15 \times 10^{-3} \times 60$ (= 0.90 V)	C1
	$V_X = 2.0 - 0.90 - 0.75$ (= 0.35 V)	C1
	$R_X = 0.35 / (15 \times 10^{-3})$ = 23 Ω	A1
	or	
	total $R = 60 + 50 + R_X$	(C1)
	$60 + 50 + R_X = 2.0 / (15 \times 10^{-3})$	(C1)
	$R_X = 23 \Omega$	(A1)
	2. $P = VI$ or $P = EI$ or $P = I^2R$ or $P = V^2 / R$	C1
	ratio = $\frac{(15 \times 10^{-3})^2 \times 60}{2.0 \times 15 \times 10^{-3}}$ or $\frac{0.90 \times 15 \times 10^{-3}}{2.0 \times 15 \times 10^{-3}}$ or $\frac{(0.90^2 / 60)}{2.0 \times 15 \times 10^{-3}}$ = 0.45	A1

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Question	Answer	Marks
7(a)(i)	proton number = 17 and nucleon number = 35	A1
7(a)(ii)	(electron) neutrino	B1
7(b)	d/down (quark charge) is $-\frac{1}{3}(e)$ or <u>two</u> d/down (quark charges) is $-\frac{2}{3}(e)$ or s/strange (quark charge) is $-\frac{1}{3}(e)$	C1
	charge = $-\frac{1}{3}(e) - \frac{1}{3}(e) - \frac{1}{3}(e)$ = $-1(e)$	A1

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Question	Answer	Marks
1(a)	scalar quantity has (only) magnitude	B1
	vector quantity has magnitude and direction	B1
1(b)(i)	$E = F / Q$	C1
	$= \text{kg m s}^{-2} / \text{A s} = \text{kg m A}^{-1} \text{s}^{-3}$	A1
1(b)(ii)	$b = Q / x^2 E$	C1
	$= \text{A s} / \text{m}^2 \text{kg m A}^{-1} \text{s}^{-3}$	
	$= \text{A}^2 \text{s}^4 \text{kg}^{-1} \text{m}^{-3}$	A1

Question	Answer	Marks
2(a)	change in velocity / time (taken)	A1
2(b)(i)	weight $\gg$ (force due to) air resistance or (force due to) air resistance is negligible <u>compared to weight</u>	B1
2(b)(ii)	$s = ut + \frac{1}{2}at^2$	C1
	$0.280 = \frac{1}{2} \times 9.81 \times t^2$	
	$t = 0.24 \text{ s}$	A1

Question	Answer	Marks
2(b)(iii)	total distance fallen = $0.280 + 0.080 = 0.360$ $0.360 = \frac{1}{2} \times 9.81 \times t^2$ $t = 0.27 \text{ s}$	C1
	time taken = $0.27 - 0.24$ = 0.03 s	A1
	or	
	$v = 9.81 \times 0.239$ or $(2 \times 9.81 \times 0.280)^{0.5}$ or $(2 \times 0.280) / 0.239$ = $2.34 \text{ (ms}^{-1}\text{)}$	(C1)
	$0.080 = 2.34t + \frac{1}{2} \times 9.81 \times t^2$ solving quadratic equation gives $t = 0.03 \text{ s}$ <i>allow any correct method using equations of uniform accelerated motion</i>	(A1)
2(c)	(average) resultant force/acceleration/speed/velocity (of low-density ball) is less	B1
	(so) time interval is longer	B1

Question	Answer	Marks
3(a)	force on body A (by body B) is equal (in magnitude) to force on body B (by body A)	B1
	force on body A (by body B) is opposite (in direction) to force on body B (by body A)	B1
3(b)(i)	$m_X \times 5v$ or $(m_X + m_Y) \times v$	C1
	$m_X \times 5v = (m_X + m_Y) \times v$ (so) $m_Y / m_X = 4$	A1
3(b)(ii)	$(E =) \frac{1}{2}mv^2$	C1
	ratio = $[\frac{1}{2} \times (m_X + m_Y) \times v^2] / [\frac{1}{2} \times m_X \times (5v)^2]$	C1
	= 0.2	A1
3(b)(iii)	ratio = 1	A1
3(c)(i)	1. (magnitude of resultant force is) zero	B1
	2. (magnitude of resultant force is) constant	B1
	(direction of resultant force is) opposite to the momentum	B1
3(c)(ii)	horizontal line from (0 ms, 0 squares) ending at (20 ms, 0 squares)	B1
	straight line from (20 ms, 0 squares) ending at (40 ms, 4.0 squares [= 4.0 cm vertically])	B1
	horizontal line from (40 ms, 4.0 squares) ending at (60 ms, 4.0 squares)	B1

Question	Answer	Marks
4(a)(i)	(vertically) upwards/up	B1
4(a)(ii)	increases (with time/velocity/depth)	B1
4(b)(i)	for a body in (rotational) equilibrium	B1
	<u>sum/total</u> of clockwise moments about a point = <u>sum/total</u> of anticlockwise moments about the (same) point	B1
4(b)(ii)	$(F_B \times 5.0)$ or (380×2.5) or (750×1.6)	C1
	$(F_B \times 5.0) = (380 \times 2.5) + (750 \times 1.6)$ $F_B = 430 \text{ N}$	A1
4(b)(iii)	taking moments about C: $(380 \times 2.5) = 750 \times (2.0 - x)$	C1
	$(2.0 - x) = 1.3$ $x = 0.7 \text{ m}$	A1
	or	
	moments may be taken about other points, e.g. about D: $(380 \times 4.5) + (750 \times x) = 1130 \times 2.0$	(C1)
	$x = 0.7 \text{ m}$	(A1)

Question	Answer	Marks
5(a)	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
5(b)	$(T =) 2.0 \times 2.5 (= 5.0 \text{ ms})$ or $2.0 \times 2.5 \times 10^{-3} (= 5.0 \times 10^{-3} \text{ s})$	C1
	$f = 1 / (5.0 \times 10^{-3})$ $= 200 \text{ Hz}$	A1
5(c)(i)	(path difference =) $8.0 + (20.8^2 - 8.0^2)^{0.5} - 20.8 = 6.4 \text{ (m)}$	A1
5(c)(ii)	• <u>path difference</u> = 4λ • waves (meet at C) in phase • constructive interference (of waves) <i>any two points, one mark each</i>	B2
5(c)(iii)	$v = 200 \times 1.6$ $= 320 \text{ (ms}^{-1}\text{)}$	C1
	$\Delta t = 6.4 / 320$ or $27.2 / 320 - 20.8 / 320$ $= 0.020 \text{ s}$	A1
5(c)(iv)	$3\lambda = 6.4$ $\lambda = 2.1 \text{ m}$	A1

Question	Answer	Marks
6(a)	<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(b)(i)	$R = V / I$	C1
	$= 0.60 / 7.5 \times 10^{-3}$	C1
	$= 80 \, \Omega$	A1
6(b)(ii)	resistance decreases	B1
6(c)(i)	$E = 0.60 + 0.30$ $= 0.90 \, \text{V}$	A1
6(c)(ii)	$(I =) 9.3 - 7.5$	C1
	$I = 1.8 \, (\text{mA})$ or $1.8 \times 10^{-3} \, (\text{A})$	A1
	$R = 0.90 / 1.8 \times 10^{-3}$ $= 500 \, \Omega$	
	or	
	total resistance $= 0.90 / 9.3 \times 10^{-3} = 96.8 \, (\Omega)$ total resistance of diode and X $= 0.90 / 7.5 \times 10^{-3} = 120 \, (\Omega)$ $1 / 96.8 = 1 / R + 1 / 120$	(C1)
	$R = 500 \, \Omega$	(A1)

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Question	Answer	Marks
6(c)(iii)	$P = VI$ or I^2R or V^2/R	C1
	$= 0.60 \times 7.5 \times 10^{-3}$ or $(7.5 \times 10^{-3})^2 \times 80$ or $0.60^2 / 80$	A1
	$= 4.5 \times 10^{-3} \text{ W}$	
6(c)(iv)	current = 2.5 mA	A1

Question	Answer	Marks
7(a)	number of protons = 92	A1
	number of neutrons = 142	A1
7(b)	$5.6 \text{ MeV} = 5.6 \times 1.60 \times 10^{-19} \times 10^6$ ($= 8.96 \times 10^{-13} \text{ J}$)	C1
	number $= 0.15 / (5.6 \times 1.60 \times 10^{-13})$ $= 1.7 \times 10^{11}$	A1
	or	
	$0.15 \text{ W} = 0.15 / (1.60 \times 10^{-19} \times 10^6)$ ($= 9.38 \times 10^{11} \text{ MeV s}^{-1}$)	(C1)
	number $= 9.38 \times 10^{11} / 5.6$ $= 1.7 \times 10^{11}$	(A1)

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1(a)	base units: $\text{kg m s}^{-2} \times \text{m}$ $= \text{kg m}^2 \text{s}^{-2}$	A1
1(b)(i)	distance of COG from P (= GP) $= 17 \cos 45^\circ - 4.0$ or $(144.5)^{1/2} - 4.0$ (= 8.0 cm)	C1
	moment = $0.15 \times 8.0 \times 10^{-2}$ $= 1.2 \times 10^{-2} \text{ N m}$	A1
1(b)(ii)	(line of action of) weight acts through pivot/P or distance between (line of action of) weight and pivot/P is zero	B1
	(so) weight does not have a moment about pivot/P	B1

Question	Answer	Marks
2(a)	(work done =) force $\times$ distance <u>moved</u> in direction of force	B1
2(b)(i)	1. acceleration = gradient or $a = (v - u) / t$ or $a = \Delta v / t$	C1
	e.g. $a = 2.4 / 3.0$ $= 0.80 \text{ m s}^{-2}$	A1
	2. tension in cable = $(13.0 + 2.0) \times 10^3$	C1
	work done = $15 \times 10^3 \times (3.0 \times 2.4)$ $= 1.1 \times 10^5 \text{ J}$	A1
2(b)(ii)	power = Fv	C1
	$v = 2.0 \text{ (ms}^{-1}\text{)}$	C1
	input power = $(1.6 \times 10^4 \times 2.0) / 0.67$ $= 4.8 \times 10^4 \text{ W}$	A1
2(b)(iii)	work is done against friction so (increase in) GPE is less (than work done by motor) or energy is lost or transferred or converted to heat/thermal energy due to friction or resistance force or work is done lifting the cable so GPE is less	A1

Question	Answer	Marks
3(a)(i)	mass	B1
3(a)(ii)	charge	B1
3(b)(i)	$E = V/d$ or $E = F/q$	C1
	$F = (1.2 \times 10^3 \times 4.2 \times 10^{-9}) / 3.6 \times 10^{-2}$	C1
	$= 1.4 \times 10^{-4} \text{ N}$	A1
3(b)(ii)	$W = mg$	C1
	$= 5.9 \times 10^{-6} \times 9.81$	C1
	resultant force $= 1.4 \times 10^{-4} - (5.9 \times 10^{-6} \times 9.81)$	
	$a = F/m$	C1
	$a = [1.4 \times 10^{-4} - (5.9 \times 10^{-6} \times 9.81)] / [5.9 \times 10^{-6}] = 14 \text{ ms}^{-2}$	A1
3(b)(iii)	1. $s = ut + \frac{1}{2}at^2$ $1.8 \times 10^{-2} = \frac{1}{2} \times 14 \times t^2$	C1
	$t = 0.051 \text{ s}$	A1
	2. $p = 0.75 \times 0.051$ $= 0.038 \text{ m}$	A1

Question	Answer	Marks
4(a)(i)	$p = mv$	C1
	$= 0.2(00) \times 6.(00) \times \sin 60(.0)^\circ$ or $0.2(00) \times 6.(00) \times \cos 30(.0)^\circ$	A1
	$= 1.04 \text{ kg m s}^{-1}$	
4(a)(ii)	$0.300 \times v_x \times \sin 60.0^\circ = 1.04$ $v_x = 4.00 \text{ m s}^{-1}$	A1
4(a)(iii)	$0.30 \times 4.0 \times \cos 60^\circ$ or $0.20 \times 6.0 \times \cos 60^\circ$ or $(0.30 + 0.20)v$ or $0.50v$	C1
	$0.30 \times 4.0 \times \cos 60^\circ + 0.20 \times 6.0 \times \cos 60^\circ = (0.30 + 0.20)v$ or $0.50v$	A1
	so $v = 2.4 \text{ m s}^{-1}$	
4(b)(i)	$E = \frac{1}{2}mv^2$	C1
	$\frac{1}{2} \times 0.50 \times 2.4^2 = \frac{1}{2} \times 72 \times x^2$	C1
	$x = 0.20 \text{ m}$	A1
4(b)(ii)	1. straight line from the origin sloping upwards	B1
	2. line drawn from a positive value of E_k at $x = 0$ to a positive value of x at $E_k = 0$	M1
	line has an increasing downwards slope	A1

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Question	Answer	Marks
5(a)(i)	(coherence means) constant phase difference (between waves)	B1
5(a)(ii)	(interference is) the sum/addition/combination of the displacements of overlapping/meeting waves	B1
5(b)(i)	$n\lambda = d \sin \theta$	C1
	$\lambda = \sin 51^\circ / (2 \times 6.7 \times 10^5)$	A1
	$= 5.8 \times 10^{-7} \text{ m}$	
5(b)(ii)	smaller angle (corresponding to second order maxima and so) shorter distance (between second order maxima spots)	B1

Question	Answer	Marks
6(a)(i)	$R = V / I$	C1
	resistance = $(12 / 0.20) / 2$ or $6 / 0.20$	A1
	$= 30 \Omega$	
6(a)(ii)	$I = 0.50 - 0.20$ (= 0.30 A)	C1
	$R + 28 = 12 / 0.30$ (= 40 Ω)	A1
	$R = 12 \Omega$	

Question	Answer	Marks
6(b)	p.d. across lamp = 0.20×30 (= 6.0 V)	C1
	p.d. across $R = 0.30 \times 12$ (= 3.6 V)	C1
	$V_{XY} = 6.0 - 3.6$ = 2.4 V	A1
	or	
	p.d. across lamp = 0.20×30 (= 6.0 V)	(C1)
	p.d. across 28Ω resistor = 0.30×28 (= 8.4 V)	(C1)
	$V_{XY} = 8.4 - 6.0$ = 2.4 V	(A1)
6(c)	$P = VI$ or $P = EI$ or $P = I^2R$ or $P = V^2/R$	C1
	ratio = $(6.0 \times 0.20) \times 2 / (12 \times 0.50)$ or $0.20 / 0.50$ = 0.40	A1
6(d)	no change to V across lamps, so power in lamps unchanged or current in battery/total current increases (and e.m.f. the same) so power produced by battery increases	B1
	both the above statements and so the ratio decreases	B1

Question	Answer	Marks
7(a)	number of protons = 95	A1
	number of neutrons = 146	A1
7(b)	Np/neptunium (nucleus) has <u>kinetic</u> energy or gamma/ γ -radiation produced	B1
7(c)(i)	$I = NQ / t$	C1
	$I = (6.9 \times 10^{11} \times 2 \times 1.60 \times 10^{-19}) / 30$	A1
	$= 7.4 \times 10^{-9} \text{ A}$	
7(c)(ii)	$P = (6.9 \times 10^{11} \times 5.5 \times 10^6 \times 1.60 \times 10^{-19}) / 30$	C1
	$= 0.020 \text{ W}$	A1