

MARK SCHEME for the May/June 2010 question paper
for the guidance of teachers

9702 PHYSICS

9702/21

Paper 2 (AS Structured Questions), maximum raw mark 60

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	GCE AS/A LEVEL – May/June 2010	9702	21

1	10 ⁻⁹	B1	
	c	B1	
	mega	B1	
	tera	B1	[4]
2	(a) scalar	B1	
	scalar	B1	
	vector	B1	[3]
	(b) (i) 1 gradient (of graph) is the speed/velocity (<i>can be scored here or in 2</i>).....	B1	
	initial gradient is zero	B1	[2]
	2 gradient (of line/graph) becomes constant	B1	[1]
	(ii) speed = (2.8 ± 0.1) m s ⁻¹	A2	[2]
	(if answer > ±0.1 but ≤ ±0.2, then award 1 mark)		
	(iii) curved line never below given line and starts from zero	B1	
	continuous curve with increasing gradient	B1	
	line never vertical or straight	B1	[3]
3	(a) either energy (stored)/work done represented by area under graph		
	or energy = <u>average</u> force × extension	B1	
	energy = $\frac{1}{2} \times 180 \times 4.0 \times 10^{-2}$	C1	
	= 3.6 J	A1	[3]
	(b) (i) either momentum before release is zero	M1	
	so sum of <u>momenta</u> (of trolleys) after release is zero	A1	
	or force = rate of change of momentum (M1)		
	force on trolleys equal and opposite (A1)		
	or impulse = change in momentum (M1)		
	impulse on each equal and opposite (A1)		[2]
	(ii) 1 $M_1 V_1 = M_2 V_2$	B1	[1]
	2 $E = \frac{1}{2} M_1 V_1^2 + \frac{1}{2} M_2 V_2^2$	B1	[1]
	(iii) 1 $E_K = \frac{1}{2} m v^2$ and $p = m v$ combined to give	M1	
	$E_K = p^2 / 2m$	A0	[1]
	2 m smaller, E_K is larger because p is the same/constant	M1	
	so trolley B	A0	[1]

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- 4 (a) when a wave (front) passes by/incident on an edge/slit M1
wave bends/spreads (into the geometrical shadow) A1 [2]
- (b) $\tan \theta = \frac{38}{165}$
 $\theta = 13^\circ$ C1
 $d \sin \theta = n\lambda$ C1
 $d = 2.82 \times 10^{-6}$ C1
number = $(1/d) 3.6 \times 10^5$ A1 [4]
- (c) P remains in same position B1
X and Y rotate through 90° B1 [2]
- (d) *either* screen not parallel to grating
or grating not normal to (incident) light B1 [1]
- 5 (a) region/area where a charge experiences a force B1 [1]
- (b) (i) left-hand sphere (+), right-hand sphere (–) B1 [1]
- (ii) 1 correct region labelled C within 10 mm of central part of plate
otherwise within 5 mm of plate B1 [1]
- 2 correct region labelled D area of field not included for (b)(ii)1 B1 [1]
- (c) (i) arrows through P and N in correct directions B1 [1]
- (ii) torque = force $\times$ perpendicular distance (between forces) C1
 $= 1.6 \times 10^{-19} \times 5.0 \times 10^4 \times 2.8 \times 10^{-10} \times \sin 30$
 $= 1.1 \times 10^{-24} \text{ N m}$ A1 [2]
- 6 (a) (i) $P = VI$ C1
 $60 = 12 \times I$
 $I = 5.0 \text{ A}$ A1 [2]
- (ii) *either* $V = IR$ *or* $P = I^2 R$ *or* $P = V^2 / R$ C1
either $12 = 5 \times R$ *or* $60 = 5^2 \times R$ *or* $60 = 12^2 / R$ M1
 $R = 2.4 \Omega$ A0 [2]
- (b) $R = \rho L / A$ C1
 $A = \pi \times (0.4 \times 10^{-3})^2 (= 5.03 \times 10^{-7})$ C1
 $L = (2.4 \times 5.03 \times 10^{-7}) / (1.0 \times 10^{-6})$
 $= 1.2 \text{ m}$ A1 [3]
- (c) resistance is halved M1
either current is doubled *or* power $\propto 1/R$ M1
power is doubled A1 [3]

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- 7 (a) nuclei/atoms with same proton number/atomic number B1
nuclei/atoms contain different numbers of neutrons/different atomic mass B1 [2]
- (b) (i) 92 A1 [1]
(ii) 146 A1 [1]
- (c) (i) mass = $238 \times 1.66 \times 10^{-27}$ C1
= 3.95×10^{-25} kg A1 [2]
- (ii) volume = $\frac{4}{3} \pi \times (8.9 \times 10^{-15})^3$ (= 2.95×10^{-42}) C1
density = $(3.95 \times 10^{-25}) / (2.95 \times 10^{-42})$
= 1.3×10^{17} kg m⁻³ A1 [2]
- (d) nucleus contains most of mass of atom B1
either nuclear diameter/volume very much less than that of atom
or atom is mostly (empty) space B1 [2]

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- 1 (a) micrometer/screw gauge/digital callipers B1 [1]
- (b) (i) look/check for zero error B1 [1]
- (ii) take several readings M1
around the circumference/along the wire A1 [2]
- 2 (a) e.g. initial speed is zero
constant acceleration
straight line motion
(any two, one mark each) B2 [2]
- (b) (i) $s = \frac{1}{2}at^2$
 $0.79 = \frac{1}{2} \times 9.8 \times t^2$ C1
 $t = 0.40$ s allow 1 SF or greater A1
2 or 3 SF answer A1 [3]
- (ii) distance travelled by end of time interval = 90 cm C1
 $0.90 = \frac{1}{2} \times 9.8 \times t^2$
 $t = 0.43$ s allow 2 SF or greater C1
time interval = 0.03 s A1 [3]
- (c) (air resistance) means ball's speed/acceleration is less M1
length of image is shorter A1 [2]
- 3 (a) (i) force is rate of change of momentum B1 [1]
- (ii) force on body A is equal in magnitude to force on body B (from A) M1
forces are in opposite directions A1
forces are of the same kind A1 [3]
- (b) (i) 1 $F_A = -F_B$ B1 [1]
2 $t_A = t_B$ B1 [1]
- (ii) $\Delta p = F_A t_A = -F_B t_B$ B1 [1]
- (c) graph: momentum change occurs at same times for both spheres B1
final momentum of sphere B is to the right M1
and of magnitude 5 N s A1 [3]
- 4 (a) e.g. no energy transfer
amplitude varies along its length/nodes and antinodes
neighbouring points (in inter-nodal loop) vibrate in phase, etc.
(any two, 1 mark each to max 2 B2 [2]

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	(b) (i)	$\lambda = (330 \times 10^2)/550$	M1	[1]
		$\lambda = 60 \text{ cm}$	A0	
	(ii)	node labelled at piston	B1	[3]
		antinode labelled at open end of tube	B1	
		additional node and antinode in correct positions along tube	B1	
	(c)	at lowest frequency, length = $\lambda/4$	C1	[3]
		$\lambda = 1.8 \text{ m}$		
		frequency = $330/1.8$	C1	
		= 180 Hz	A1	
5	(a) (i)	Young modulus = stress/strain	C1	[3]
		data chosen using point in linear region of graph	M1	
		Young modulus = $(2.1 \times 10^8)/(1.9 \times 10^{-3})$		
		= $1.1 \times 10^{11} \text{ Pa}$	A1	
	(ii) This mark was removed from the assessment, owing to a power-of-ten inconsistency in the printed question paper.			
	(b)	area between lines represents energy/area under curve represents energy ..	M1	[3]
		when rubber is stretched and then released/two areas are different	A1	
		this energy seen as thermal energy/heating/difference represents energy released as heat	A1	
6	(a)	<i>either</i> $P \propto V^2$ <i>or</i> $P = V^2/R$	C1	[2]
		reduction = $(230^2 - 220^2)/230^2$		
		= 8.5%	A1	
	(b) (i)	zero	A1	[1]
		(ii) $0.3(0) \text{ A}$	A1	[1]
	(c)	(i) correct plots to within $\pm 1 \text{ mm}$	B1	[1]
		(ii) <u>reasonable line/curve</u> through points giving current as 0.12 A <i>allow</i> $\pm 0.005 \text{ A}$	B1	[1]
		(iii) $V = IR$	C1	[2]
		$V = 0.12 \times 5.0$ = $0.6(0) \text{ V}$	A1	
	(d)	circuit acts as a potential divider/current divides/current in AC not the same as current in BC	B1	[2]
		resistance between A and C not equal to resistance between C and B	B1	
		or current in wire AC $\times R$ is not equal to current in wire BC $\times R$ any 2 statements	B1	

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- 7 (a) (i) *either* helium nucleus
or contains 2 protons and 2 neutrons B1 [1]
- (ii) e.g. range is a few cm in air/sheet of thin paper
speed up to 0.1 c
causes dense ionisation in air
positively charged or deflected in magnetic or electric fields
(any two, 1 each to max 2) B2 [2]
- (b) (i) ${}^4_2\alpha$ B1
either ${}^1_1\text{p}$ *or* ${}^1_1\text{H}$ B1 [2]
- (ii) 1 initially, α -particle must have some kinetic energy B1 [1]
- (ii) 2 $1.1 \text{ MeV} = 1.1 \times 1.6 \times 10^{-13} = 1.76 \times 10^{-13} \text{ J}$ C1
 $E_K = \frac{1}{2}mv^2$ C1
 $1.76 \times 10^{-13} = \frac{1}{2} \times 4 \times 1.66 \times 10^{-27} \times v^2$ C1
 $v = 7.3 \times 10^6 \text{ m s}^{-1}$ A1 [4]
use of $1.67 \times 10^{-27} \text{ kg}$ for mass is a maximum of 3/4

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- 1 (a) (i) 1% of ± 2.05 is ± 0.02 A1 [1]
(ii) max. value is 2.08 V A1 [1]
- (b) there may be a zero error/calibration error/systematic error M1
which makes all readings either higher or lower than true value A1 [2]
- 2 (a) no resultant force/sum of forces zero B1
no resultant moment/torque/sum of moments/torques zero B1 [2]
- (b) (i) each force is represented by the side of a triangle/by an arrow M1
in magnitude and direction A1
arrows joined, head to tail B1 [3]
(*could be shown on a sketch diagram*)
- (ii) if the triangle is 'closed' (then the forces are in equilibrium) B1 [1]
- (c) triangle drawn with correct shape (incorrect arrows loses this mark) B1
 $T_1 = 5.4 \pm 0.2 \text{ N}$ B1
 $T_2 = 4.0 \pm 0.2 \text{ N}$ B1 [3]
- (d) forces in strings would be horizontal B1
(so) no vertical force to support the weight B1 [2]
- 3 (a) evidence of use of area below the line B1
distance = 39 m (*allow $\pm 0.5 \text{ m}$*) A2 [3]
(*if $> \pm 0.5 \text{ m}$ but $\leq 1.0 \text{ m}$, then allow 1 mark*)
- (b) (i) 1 $E_K = \frac{1}{2}mv^2$ C1
 $\Delta E_K = \frac{1}{2} \times 92 \times (6^2 - 3^2)$
= 1240 J A1 [2]
- 2 $E_P = mgh$ C1
 $\Delta E_P = 92 \times 9.8 \times 1.3$
= 1170 J A1 [2]
- (ii) $E = Pt$ C1
 $E = 75 \times 8$
= 600 J A1 [2]
- (c) (i) energy = $(1240 + 600) - 1170$ M1
= 670 J A0 [1]
- (ii) force = $670/39 = 17 \text{ N}$ A1 [1]
- (d) frictional forces include air resistance B1
air resistance decreases with decrease of speed B1 [2]

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4	(a) (i)	solid has fixed volume and fixed shape/incompressible	B1	[1]
	(ii)	gas fills any space into which it is put	B1	[1]
	(b)	atoms/molecules have (elastic) collisions with the walls (of the vessel)	B1	
		momentum of atom/molecule changes so impulse (on wall)/force on wall random motion/many collisions (per unit time) gives rise to (constant) force/pressure	B1 B1 B1 B1	[4]
5	(c)	spacing (much) greater in gases than in liquids/about ten times	C1	
		either spacing depends on $1/\sqrt[3]{\rho}$		
		or ratio of spacings is about 8.8	A1	[2]
	(a) (i)	1 number of oscillations per unit time (not per second)	B1	[1]
		2 $n\lambda$	A1	[1]
	(ii)	$v = \text{distance} / \text{time} = n\lambda/t$	M1	
		$n/t = f$ hence $v = f\lambda$	A1	
		or f oscillations per unit time so $f\lambda$ is distance per unit time distance per unit time is v so $v = f\lambda$	M1 A1	[2]
	(b) (i)	1.0 period is $3 \times 2 = 6.0 \text{ ms}$	C1	
		frequency = $1/(6 \times 10^{-3}) = 170 \text{ Hz}$	A1	[2]
	(ii)	wave (with approx. same amplitude and) with correct phase difference	B1	[1]
6	(a) (i)	movement/flow of charged particles	B1	[1]
	(ii)	work done per unit charge (transferred)	B1	[1]
	(b)	straight line through origin resistance = V/I , with values for V and I shown = 20Ω (using the gradient loses the last mark)	B1 M1 A0	[2]
	(c) (i)	0.5 A	A1	[1]
	(ii)	either resistance of each resistor is 20Ω or total current = 0.8 A either combined resistance = 10Ω or $R = E/I = 10 \Omega$	C1 A1	[2]
	(d) (i)	10 V	A1	[1]
	(ii)	power = EI = $10 \times 0.2 = 2.0 \text{ W}$	C1 A1	[2]

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- 7 (a) (i) *either* helium nucleus
or particle containing two protons and two neutrons B1 [1]
- (ii) allow any value between 1 cm and 10 cm B1 [1]
- (b) (i) energy = $(8.5 \times 10^{-13}) / (1.6 \times 10^{-13})$
= 5.3 MeV M1
A0 [1]
- (ii) number = $(5.3 \times 10^6) / 31$
= 1.7×10^5 (*allow 2 s.f. only*) C1
A1 [2]
- (iii) number per unit length = $(1.7 \times 10^5) / (a)(ii)$
correct numerical value A1
correct unit B1 [2]