

MARK SCHEME for the May/June 2013 series

9702 PHYSICS

9702/21

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

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- 1 (a) the wire returns to its original length (not 'shape') when the load is removed M1 A1 [2]
- (b) energy: $\text{N m} / \text{kg m}^2 \text{s}^{-2}$ and volume m^3
energy / volume: $\text{kg m}^2 \text{s}^{-2} / \text{m}^3$
energy / volume: $\text{kg m}^{-1} \text{s}^{-2}$ C1 M1 A0 [2]
- (c) ε has no units B1
 E : $\text{kg m s}^{-2} \text{m}^{-2}$ M1
units of RHS: $\text{kg m}^{-1} \text{s}^{-2} = \text{LHS units} / \text{satisfactory conclusion to show C has no units}$ A1 [3]
- 2 (a) mass is the property of a body resisting changes in motion / quantity of matter in a body / measure of inertia to changes in motion B1
- weight is the force due to the gravitational field/force due to gravity or gravitational force B1 [2]
- Allow 1/2 for 'mass is scalar weight is vector'
- (b) (i) arrow vertically down through O B1
tension forces in correct direction on rope B1 [2]
- (ii) 1. weight = $mg = 4.9 \times 9.81 (= 48.07)$ C1
 $69 \sin \theta = mg$ C1
 $\theta = 44.(1)^\circ$ scale drawing allow $\pm 2^\circ$ A1 [3]
use of cos or tan 1/3 only
2. $T = 69 \cos \theta$ C1
 $= 49.6 / 50 \text{ N}$ scale drawing $50 \pm 2 (2/2)$ $50 \pm 4 (1/2)$ A1 [2]
- correct answers obtained using scale diagram or triangle of forces will score full marks
cos in 1. then sin in 2. (2/2)
- 3 (a) loss in potential energy due to decrease in height (as P.E. = mgh) (B1)
gain in kinetic energy due to increase in speed (as K.E. = $\frac{1}{2} mv^2$) (B1)
special case 'as PE decreases KE increases' (1/2)
increase in thermal energy due to work done against air resistance (B1)
loss in P.E. equals gain in K.E. and thermal energy (B1)
max. 3 [3]

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- (b) (i) kinetic energy $= \frac{1}{2}mv^2$
 $= \frac{1}{2} \times 0.150 \times (25)^2$
 $= 46.875 = 47 \text{ J}$ C1
C1
A1 [3]
- (ii) 1. potential energy ($= mgh$) $= 0.150 \times 9.81 \times 21$ C1
loss = KE – $mgh = 46.875 - (30.9)$ C1
 $= 15.97 = 16 \text{ J}$ A1 [3]
2. work done = 16 J
work done = force $\times$ distance C1
 $F = 16 / 21 = 0.76 \text{ N}$ A1 [2]
- 4 (a) pressure = force / area (normal to force) A1 [1]
- (b) molecules/atoms/particles in (constant) random/haphazard motion B1
molecules have a change in momentum when they collide with the walls M1
(force exerted on molecules) therefore force on the walls A1
reference to average force from many molecules/many collisions A1 [4]
- (c) elastic collision when kinetic energy conserved B1
temperature constant for gas B1 [2]
- 5 (a) waves overlap / meet / superpose (B1)
coherence / constant phase difference (*not constant λ or frequency*) (B1)
path difference = 0, λ , 2λ or phase difference = 0, 2π , 4π (B1)
same direction of polarisation/unpolarised (B1)
max. 3 [3]
- (b) $\lambda = v / f$ C1
 $f = 12 \times 10^9 \text{ Hz}$ C1
 $\lambda = 3 \times 10^8 / 12 \times 10^9$ (*any subject*) M1
 $= 0.025 \text{ m}$ A0 [3]
- (c) maximum at P B1
several minima or maxima between O and P B1
5 maxima / 6 minima between O and P
or 7 maxima / 6 minima including O and P B1 [3]
- (d) slits made narrower B1
slits put closer together B1 [2]
(*not just 'make slits smaller'*)
Allow tilting the slits M1 and explanation of axes of rotation A1

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- 6 (a) (i) chemical to electrical B1 [1]
- (ii) electrical to thermal / heat or heat and light B1 [1]
- (b) (i) $(P_B =) EI$ or $I^2(R_1 + R_2)$ A1 [1]
- (ii) $(P_R =) I^2 R_1$ A1 [1]
- (c) $R = \rho l / A$ or clear from the following equation B1
ratio = $I^2 R_1 / I^2 R_2 = \frac{\rho l / \pi d^2}{\rho(2l) / \pi(2d)^2}$ or R_1 has $8 \times$ resistance of R_2 C1
= 8 or 8:1 A1 [3]
- (d) $P = V^2 / R$ or E^2 / R C1
(V or E the same) hence ratio is 1/8 or 1:8 = 0.125 (allow ecf from (c)) A1 [2]
- 7 (a) the majority/most went straight through B1
or were deviated by small angles
a very small proportion/a few were deviated by large angles B1
small angles described as $< 10^\circ$ and large angles described as $> 90^\circ$ B1 [3]
- (b) most of the atom is empty space/nucleus very small compared with atom B1
mass and charge concentrated in (very small) nucleus B1
correct links made with statements in (a) B1 [3]

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- 1 (a) power = energy / time
= (force × distance / time) = $\text{kg m}^2 \text{s}^{-2} / \text{s}$
= $\text{kg m}^2 \text{s}^{-3}$ C1
C1
A1 [3]
- (b) (i) units of L^2 : m^2 and units of ρ : kg m^{-3} and units of v^3 : $\text{m}^3 \text{s}^{-3}$
($C = P / L^2 \rho v^3$) hence units of C: $\text{kg m}^2 \text{s}^{-3} \text{m}^{-2} \text{kg}^{-1} \text{m}^3 \text{m}^{-3} \text{s}^3$
or any correct statement of component units M1
argument /discussion / cancelling leading to C having no units A1 [3]
- (ii) power available from wind = $3.5 \times 10^5 \times 100 / 55 (= 6.36 \times 10^5)$ C1
 $v^3 = 3.5 \times 10^5 \times 100 / (55 \times 0.931 \times (25)^2 \times 1.3)$ C1
 $v = 9.4 \text{ m s}^{-1}$ A1 [3]
- (iii) not all kinetic energy of wind converted to kinetic energy of blades B1
generator / conversion to electrical energy not 100% efficient / heat B1 [2]
produced in generator / bearings etc
(there must be cause of loss and where located)
- 2 (a) force = rate of change of momentum A1 [1]
- (b) (i) horizontal line on graph from $t = 0$ to t about $2.0 \text{ s} \pm \frac{1}{2}$ square, $a > 0$ M1
horizontal line at 3.5 on graph from 0 to 2 s A1
vertical line at $t = 2.0 \text{ s}$ to $a = 0$ or sharp step without a line B1
horizontal line from $t = 2 \text{ s}$ to $t = 4 \text{ s}$ with $a = 0$ B1 [4]
- (ii) straight line and positive gradient M1
starting at (0,0) A1
finishing at (2,16.8) A1
horizontal line from 16.8 M1
from 2.0 to 4.0 A1 [5]
- 3 (a) the point where (all) the weight (of the body) M1
is considered / seems to act A1 [2]
- (b) (i) vertical component of $T (= 30 \cos 40^\circ) = 23 \text{ N}$ A1 [1]
- (ii) the sum of the clockwise moments about a point equals the sum of the anticlockwise moments (about the same point) B1 [1]
- (iii) (moments about A): $23 \times 1.2 (27.58)$ M1
 $= 8.5 \times 0.60 + 1.2 \times W$ M1
working to show $W = 19$ or answer of 18.73 (N) A1 [3]
- (iv) ($M = W / g = 18.73 / 9.81 =$) 1.9(09) kg A1 [1]

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	(c) (for equilibrium) resultant force (and moment) = 0 upward force does not equal downward force / horizontal component of T not balanced by forces shown	B1 B1	[2]
4	(a) apparatus: cell with particles e.g. smoke (container must be closed) diagram showing suitable arrangement with light illumination and microscope	B1 B1	[2]
	(b) specks / flashes of light in random motion	M1 A1	[2]
	(c) cannot see what is causing smoke to move hence molecules smaller than smoke particles	(B1)	
	continuous motion of smoke particles implies continuous motion of molecules	(B1)	
	random motion of particles implies random motion of molecules	(B1)	
		max. 2	[2]
5	(a) (i) $v = f\lambda$ $\lambda = 40 / 50 = 0.8(0) \text{ m}$	C1 A1	[2]
	(ii) waves (travel along string and) reflect at Q / wall / fixed end incident and reflected waves interfere / superpose	B1 B1	[2]
	(b) (i) nodes labelled at P, Q and the two points at zero displacement antinodes labelled at the three points of maximum displacement	B1 B1	[2]
	(ii) $(1.5\lambda \text{ for PQ hence } PQ = 0.8 \times 1.5) = 1.2 \text{ m}$	A1	[1]
	(iii) $T = 1 / f = 1/50 = 20 \text{ ms}$ 5 ms is $\frac{1}{4}$ of cycle horizontal line through PQ drawn on Fig. 5.2	C1 A1 B1	[3]
6	(a) charge = current $\times$ time	B1	[1]
	(b) (i) $P = V^2 / R$ $= (240)^2 / 18 = 3200 \text{ W}$	C1 A1	[2]
	(ii) $I = V / R = 240 / 18 = 13.3 \text{ A}$	A1	[1]
	(iii) charge = $It = 13.3 \times 2.6 \times 10^6$ $= 3.47 \times 10^7 \text{ C}$	C1 A1	[2]
	(iv) number of electrons = $3.47 \times 10^7 / 1.6 \times 10^{-19} (= 2.17 \times 10^{26})$ number of electrons per second = $2.17 \times 10^{26} / 2.6 \times 10^6 = 8.35 \times 10^{19}$	C1 A1	[2]

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- 7 (a) (i) $W = 206$ and $X = 82$
 $Y = 4$ and $Z = 2$ A1
A1 [2]
- (ii) mass-energy is conserved B1
mass on rhs is less because energy is released B1 [2]
- (b) not affected by external conditions/factors/environment B1 [1]
or two examples temperature and pressure

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- 1 (a) force: kg m s^{-2} A1 [1]
- (b) (i) I^2 : A^2 l : m x : m
 K : $\text{kg m s}^{-2} \text{A}^{-2}$ C1
A1 [2]
- (ii) curve of the correct shape (for inverse proportionality)
clearly approaching each axis but never touching the axis M1
A1 [2]
- (iii) curving upwards and through origin A1 [1]
- 2 (a) (i) 1. distance of path / along line AB B1 [1]
2. shortest distance between AB / distance in straight line between AB
or displacement from A to B B1 [1]
- (ii) acceleration = rate of change of velocity A1 [1]
- (b) (i) distance = area under line or $(v/2)t$ or $s = (8.8)^2 / (2 \times 9.81)$ C1
 $= 8.8 / 2 \times 0.90 = 3.96 \text{ m}$ or $s = 3.95 \text{ m} = 4(.0) \text{ m}$ A1 [2]
- (ii) acceleration = $(-4.4 - 8.8) / 0.50$ C1
 $= (-) 26(.4) \text{ m s}^{-2}$ A1 [2]
- (c) (i) the accelerations are constant as straight lines B1
- the accelerations are the same as same gradient or
no air resistance as acceleration is constant or
change of speed in opposite directions (one speeds up one slows down) B1 [2]
- (ii) area under the lines represents height
or KE at trampoline equals PE at maximum height B1
- second area is smaller / velocity after rebound smaller hence KE less B1
- hence less height means loss in potential energy A0 [2]
- 3 (a) (i) the total momentum of a system (of interacting bodies) remains constant
provided there are no resultant external forces / isolated system M1
A1 [2]
- (ii) elastic: total kinetic energy is conserved, inelastic: loss of kinetic energy
[allow elastic: relative speed of approach equals relative speed of separation] B1 [1]

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- (b) (i) initial mom: $4.2 \times 3.6 - 1.2 \times 1.5$ (= 15.12 – 1.8 = 13.3)
 final mom: $4.2 \times v + 1.5 \times 3$
 $v = (13.3 - 4.5) / 4.2 = 2.1 \text{ m s}^{-1}$ C1
 C1
 A1 [3]
- (ii) initial kinetic energy = $\frac{1}{2} m_A (v_A)^2 + \frac{1}{2} m_B (v_B)^2$
 $= 27.21 + 1.08 = 28(.28)$ M1
 final kinetic energy = $9.26 + 6.75 = 16$ M1
 initial KE is not the same as final KE hence inelastic A1 [3]
provided final KE less than initial KE
 [allow in terms of relative speeds of approach and separation]
- 4 (a) (i) stress = force / cross-sectional area B1 [1]
- (ii) strain = extension / original length B1 [1]
- (b) (i) $E = \text{stress} / \text{strain}$ C1
 $E = 0.17 \times 10^{12}$ C1
 stress = $0.17 \times 10^{12} \times 0.095 / 100$ C1
 $= 1.6(2) \times 10^8 \text{ Pa}$ A1 [4]
- (ii) force = (stress $\times$ area) = $1.615 \times 10^8 \times 0.18 \times 10^{-6}$ C1
 $= 29(.1) \text{ N}$ A1 [2]
- 5 (a) when waves overlap / meet B1
 the resultant displacement is the sum of the individual displacements of the waves B1 [2]
- (b) (i) 1. phase difference = $180^\circ / (n + \frac{1}{2}) 360^\circ$ (allow in rad) B1 [1]
 2. phase difference = $0 / 360^\circ / (n360^\circ)$ (allow in rad) B1 [1]
- (ii) $v = f\lambda$ C1
 $\lambda = 320 / 400 = 0.80 \text{ m}$ A1 [2]
- (iii) path difference = $7 - 5 = 2 \text{ (m)}$
 $= 2.5\lambda$ M1
 hence minimum
 or maximum if phase change at P is suggested A1 [2]
- 6 (a) p.d. = work done / energy transformed (from electrical to other forms)
 charge B1 [1]
- (b) (i) maximum 20 V A1 [1]
- (ii) minimum = $(600 / 1000) \times 20$ C1
 $= 12 \text{ V}$ A1 [2]

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- (c) (i) use of $1.2\text{ k}\Omega$ M1
 $1/1200 + 1/600 = 1/R$, $R = 400\Omega$ A1 [2]
- (ii) total parallel resistance ($R_2 + \text{LDR}$) is less than R_2 M1
(minimum) p.d. is reduced A1 [2]
- 7 (a) (i) nucleus contains 92 protons B1
nucleus contains 143 neutrons (missing 'nucleus' 1/2) B1
outside / around nucleus 92 electrons (B1)
most of atom is empty space / mass concentrated in nucleus (B1)
total charge is zero (B1)
diameter of atom $\sim 10^{-10}\text{ m}$ or size of nucleus $\sim 10^{-15}\text{ m}$ (B1)
any two of (B1) marks [4]
- (ii) nucleus has same number / 92 protons B1
nuclei have 143 and 146 neutrons (missing 'nucleus' 1/2) B1 [2]
- (b) (i) $Y = 35$ A1
 $Z = 85$ A1 [2]
- (ii) mass-energy is conserved in the reaction B1

mass on rhs of reaction is less so energy is released
explained in terms of $E = mc^2$ B1 [2]