

MARK SCHEME for the May/June 2011 question paper
for the guidance of teachers

9702 PHYSICS

9702/21

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

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- 1 (a) (i) metre rule / tape (*not 'rule'*) B1 [1]
- (ii) micrometer (screw gauge) / digital caliper B1 [1]
- (iii) ammeter and voltmeter / ohmmeter / multimeter on 'ohm' setting B1 [1]
- (b) (i) resistivity = RA / L C1
 $= [7.5 \times \pi \times (0.38 \times 10^{-3})^2 / 4] / 1.75$ M1
 $= 4.86 \times 10^{-7} \Omega \text{ m}$ A0 [2]
- (ii) (uncertainty in R =) $[0.2 / 7.5] \times 100 = 2.7\%$
and (uncertainty in L =) $[3 / 1750] \times 100 = 0.17\%$ C1
(uncertainty in A =) $2 \times (0.01 / 0.38) \times 100 = 5.3 \%$ C1
total = 8.13% C1
- uncertainty = $0.395 \times 10^{-7} (\Omega \text{ m})$ A1 [4]
(*missing 2 factor in uncertainty in A, then allow max 3/4*)
- (c) resistivity = $(4.9 \times 10^{-7} \pm 0.4 \times 10^{-7}) \Omega \text{ m}$ A1 [1]
- 2 (a) work done is the force $\times$ the distance moved / displacement in the direction of the force
or
work is done when a force moves in the direction of the force B1 [1]
- (b) component of weight = $850 \times 9.81 \times \sin 7.5^\circ$ C1
= 1090 N A1 [2]
(*use of incorrect trigonometric function, 0/2*)
- (c) (i) $\Sigma F = 4600 - 1090 = (3510)$ M1
deceleration = $3510 / 850$ A1
= 4.1 ms^{-2} A0 [2]
- (ii) $v^2 = u^2 + 2as$
 $0 = 25^2 + 2 \times -4.1 \times s$ C1
 $s = 625 / 8.2$
= 76 m A1 [2]
(*allow full credit for calculation of time (6.05 s) & then s*)
- (iii) 1. kinetic energy = $\frac{1}{2} mv^2$ C1
= $0.5 \times 850 \times 25^2$
= $2.7 \times 10^5 \text{ J}$ A1 [2]
2. work done = 4600×75.7
= $3.5 \times 10^5 \text{ J}$ A1 [1]
- (iv) difference is the loss in potential energy (*owtte*) B1 [1]

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- 3 (a) point where the weight of an object / gravitational force may be considered to act M1 A1 [2]
- (b) product of the force and the perpendicular distance (to the pivot) B1 [1]
- (c) (i) 1. sum / net / resultant force is zero B1
2. net / resultant moment is zero
sum of clockwise moments = sum of anticlockwise moments B1 [2]
- (ii) $W \times 0.2 = 80 \times 0.5 + 70 \times 1.3$ C1
 $= 40 + 91$ C1
 $W = 655 \text{ N}$ A1 [3]
(allow 2/3 for one error in distance but 0/3 if two errors)
- (iii) move pivot to left (M1)
gives greater clockwise moment / smaller anticlockwise moment (A1)
or
move W to right (M1)
gives smaller anticlockwise moment (A1) [2]
- 4 (a) (i) stress is force / area B1 [1]
- (ii) strain is extension / original length B1 [1]
- (b) (i) $E = [F / A] \div [e / l]$ C1
 $e = (25 \times 1.7) / (5.74 \times 10^{-8} \times 1.6 \times 10^{11})$ C1
 $e = 4.6 \times 10^{-3} \text{ m}$ A1 [3]
- (ii) A becomes A/2 or stress is doubled B1
 $e \propto l / A$ or substitution into full formula B1
total extension increase is 4e A1 [3]
- 5 (a) (i) $I = 12 / (6 + 12)$ C1
minimum current = 0.67 A A1 [2]
- (ii) correct start and finish points M1
correct shape for curve with decreasing gradient A1 [2]
- (b) maximum current = 2.0 A A1
minimum current = 0 A1 [2]
- (c) (i) smooth curve starting at (0,0) with decreasing gradient M1
end section not horizontal A1 [2]
- (ii) full range of current / p.d. possible
or currents / p.d. down to zero
or brightness ranging from off to full brightness B1 [1]

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- 6 (a) any two of:
large number of molecules / atoms / particles
molecules in random motion
no intermolecular forces
elastic collisions
time of collisions much less than time between collisions
volume of molecules much less than volume of containing vessel
B1 + B1 [2]
- (b) molecules collide with the walls
change in momentum of molecules implies force (on molecules)
molecules exert equal and opposite force on wall
pressure is averaging effect of many collisions
(any three statements, 1 each)
B3 [3]
- 7 (a) when waves overlap / meet, (resultant) displacement is the sum of the individual displacements
B1 [1]
- (b) (i) two (ball-type) dippers (M1)
connected to the same vibrating source /motor (A1)
or
one wave source described (M1)
with two slits (A1) [2]
- (ii) lamp with viewing screen on opposite side of tank
means of freezing picture e.g. strobe
B1
B1 [2]
- (c) (i) two correct lines labelled X
B1 [1]
- (ii) correct line labelled N
B1 [1]

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- 1 (a) scalar has only magnitude
vector has magnitude and direction B1 B1 [2]
- (b) kinetic energy, mass, power all three underlined B1 [1]
- (c) (i) $s = ut + \frac{1}{2} at^2$
 $15 = 0.5 \times 9.81 \times t^2$
 $T = 1.7 \text{ s}$ C1 A1 [2]
- if $g = 10$ is used then -1 but only once on paper
- (ii) vertical component v_v :
 $v_v^2 = u^2 + 2as = 0 + 2 \times 9.81 \times 15$ or $v_v = u + at = 9.81 \times 1.7(5)$
 $v_v = 17.16$ C1
resultant velocity: $v^2 = (17.16)^2 + (20)^2$ C1
 $v = 26 \text{ ms}^{-1}$ A1 [3]
- If $u = 20$ is used instead of $u = 0$ then 0/3
Allow the solution using:
initial (potential energy + kinetic energy) = final kinetic energy
- (iii) distance is the actual path travelled B1
displacement is the straight line distance between start and finish points (in that direction) / minimum distance B1 [2]
- 2 (a) (i) base units of D :
force: kg ms^{-2} B1
radius: m velocity: ms^{-1} B1
- base units of D : $[F / (R \times v)] \text{ kg ms}^{-2} / (\text{m} \times \text{ms}^{-1})$ M1
 $= \text{kg m}^{-1} \text{s}^{-1}$ A0 [3]
- (ii) 1. $F = 6\pi \times D \times R \times v = [6\pi \times 6.6 \times 10^{-4} \times 1.5 \times 10^{-3} \times 3.7]$
 $= 6.9 \times 10^{-5} \text{ N}$ A1 [1]
2. $mg - F = ma$ hence $a = g - [F / m]$
 $m = \rho \times V = \rho \times \frac{4}{3} \pi R^3 = (1.4 \times 10^{-5})$ C1
 $a = 9.81 - [6.9 \times 10^{-5}] / \rho \times \frac{4}{3} \pi \times (1.5 \times 10^{-3})^3$ (9.81 – 4.88) M1
 $a = 4.9(3) \text{ ms}^{-2}$ A1 [3]
- (b) (i) $a = g$ at time $t = 0$ B1
 a decreases (as time increases) B1
 a goes to zero B1 [3]
- (ii) Correct shape below original line M1
sketch goes to terminal velocity earlier A1 [2]

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- 3 (a) (i) work done equals force $\times$ distance moved / displacement in the direction of the force B1 [1]
- (ii) power is the rate of doing work / work done per unit time B1 [1]
- (b) (i) kinetic energy $= \frac{1}{2} mv^2$
 $= 0.5 \times 600 (9.5)^2$
 $= 27075 \text{ (J)} = 27 \text{ kJ}$ C1
C1
A1 [3]
- (ii) potential energy $= mgh$
 $= 600 \times 9.81 \times 4.1$
 $= 24132 \text{ (J)}$
 $= 24 \text{ kJ}$ M1
A1
A0 [2]
- (iii) work done $= 27 - 24 = 3.0 \text{ kJ}$ A1 [1]
- (iv) resistive force $= 3000 / 8.2$ (distance along slope $= 4.1 / \sin 30^\circ$)
 $= 366 \text{ N}$ C1
A1 [2]
- 4 (a) clamped horizontal wire over pulley or vertical wire attached to ceiling with mass attached B1
details: reference mark on wire with fixed scale alongside B1 [2]
- (b) measure original length of wire to reference mark with metre ruler / tape (B1)
measure diameter with micrometer / digital calipers (B1)
measure initial and final reading (for extension) with metre ruler or other suitable scale (B1)
measure / record mass or weight used for the extension (B1)
good physics method:
measure diameter in several places / remove load and check wire returns to original length / take several readings with different loads (B1)
- MAX of 4 points B4 [4]
- (c) determine extension from final and initial readings (B1)
plot a graph of force against extension (B1)
determine gradient of graph for F / e (B1)
calculate area from $\pi d^2 / 4$ (B1)
calculate E from $E = F l / e A$ or gradient $\times l / A$ (B1)
- MAX of 4 points B4 [4]

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- 5 (a) (i) energy converted from chemical to electrical when charge flows through cell or round complete circuit B1
- (ii) (resistance of the cell) causing loss of voltage or energy loss in cell B1 [2]
- (b) (i) $E_B - E_A = I(R + r_B + r_A)$
 $12 - 3 = I(3.3 + 0.1 + 0.2)$
 $I = 2.5 \text{ A}$ C1
A1 [2]
- (ii) Power = $E \times I$
 $= 12 \times 2.5$
 $= 30 \text{ W}$ C1
A1 [2]
- (iii) $P = I^2 \times R$ or $P = V^2 / R$ or $P = VI$
 $= (2.5)^2 \times 3$ $= 9^2 / 3.6$ $= 9 \times 2.5$
 $= 22.5 \text{ J s}^{-1}$ C1
A1 [2]
- (c) power supplied from cell B is greater than energy lost per second in circuit B1 [1]
- 6 (a) (i) to produce coherent sources or constant phase difference B1 [1]
- (ii) 1. $360^\circ / 2\pi \text{ rad}$ allow $n \times 360^\circ$ or $n \times 2\pi$ (unit missing –1) B1 [1]
2. $180^\circ / \pi \text{ rad}$ allow $(n \times 360^\circ) - 180^\circ$ or $(n \times 2\pi) - \pi$ B1 [1]
- (iii) 1. waves overlap / meet B1
(resultant) displacement is sum of displacements of each wave B1 [2]
2. at P crest on trough (OWTTE) B1 [1]
- (b) $\lambda = ax / D$ C1
 $= 2 \times 2.3 \times 10^{-3} \times 0.25 \times 10^{-3} / 1.8$ C1
 $= 639 \text{ nm}$ A1 [3]

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- 1 (a) 2nd row random, 3rd row neither, 4th row systematic all correct
two correct scores 1 only B2 [2]
- (b) (i) 1. systematic error: the average / peak is not the true value / the readings are not centred around the true value B1 [1]
2. random error: readings have positive and negative values around the peak value / values are scattered / wide range B1 [1]
- (ii) 1. accurate: peak / average value moves towards the true value B1 [1]
2. precise: lines are closer together / sharper peak B1 [1]
- 2 (a) resultant moment = zero / sum of clockwise moments = sum of anticlockwise moments
resultant force = 0 B1
B1 [2]
- (b) shape and orientation correct and forces labelled and arrows correct
angles correct / labelled M1
A1 [2]
- (c) (i) $T \cos 18^\circ = W$ Scale diagram: C1
 $T = 520 / \cos 18^\circ = 547 \text{ N}$ $\pm 20 \text{ N}$ A1 [2]
- (ii) $R = T \sin 18^\circ$
 $= 169 \text{ N}$ $\pm 20 \text{ N}$ A1 [1]
- (d) θ is larger hence $\cos \theta$ is smaller, $T = W / \cos \theta$
hence T is larger M1
A0 [1]
- 3 (a) weight = $m \times g$
 $= 130.5 \times 9.81 = 1280 \text{ N}$ A1 [1]
- (b) (i) $F = ma$
 $T - 1280 = 130.5 \times 0.57$ C1
 $T = 1280 + 74.4 = 1350 \text{ N}$ A1 [2]
- (ii) 1280 N A1 [1]
- (c) $1240 - 1280 = 130.5 \times a$ C1
 $a = (-) 0.31 \text{ ms}^{-2}$ A1 [2]
- (d) (i) 1. 3.5 s A1 [1]
2. 6.5 s A1 [1]

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	(ii) basic shape correct points	M1 A1	[2]
4	(a) force is proportional to extension	B1	[1]
	(b) (i) gradient of graph determined (e.g. $50 / 40 \times 10^{-3}$) = 1250 N m^{-1}	A1	[1]
	(ii) $W = \frac{1}{2} k x^2$ or $W = \frac{1}{2} \text{ final force} \times \text{extension}$ = $0.5 \times 1250 \times (36 \times 10^{-3})^2$ or $0.5 \times 45 \times 36 \times 10^{-3}$ = 0.81 J	M1 M1 A0	[2]
	(c) (i) $0.81 = \frac{1}{2} m v^2$ $v = 8.0 \text{ (8.0498) m s}^{-1}$	C1 A1	[2]
	(ii) $4 \times \text{KE} / 4 \times \text{WD}$ or 3.24 J hence twice the compression = 72 mm	C1 A1	[2]
	(iii) Max height is when all KE or WD or elastic PE is converted to GPE ratio = 1/4 or 0.25	C1 A1	[2]
5	(a) (i) Start from (0,0) and smooth curve in correct direction Curve correct for end section never horizontal	B1 B1	[2]
	(ii) $R = V / I$ hence take co-ords of V and I from graph and calculate V / I	B1	[1]
	(b) (i) each lamp in parallel has a greater p.d. / greater current lamp hotter resistance of lamps in parallel greater	M1 M1 A1	[3]
	(ii) $P = V^2 / R$ or $P = VI$ and $V = IR$ $R = 144 / 50 = 2.88$ for each lamp total $R = 1.44 \Omega$	C1 C1 A1	[3]
6	(a) (i) amplitude = 7.6 mm allow 7.5 mm	A1	[1]
	(ii) $180^\circ / \pi \text{ rad}$	A1	[1]
	(iii) $v = f \times \lambda$ = 15×0.8 = 12 m s^{-1}	C1 A1	[2]
	(b) correct sketch with peak moved to the right curve moved by the correct phase angle / time period of 0.25 T	B1 B1	[2]
	(c) (i) zero (rad)	A1	[1]
	(ii) antinode maximum amplitude, node zero amplitude / displacement	A1	[1]

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- (iii) 3 A1 [1]
- (iv) horizontal line through central section of wave B1 [1]
- 7 (a) density in solids and liquids similar M1
spacing in solids and liquids about the same A1
density in gases much less as spacing in gases much greater B1 [3]
- (b) density = mass / volume C1
mass = 1.67×10^{-27} kg and volume = $\frac{4}{3} \pi r^3$ C1
density = $(1.67 \times 10^{-27}) / \frac{4}{3} \times \pi \times (1.0 \times 10^{-15})^3$
= 3.99×10^{17} kg m⁻³ A1 [3]
- (c) atoms / molecules composed of large amount of empty space / nucleus has very small volume compared to volume of atom / space between atoms in a gas is very large B1 [1]