Mark Scheme (Results)

June 2024

Pearson Edexcel International Advanced Subsidiary Level In Physics (WPH11) Paper 01 Mechanics and Materials

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June 2024
Question Paper Log Number P75806A
Publications Code WPH11_01_2406_MS

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Question Number	Answer	Mark
1	**The correct answer is A $\left(\frac{180}{240}\right)$** B is incorrect because 60 kW is the wasted energy C is incorrect because 60 kW is the wasted energy and 180 kW is the useful energy D is incorrect because 300 kW is the sum of the wasted and input energy	1
2	**The correct answer is C (decreasing acceleration)** A is incorrect because constant acceleration has a straight line B is incorrect because displacement is increasing D is incorrect because displacement is increasing	1
3	**The correct answer is C (small, spherical, laminar)** A is incorrect because the object must be small and spherical, and there should be laminar flow B is incorrect because the object must be small and there should be laminar flow D is incorrect because the object must be spherical	1
4	**The correct answer is C (mass × velocity)** A is incorrect because mass is a scalar B is incorrect because work is a scalar D is incorrect because extension is a scalar	1
5	**The correct answer is D $\left(\frac{R}{q-p}\right)$** A is incorrect because stiffness is not extension / force B is incorrect because stiffness is not length / force C is incorrect because stiffness is not force / length	1
6	**The correct answer is B $\left(\frac{(q-p)\times R}{2}\right)$** A is incorrect because work done ≠ ½ force × length C is incorrect because work done ≠ ½ force × (final + original length) D is incorrect because the factor of ½ is missing	1
7	**The correct answer is D (the point where the weight of the object may be considered to act)** A is incorrect because mass is not a force B is incorrect because mass is not a force C is incorrect because the weight acts everywhere, centre of gravity gives an average point of action	1

8	**The correct answer is A (The ball bearing is moving downwards when the student starts the stopwatch)** B is incorrect because time would be greater giving a lower value C is incorrect because time would be greater giving a lower value D is incorrect because time would be greater giving a lower value	**1**
9	**The correct answer is B (The second wire had a longer length)** A is incorrect because the wire would break at the same extension C is incorrect because the wire would break at the same extension D is incorrect because the wire would break at a smaller extension	**1**
10	**The correct answer is A** $\left(\mathbf{8.0 \times 10^{5} - (0.03 \times 1.2 \times 10^{7})}\right)$ B is incorrect because the force from the ship's engine has been added to resultant force C is incorrect because the force from the ship's engine has been divided by resultant force D is incorrect because the force from the ship's engine has been multiplied by resultant force	**1**

Question Number	Answer	Mark
11(a)	Use of $\Delta E_{grav} = mg\Delta h$ **(1)** $\Delta E_{grav} = 420 \times 10^6$ (J) **(1)** <u>Example of calculation</u> $\Delta E_{grav} = 1.7 \times 10^6 \text{ kg} \times 9.81 \text{ N kg}^{-1} \times 25 \text{ m} = 4.17 \times 10^8 \text{ J}$	**2**
11(b)	Use $P = W / t$ **(1)** Use of energy conservation **(1)** 2.8×10^8 J (ecf from (a)) **(1)** <u>Example of calculation</u> $W = 20 \times 10^6 \text{ W} \times 35 \text{ s} = 7.00 \times 10^8 \text{ J}$ $7.00 \times 10^8 \text{ J} - 4.17 \times 10^8 \text{ J} = 2.83 \times 10^8 \text{ J}$	**3**
	Total for question 11	**5**

Question Number	Answer		Mark
12(a)	Calculates volume of seawater displaced	**(1)**	
	Use of $\rho = m / V$ **and** Use of $W = mg$	**(1)**	
	Weight of block = 2.4×10^{8} N	**(1)**	**3**
	<u>Example of calculation</u> Volume displaced = $3\,500 \text{ m}^2 \times 6.7 \text{ m} = 2.35 \times 10^{4} \text{ m}^3$ Mass displaced = $2.35 \times 10^{4} \text{ m}^3 \times 1.03 \times 10^{3} \text{ kg m}^{-3}$ $= 2.42 \times 10^{7}$ kg Weight of block = weight displaced $= 2.42 \times 10^{7} \text{ kg} \times 9.81 \text{ N kg}^{-1} = 2.37 \times 10^{8}$ N		
12(b)	(at equilibrium) The weight of the block/iceberg equals the weight of water displaced **Or** (at equilibrium) The upthrust is equal (in magnitude) to the weight of the block/iceberg **Or** Upthrust is equal (in magnitude) to the weight of water displaced	**(1)**	
	(So, in lower density seawater,) a greater volume of water must be displaced (for iceberg to float) **Or** (at equilibrium) density of seawater is inversely proportional to volume of water displaced	**(1)**	**2**
	Total for question 12		**5**

Question Number	Answer		Mark
13(a)	Use of $s = ut + ½ at^2$ Allow any valid suvat method. Uses difference in distances travelled by A and B of 9m t = 1.13 (s) <u>Example calculation</u> $(93\text{ ms}^{-1} \times t) + 9\text{ m} = (93\text{ ms}^{-1} \times t) + \left(\frac{1}{2} \times 14\text{ ms}^{-2} \times t^2\right)$ $9\text{ m} = \left(\frac{1}{2} \times 14\text{ ms}^{-2} \times t^2\right)$ $t = \sqrt{\frac{9\text{ m}}{\frac{1}{2} \times 14\text{ ms}^{-1}}} = \sqrt{1.29\text{ s}} = 1.13\text{ s}$	(1) (1) (1)	3
13(b)	Use of $s = ut + \frac{1}{2}at^2$ Allow any valid suvat method. Time for A to finish = 1.075 s **Or** Time for B to finish = 1.084 s (allow correctly calculated value for another quantity given in the question) Comparison of time for A to finish with time for B to finish and valid conclusion **Or** comparison of time for A to finish with 1.13 s and valid conclusion (ecf from **13(b)**) (allow valid conclusion based on comparison of calculated values for other quantities given in the question) <u>Example calculation</u> $t_A = \frac{100\text{ m}}{93} = 1.075\text{ s}$ $109 = 93t_B + \frac{1}{2} \times 14 \times {t_B}^2$ $t_B = \frac{-93 + \sqrt{93^2 - 4 \times \left(\frac{14}{2}\right) \times (-109)}}{2 \times \frac{14}{2}} = 1.084\text{ s}$ 1.075 s < 1.084 s so car A will finish first.	(1) (1) (1)	3
	Total for question 13		**6**

Question Number	Answer		Mark
14(a)	The weight of the grain is equal to the sum of the drag and upthrust acting on it **Or** Resultant force = 0 **Or** The sum of the upward forces is equal to the sum of the downward forces **Or** The (vector) sum of the forces is zero	**(1)**	**1**
14(b)	Use of weight = upthrust + drag Use of viscous drag = $6\pi\eta rv$ $v = 1.7\ \text{m s}^{-1}$ **and** comparison with $0.050\ \text{m s}^{-1}$ **and** consistent conclusion. (allow correctly calculated values for other quantities given in the question, with consistent conclusion) <u>Example of calculation</u> Drag = $4.3 \times 10^{-5}\text{N} - 1.5 \times 10^{-5}\text{N} = 2.8 \times 10^{-5}\text{N}$ $v = \dfrac{2.8 \times 10^{-5}\ \text{N}}{6 \times \pi \times 1.2 \times 10^{-3}\ \text{Pa s} \times \left(\dfrac{1.5 \times 10^{-3}\ \text{m}}{2}\right)} = 1.65\ \text{m s}^{-1}$ $1.65 \neq 0.05$ so Stokes' law does not apply	**(1)** **(1)** **(1)**	**3**
14(c)	As temperature increases, viscosity decreases So (value of) <u>terminal</u> velocity increases (to make drag equal to weight) (dependent on MP1) Allow converse argument	**(1)** **(1)**	**2**
	Total for question 14		**6**

Question Number	Answer		Mark
15(a)	Use of $p = mv$	(1)	
	Use of momentum conservation	(1)	
	$v = 0.048$ (m s^{-1})	(1)	3
	<u>Example of calculation</u> Initial momentum = 0.165 kg × 0.739 m s^{-1} = 0.122 N s 0.165 kg × 0.691 m s^{-1} + 0.165 kg × v = 0.122 N s $v = \frac{0.122\text{ N s} - 0.114\text{ Ns}}{0.165\text{ kg}} = 0.048\text{ m s}^{-1}$		
15(b)	Use of $E_k = ½\, m\, v^2$	(1)	
	Decrease in $E_k = 5.4 \times 10^{-3}$ (J) (ecf from 15(a))	(1)	2
	<u>Example of calculation</u> A: final $E_k = 0.5 \times 0.165\text{ kg} \times (0.048\text{ m s}^{-1})^2 = 1.90 \times 10^{-4}\text{ J}$ B: final $E_k = 0.5 \times 0.165\text{ kg} \times (0.691\text{ m s}^{-1})^2 = 3.94 \times 10^{-2}\text{ J}$ Total final $E_k = 3.94 \times 10^{-2}\text{ J} + 1.90 \times 10^{-4}\text{ J} = 3.96 \times 10^{-2}\text{ J}$ Decrease in $E_k = 4.5 \times 10^{-2} - 3.96 \times 10^{-2} = 5.40 \times 10^{-3}\text{ J}$		
15(c)	(By Newton's third law) ball B exerts a force equal (in magnitude) and opposite (in direction) on ball A	(1)	
	(By Newton's first / second law), resultant force on A causes A to decelerate	(1)	2
	To score **2** marks, there must be a reference to Newton's second law or Newton's third law.		
	Total for question 15		**7**

Question Number	Answer	Mark
16(a)*	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content.	6

IC points	IC mark	Max linkage mark	Max final mark
6	4	2	6
5	3	2	5
4	3	1	4
3	2	1	3
2	2	0	2
1	1	0	1
0	0	0	0

The following table shows how the marks should be awarded for structure and lines of reasoning.

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

Indicative content

IC1 Measure the original length (from clamp to marker)

IC2 Measure distance moved by marker from original position to determine extension.
Or Measure new length and subtract original length to determine extension

IC3 Calculate weight of masses using $W = mg$
Or Use a newtonmeter to measure weight of masses

IC4 Use diameter to calculate cross-sectional area

IC5 Calculate stress using $\frac{\text{force}}{\text{area}}$ **and** calculate strain using $\frac{\text{extension}}{\text{original length}}$ (allow symbol equations if terms defined)
Or plot a graph of stress against strain
Or plot a graph of force against extension

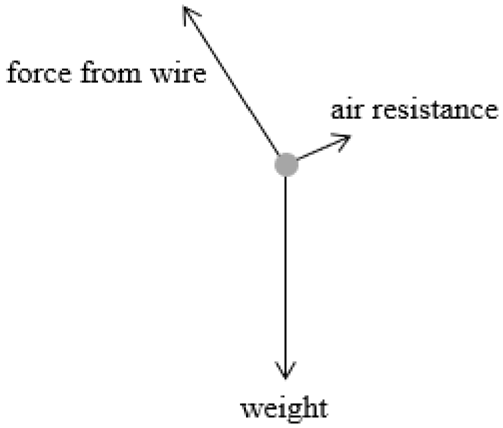
IC6 Calculate Young Modulus using $\frac{\text{stress}}{\text{strain}}$ (allow symbol equations if terms defined)
Or Correctly relate gradient of (straight section of) graph to Young Modulus.

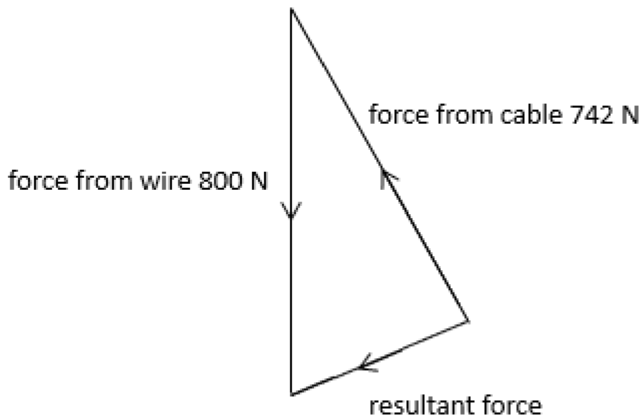
16(b)	Calculates cross-sectional area	**(1)**	
	Use of $\sigma = \frac{F}{A}$	**(1)**	
	Use of $E = \frac{\sigma}{\varepsilon}$ **and** use of $\varepsilon = \frac{\Delta x}{x}$	**(1)**	
	$\Delta x = 4.6 \times 10^{-4}$ m	**(1)**	**4**
	<u>Example calculation</u> $A = \pi \times \left(\frac{0.56\times10^{-3}\text{ m}}{2}\right)^2 = 2.46 \times 10^{-7}\text{m}^2$ $\sigma = \frac{5.0\text{ N}}{2.46\times10^{-7}\text{m}^2} = 2.03 \times 10^7$ Pa $\varepsilon = \frac{2.03\times10^7\text{Pa}}{1.1\times10^{11}\text{Pa}} = 1.85 \times 10^{-4}$ $\Delta x = 1.85 \times 10^{-4} \times 2.5 = 4.61 \times 10^{-4}$ m		
	Total for question 16		**10**

Question Number	Answer	Mark
17(a)	Use of trigonometry to show $u_v = 5.2$ (m s^{-1}) **(1)** Use of trigonometry to show $u_h = 3.6$ (m s^{-1}) **(1)** <u>Example of calculation</u> $u_v = 6.3 \text{ m s}^{-1} \times \sin 55° = 5.16 \text{ m s}^{-1}$ $u_h = 6.3 \text{ m s}^{-1} \times \cos 55° = 3.61 \text{ m s}^{-1}$	**2**
17(b)	Use of $v^2 = u^2 + 2as$ with $a = -g$ and $u = u_v$ **(1)** Adds 1.25 m to height gained **(1)** Greatest height = 2.6 (m) (allow ecf from 17(a)) **(1)** <u>Example of calculation</u> $0 = (5.16 \text{ m s}^{-1})^2 - 2 \times 9.81 \text{ m s}^{-2} \times s$ $s = \dfrac{26.6 \text{ m}^2 \text{ s}^{-2}}{19.6 \text{ m s}^{-2}} = 1.36 \text{ m}$ $1.36 + 1.25 = 2.61$ m	**3**

17(c)	**EITHER** Uses valid suvat equation(s) to determine time taken for stone to land in water **(1)** Uses valid suvat equation(s) to determine horizontal distance travelled by stone **(1)** Horizontal distance travelled before landing = 4.5m (ecf from 17(a) and/or 17(b)) **(1)** Comparison of horizontal distance travelled with 3.9 (m) and 4.7 (m) **and** consistent conclusion **(1)** **OR** Uses valid suvat equation(s) to determine time taken for stone to reach front or back of ring **(1)** Uses valid suvat equation(s) to determine height of stone above front or back of ring **(1)** Height at front of ring = 1.10m **and** height at back of ring = -0.33 m (ecf from 17(a) and/or 17(b)) **(1)** Comparison of height at front of ring and height at back of ring with 0 **and** consistent conclusion **(1)** <u>Example of calculation</u> Vertically $v^2 = (5.16 \text{ m s}^{-1})^2 + 2 \times (-9.81 \text{ m s}^{-2}) \times (-1.25 \text{ m})$ $v = -7.15 \text{ m s}^{-1}$ $-7.15 \text{ m s}^{-1} = 5.16 - 9.81 \text{ m s}^{-2} \times t$ $t = 1.25\ s$ Horizontally $s = 3.61 \text{ m s}^{-1} \times 1.25 \text{ s} = 4.51 \text{ m}$ 3.9 m < 4.5 m < 4.7 m, so the stone will land in the tyre	4
	Total for question 17	**9**

Question Number	Answer	Mark
18(a)	Use of moment of a force = Fx **(1)** Use of principle of moments **(1)** Use of Newton's first law **Or** Second use of principle of moments **(1)** $P = 7.9 \times 10^5$ N **(1)** $Q = 6.1 \times 10^5$ N **(1)** Maximum 4 marks if incorrect / no unit with answers. <u>Example of calculation</u> Total clockwise moment = 4.2×10^5 N × 35 m + 9.8×10^5 N × 60 m = 7.35×10^7 N m Total anticlockwise moment = Q × 120 m Q × 120 m = 7.35×10^7 N m $Q = \frac{7.35 \times 10^7 \text{ N m}}{120 \text{ m}} = 6.12 \times 10^5 \text{ N}$ $P = 4.2 \times 10^5 \text{ N} + 9.8 \times 10^5 \text{ N} - 6.12 \times 10^5 \text{ N} = 7.88 \times 10^5 \text{ N}$	**5**
18(b)	Allow P for X throughout Allow Q for Y throughout **EITHER** Distance from X to (centre of gravity of) lorry increases **(1)** (So) moment (about X) due to (force from) lorry increases **(1)** Sum of moments remains zero (for equilibrium) **(1)** So moment (about X) due to Q increases **(1)** Distance from X to Q remains the same therefore Q increases **(1)** **OR** Distance from other end of bridge (Y) to (centre of gravity of) lorry decreases **(1)** (So) moment about Y due to (force from) lorry decreases **(1)** Sum of moments remains zero (for equilibrium) **(1)** So moment about Y due to P decreases, and P must decrease **(1)** And (at equilibrium) the sum of P and Q remains the same therefore Q increases **(1)**	**5**
	Total for question 18	**10**

Question Number	Answer	Mark
19(a)	Arrow to the left and upwards labelled force from wire / harness **(1)** Arrow vertically downwards labelled weight / W / mg **(1)** Arrow to right (and slightly upward) labelled (viscous) drag / D or labelled air resistance **(1)** <u>Example diagram</u> 	**3**
19(b)(i)	Appropriate trigonometry used **(1)** 742 (N) **(1)** <u>Example of calculation</u> $R = 2 \times 1\,200\ \text{N} \times \cos(72°) = 741.6\ \text{N}$	**2**

19(b)(ii)	Straight line at least 8 cm long representing force from wire (800 N), with label **(1)** Vector triangle drawn with at least two sides labelled, and resultant force on shortest side **(1)** All 3 arrows in correct relative directions (dependent on MP2) **(1)** Resultant force = 400 N (Range from 390 to 410) **(1)** <u>Example diagram</u> 	**4**
19(c)	(most) E_{grav} transferred to E_k and mass is in both equations **(1)** (So final) speed does not depend on mass of person **Or** (So final) speed only depends on change in height **Or** (So final) speed = $\sqrt{2g\Delta h}$ (and g is constant) **(1)** (assuming) work done against resistive forces is negligible **(1)**	**3**
	Total for question 19	**12**

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