Mark Scheme (Results)

June 2022

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

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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.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear

  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter

  iii) organise information clearly and coherently, using specialist vocabulary when appropriate.

Mark scheme notes

Underlying principle

The mark scheme will clearly indicate the concept that is being rewarded, backed up by examples. It is not a set of model answers.

1. Mark scheme format

1.1 You will not see 'wtte' (words to that effect). Alternative correct wording should be credited in every answer unless the MS has specified specific words that must be present. Such words will be indicated by underlining e.g. '<u>resonance</u>'

1.2 Bold lower case will be used for emphasis e.g. '**and'** when two pieces of information are needed for 1 mark.

1.3 Round brackets ( ) indicate words that are not essential e.g. "(hence) distance is increased".

1.4 Square brackets [ ] indicate advice to examiners or examples e.g. [Do not accept gravity] [ecf].

2. Unit error penalties

2.1 A separate mark is not usually given for a unit but a missing or incorrect unit will normally mean that the final calculation mark will not be awarded.

2.2 This does not apply in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.

2.3 The mark will not be awarded for the same missing or incorrect unit only once within one clip in epen.

2.4 Occasionally, it may be decided not to insist on a unit e.g the candidate may be calculating the gradient of a graph, resulting in a unit that is not one that should be known and is complex.

2.5 The mark scheme will indicate if no unit error is to be applied by means of [no ue].

3. Significant figures

3.1 Use of too many significant figures in the theory questions will not be prevent a mark being awarded if the answer given rounds to the answer in the MS.

3.2 Too few significant figures will mean that the final mark cannot be awarded in 'show that' questions where one more significant figure than the value in the question is needed for the candidate to demonstrate the validity of the given answer.

3.3 The use of one significant figure might be inappropriate in the context of the question e.g. reading a value off a graph. If this is the case, there will be a clear indication in the MS.

3.4 The use of g = 10 m s^{-2} or 10 N kg^{-1} instead of 9.81 m s^{-2} or 9.81 N kg^{-1} will mean that one mark will not be awarded. (but not more than once per clip). Accept 9.8 m s^{-2} or 9.8 N kg^{-1}

3.5 In questions assessing practical skills, a specific number of significant figures will be required e.g. determining a constant from the gradient of a graph or in uncertainty calculations. The MS will clearly identify the number of significant figures required.

4. Calculations

4.1 Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.

4.2 If a 'show that' question is worth 2 marks. then both marks will be available for a reverse working; if it is worth 3 marks then only 2 will be available.

4.3 **use** of the formula means that the candidate demonstrates substitution of physically correct values, although there may be conversion errors e.g. power of 10 error.

4.4 **recall** of the correct formula will be awarded when the formula is seen or implied by substitution.

4.5 The mark scheme will show a correctly worked answer for illustration only.

5. Quality of Written Communication

5.1 Indicated by QoWC in mark scheme. QWC – Work must be clear and organised in a logical manner using technical wording where appropriate.

5.2 Usually it is part of a max mark, the final mark not being awarded unless the QoWC condition has been satisfied.

6. Graphs

6.1 A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.

6.2 Sometimes a separate mark will be given for units or for each axis if the units are complex. This will be indicated on the mark scheme.

6.3 A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale e.g. multiples of 3, 7 etc.

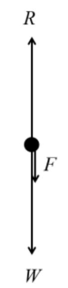
6.4 Points should be plotted to within 1 mm.

- Check the two points furthest from the best line. If both OK award mark.
- If either is 2 mm out do not award mark.
- If both are 1 mm out do not award mark.
- If either is 1 mm out then check another two and award mark if both of these OK, otherwise no mark.

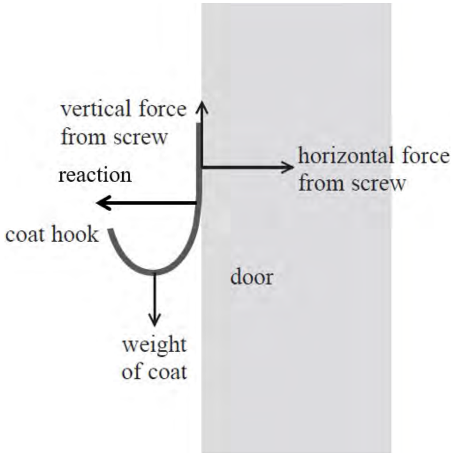
For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

Question Number	Answer	Mark
1	The correct answer is **C** A is incorrect because the numerator and denominator are the wrong way around, and a factor of 1 000 is missing in the numerator B is incorrect because the factor 750 should be in the denominator and the 1 000 in the numerator D is incorrect because the numerator and denominator are the wrong way around.	**1**
2	The correct answer is **B** A is incorrect because the upthrust is constant C is incorrect because the upthrust is constant and the viscous drag is increasing D is incorrect because the viscous drag is increasing	**1**
3	The correct answer is **D** A is incorrect because force is a vector B is incorrect because momentum is a vector C is incorrect because velocity is a vector	**1**
4	The correct answer is **C** A is incorrect because area represents work done per unit volume B is incorrect because area represents work done per unit volume D is incorrect because the breaking point is outside the linear region	**1**
5	The correct answer is **B** A is incorrect because air resistance would reduce the acceleration C is incorrect because drop time is unaffected by horizontal motion D is incorrect because a greater time would give a lower acceleration	**1**

Question Number	Answer	Mark
6	The correct answer is **B** because for a constant resultant force acceleration increases if mass decreases A is incorrect because a constant acceleration for a decreasing mass would require a decreasing resultant force C is incorrect because a decreasing acceleration for a decreasing mass would require a decreasing resultant force D is incorrect because a decreasing acceleration for a decreasing mass would require a decreasing resultant force	**1**
7	The correct answer is **D** A is incorrect because springs in series increase the extension and springs in parallel decrease the extension for the same force B is incorrect because springs in series increase the extension for the same force C is incorrect because springs in parallel decrease the extension for the same force	**1**
8	The correct answer is **D** because the area below the t axis represents negative displacement A is incorrect because P is above the line and Q should be subtracted B is incorrect because P is above the line C is incorrect because Q should be subtracted	**1**
9	The correct answer is **D** A is incorrect because the distance moved by the force is not $\Delta h \cos \theta$ B is incorrect because the distance moved by the force is not $\Delta h / \cos \theta$ C is incorrect because the distance moved by the force is not $\Delta h \sin \theta$	**1**
10	The correct answer is **B** A is incorrect because the spring constant is $\Delta F / \Delta x$ C is incorrect because the spring constant is $\Delta F / \Delta x$ D is incorrect because the spring constant is $\Delta F / \Delta x$	**1**
	Total for Section A	**10**

Question Number	Answer	Mark
11(a)	The forces act on the same object. **(1)** They are different types of force. **(1)**	**2**
11(b)	Downward arrow labelled magnetic force (from disc) **Or** Downward arrow labelled *F*. **(1)** Upward arrow labelled (normal) reaction / contact / *R* / *N* / **and** arrow length approximately equal to *F* + *W*. **(1)** 	**2**
	Total for question 11	**4**

Question Number	Answer	Mark
12(a)	It's the force / stress beyond which the cable does not return to its original length when the force / stress is removed **(1)**	**1**
12(b)(i)	Use of $\varepsilon = \Delta x / x$ **(1)** $\varepsilon = 0.021$ **(1)** Example of calculation $\varepsilon = 0.126\ \text{m} \div 6\ \text{m} = 0.021$	**2**
12(b)(ii)	Use of $\sigma = F/A$ **(1)** $\sigma = 1.4 \times 10^{9}$ Pa **(1)** Example of calculation $\sigma = 1.34 \times 10^{6}\ \text{N} \div 9.6 \times 10^{-3}\ \text{m}^{2} = 1.40 \times 10^{9}$ Pa	**2**
	Total for question 12	**5**

Question Number	Answer		Mark
13(a)	 Horizontal arrow pointing to the left labelled "reaction (force from the wall on the hook)" Arrow drawn below screw and not lower than last point of contact between hook and wall MP2 depends upon MP1	**(1)** **(1)**	**2**
13(b)	Use of moment of force = $F\ x$ Use of principle of moments Use of $W = m\ g$ Correct calculation leading to conclusion no (as maximum is two coats) <u>Example of calculation</u> 150 N × 0.009 m = W × 0.025 m W = 1.35 N m ÷ 0.025 m = 54.0 N m = 54.0 N ÷ 9.81 N kg^{-1} = 5.50 kg 5.50 kg ÷ 2.6 kg = 2.12 ∴ two coats max, so no.	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 13		**6**

Question Number	Answer		Mark
14(a)	Use $E_K = ½\, m\, v^2$	**(1)**	
	Use of efficiency = $\frac{\text{useful energy output}}{\text{total energy input}}$	**(1)**	
	Efficiency = 0.56 **Or** 56%	**(1)**	**3**
	<u>Example of calculation</u> $E_K = 0.5 \times 1\,560 \text{ kg} \times (13 \text{ m s}^{-1})^2 = 1.32 \times 10^5$ J efficiency = $73.9 \times 10^4 \text{ J} \div 1.32 \times 10^5 \text{ J} = 0.56$		
14(b)(i)	As the velocity increases the drag forces increase.	**(1)**	**1**
14(b)(ii)	At higher speeds more work done against air resistance.	**(1)**	
	So more energy dissipated.	**(1)**	
	So a smaller proportion of energy is available to charge battery.	**(1)**	
	(Hence) the efficiency of the system is lower.	**(1)**	**4**
	Total for question 14		**8**

Question Number	Answer	Mark
15*	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 and lines of reasoning.	

IC points	IC mark	Max linkage mark available	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**

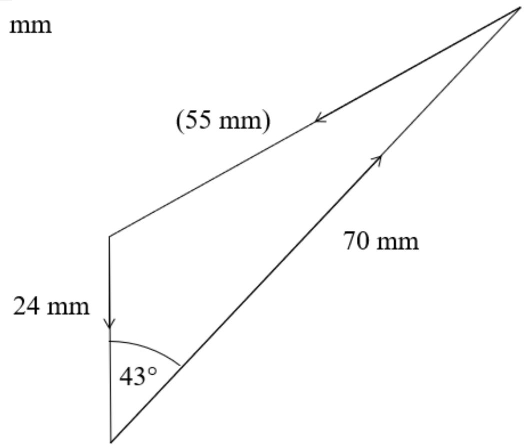
	Marks
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout.	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

Indicative content:

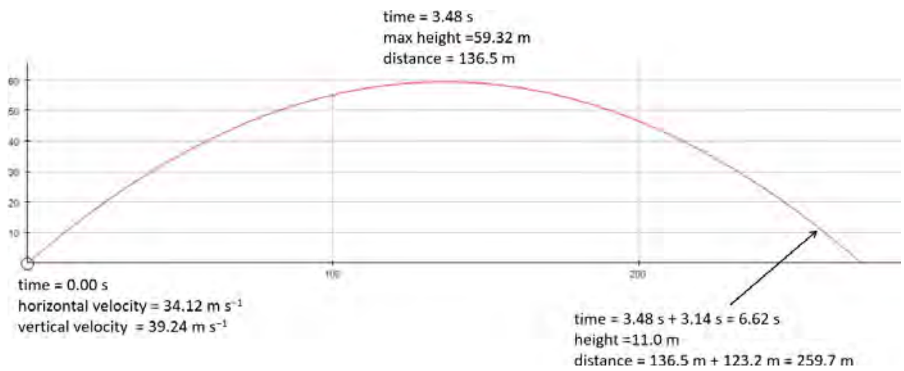
- Upthrust on a bulb is equal to weight of liquid displaced. **(1)**
- When upthrust equals/exceeds weight of bulb / disc, bulb floats **(1)**
- Weight of a bulb / disc is constant **(1)**
- As temperature increases the weight of displaced liquid decreases
  Or As temperature increases upthrust on bulb decreases **(1)**
- Until weight of a bulb / disc exceeds the upthrust **(1)**
- There is a resultant force and bulb will sink **(1)**

Mark: **6**

	Total for question 15	**6**

Question Number	Answer	Mark
16(a)	Two arrowed lines for 70 N and 24 N with correct orientation **(1)** [use template for angle] Lines labelled with name/force/scaled length **(1)** Tension drawn in correctly i.e. correct vector diagram with correct direction **(1)** Answer in range 55 ± 2 N **(1)** [Correct answer from trigonometry scores MP4 only] <u>Example of calculation</u> SCALE 1 N : 1 mm  	**4**
16(b)	Measure angle of string to vertical **(1)** Using a protractor **(1)** Calculate weight of mass holder and masses using $W = mg$ **(1)** Vertical component of T is equal to W **(1)** Vertical component is $T \cos \theta$, so T can be calculated **(1)**	**5**
	Total for question 16	**9**

Question Number	Answer		Mark
17(a)(i)	Use of $p = m\,v$	**(1)**	
	Use of conservation of momentum	**(1)**	
	m = 151 (kg)	**(1)**	**3**
	Use of $F = \Delta p / \Delta t$ scores MP1 and MP2		
	Example of calculation $p = 250\text{ kg} \times 2.10\text{ m s}^{-1} = 250\text{ kg} \times 1.15\text{ m s}^{-1} + m \times 1.57\text{ m s}^{-1} = 525.0\text{ kg m s}^{-1}$ $m = (525.0 - 287.5\text{ N s})\text{ kg m s}^{-1} \div 1.57\text{ m s}^{-1}$ $= 237.5\text{ kg m s}^{-1} \div 1.57\text{ m s}^{-1} = 151.3\text{ kg}$		
17(a)(ii)	No external horizontal forces acted on either car during the collision.	**(1)**	**1**
17(a)(iii)	Use of $a = \Delta v / \Delta t$	**(1)**	
	Use of $\Sigma F = ma$	**(1)**	
	$\Sigma F = 1.76 \times 10^2$ N (ecf from (a)(i))	**(1)**	**3**
	Example of calculation average acceleration = $1.57\text{ m s}^{-1} \div 1.35\text{ s} = 1.16\text{ m s}^{-2}$ $\Sigma F = 151.3\text{ kg} \times 1.16\text{ m s}^{-2} = 1.76 \times 10^2\text{ N}$		
17(b)	P exerts a force on Q so Q exerts a force on P	**(1)**	
	Due to N3 forces are equal and opposite in direction	**(1)**	
	Resultant force on P opposite to direction of motion so according to N2, P decelerates	**(1)**	**3**
	Total for question 17		**10**

Question Number	Answer		Mark
18(a)	Use of trigonometry Vertical component = 34 (m s^{-1}) <u>Example of calculation</u> 52 m s^{-1} × sin 41° = 34.1 m s^{-1}	**(1)** **(1)**	**2**
18(b)	<u>Method 1:</u> Use of $s = u\,t + ½\,a\,t^2$ with s = 11 m and a = − 9.81 m s^{-2} Use of quadratic formula t = 6.62 (s) [Allow ecf from (a)] <u>Method 2:</u> Use of $v = u + at$, with v = 0 to find time to max height [3.48 s] Use of $s = ½(u + v)\,t$, or other correct *suvat* equation, to find max height [59.3 m] **And** Use of $s = u\,t + ½\,a\,t^2$ to find time to fall to 11 m [3.14 s] t = 6.62 (s) depending on rounding of (a) [Allow ecf from (a)] (allow ecf from (a)) [Allow any valid *suvat* method] <u>Example of calculation</u> Let time to max height = t 11 m = 34.1 m s^{-1} × t − ½ × 9.81 m s^{-2} × t^2 4.91 × t^2 − 34.1 m s^{-1} × t + 11 m = 0 t = (34.1 ± √(34.1^2 − 4 × 11 × 4.91) m s^{-1} ÷ 9.81 m s^{-2} = 6.62 s (or 0.34 s)	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
18(c)	Resolves for horizontal component of velocity Use of $s = v\,t$ 260 m so no (Allow ecf from (b) with correct conclusion based on student's value) <u>Example of calculation</u> Horizontal component of velocity = 52 m s^{-1} × cos 41° = 39.2 m s^{-1} s = 39.2 m s^{-1} × 6.62 s = 260 m Distance required 245 m to 255 m and 260 m > 255 m so no. 	**(1)** **(1)** **(1)**	**3**

	Total for question 18	8

Question Number	Answer	Mark
19(a)	The viscosity decreases (with temperature) **(1)**	**1**
19(b)(i)	Use of $V = (4/3)\pi r^3$ **(1)** Use of $\rho = m / V$ **(1)** Use of $W = m g$ **(1)** $W = 4.76 \times 10^{-3}$ N **(1)** <u>Example of calculation</u> volume = $(4/3)\pi \times (3.5 \times 10^{-3}\text{ m})^3 = 1.80 \times 10^{-7}\text{ m}^3$ $m = 1.80 \times 10^{-7}\text{ m}^3 \times 2.70 \times 10^3\text{ kg m}^{-3} = 4.85 \times 10^{-4}$ kg $W = 4.85 \times 10^{-4}\text{ kg} \times 9.81\text{ N kg}^{-1} = 4.76 \times 10^{-3}$ N	**4**
19(b)(ii)	Use of $F = 6\pi \eta r v$ **(1)** Use of U = weight of fluid displaced **(1)** Comparison of F with $W - U$ and conclusion consistent with student's values **(1)** <u>Example of calculation</u> $D = 6\pi \times 0.95\text{ Pa s} \times 0.003\,5\text{ m} \times 0.040\,5\text{ m} = 2.54 \times 10^{-3}$ N $U = 1.80 \times 10^{-7}\text{ m}^3 \times 1.26 \times 10^3\text{ kg m}^{-3} \times 9.81\text{ N kg}^{-1} = 2.22 \times 10^{-3}$ N $W - U = 4.76 \times 10^{-3}\text{ N} - 2.22 \times 10^{-3}\text{ N} = 2.54 \times 10^{-3}$ N $2.54 \times 10^{-3}\text{ N} = D$ ∴ Stokes law obeyed	**3**
19(b)(iii)	Low speed **Or** Laminar flow **Or** Small sphere **(1)** [Accept reference to wide cylinder]	**1**
19(c)	Viscosity of blood is much lower **(1)** Drag will be lower for given velocity (proportional to diameter) **(1)** Reducing diameter gives less weight (proportional to cube of diameter) **(1)** Forces balance at lower speed **Or** Terminal velocity lower **(1)** Laminar flow needs low speed **(1)** Viscosity of blood much lower (1) (For the original sphere) drag would be (much) lower at same velocity (1)	**5**

	So terminal velocity would be (much) too large for Stokes' law (1) Reducing r reduces W much more than D OR W proportional to r3 but D proportional to r (1) (With smaller sphere) forces will still balance at low speed (1)	
	Total for question 19	**14**