Pearson Edexcel

Mark Scheme (Provisional)

Summer 2021

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 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.

For example:

(iii) <u>Horizontal force of hinge on table top</u>

66.3 (N) or 66 (N) **and** correct indication of direction [no ue] ✓ **1**

[Some examples of direction: acting from right (to left) / to the left / West / opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.]

This has a clear statement of the principle for awarding the mark, supported by some examples illustrating acceptable boundaries.

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.
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 Incorrect use of case e.g. 'Watt' or 'w' will **not** be penalised.
2.3 There will be no unit penalty applied in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.
2.4 The same missing or incorrect unit will not be penalised more than once within one question (one clip in epen).
2.5 Occasionally, it may be decided not to penalise a missing or incorrect 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.
2.6 The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

3. Significant figures

3.1 Use of an inappropriate number of significant figures in the theory papers will normally only be penalised in 'show that' questions where use of too few significant figures has resulted in the candidate not demonstrating the validity of the given answer.
3.2 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 be penalised by one mark (but not more than once per clip). Accept 9.8 m s^{-2} or 9.8 N kg^{-1}

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.

4.6 Example of mark scheme for a calculation:

<u>'Show that' calculation of weight</u>

Use of L × W × H	✓	
Substitution into density equation with a volume and density	✓	
Correct answer [49.4 (N)] to at least 3 sig fig. [No ue]	✓	
[If 5040 g rounded to 5000 g or 5 kg, do not give 3rd mark; if conversion to kg is omitted and then answer fudged, do not give 3rd mark]		
[Bald answer scores 0, reverse calculation 2/3]		
Example of answer:		
80 cm × 50 cm × 1.8 cm = 7200 cm^3		
7200 cm^3 × 0.70 g cm^{-3} = 5040 g		**3**
5040 × 10^{-3} kg × 9.81 N/kg		
= 49.4 N		

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	**D is the correct answer** A is incorrect because weight is a force, which is a vector B is incorrect because momentum is a vector C is incorrect because velocity is a vector	**(1)**
2	**C is the correct answer** A is incorrect because it give units of $m^3\ kg^{-1}$ B is incorrect because it give units of $m^3\ kg\ N^{-2}$ D is incorrect because it give units of $N^2\ kg^{-1}\ m^{-3}$	**(1)**
3	**C is the correct answer** A is incorrect because the frictional force from the road is the driving force B is incorrect because a drag force is also acting D is incorrect because the frictional force from the road is the driving force	**(1)**
4	**B is the correct answer** A is incorrect because it gives units of J C is incorrect because it gives an input power less than the output power D is incorrect because it gives units of J	**(1)**
5	**D is the correct answer** A is incorrect because the units are inconsistent B is incorrect because it gives a greater length, and *F* is a compressive force C is incorrect because the units are inconsistent	**(1)**
6	**B is the correct answer** A is incorrect because it gives units of $J\ m \neq N$ C is incorrect because it gives units of $W\ m\ s^{-1} \neq N$ D is incorrect because it gives units of $m\ s\ W^{-1} \neq N$	**(1)**
7	**B is the correct answer** A is incorrect because the acceleration is *g* which has constant magnitude and direction C is incorrect because the objects gain the same k.e. for the same drop height D is incorrect because both objects start with the same k.e. and gain the same k.e.	**(1)**
8	**C is the correct answer** A is incorrect because the acceleration does not reach zero B is incorrect because the acceleration does not reach zero D is incorrect because the acceleration does not reach zero	**(1)**
9	**D is the correct answer** A is incorrect because the fracture point is at the extreme end of the graph B is incorrect because proportionality ends before point X is reached C is incorrect because point X is not the highest point reached by the graph	**(1)**
10	**C is the correct answer** A is incorrect because *R* is in the wrong direction B is incorrect because *R* is the wrong diagonal D is incorrect because *R* is the wrong diagonal	**(1)**

Question Number	Answer		Mark
11(a)	Use of $p = mv$	**(1)**	
	$p = 4.53 \times 10^5$ (kg m s^{-1}) (reverse calculation can gain both marks)	**(1)**	**2**
	<u>Example of calculation</u> $p = mv$ $p = (7.15 + 5.35) \times 10^4$ kg $\times$ 3.62 m s^{-1} = 4.53×10^5 kg m s^{-1}		
11(b)	Equates the initial with the final momentum.	**(1)**	
	v = 2.44 m s^{-1} (allow ecf from (a))	**(1)**	**2**
	<u>Example of calculation</u> 5.35×10^4 kg $\times v +$ 7.15×10^4 kg $\times$ 4.50 m s^{-1} = 4.53×10^5 kg m s^{-1} $v = (4.53 \times 10^5$ kg m s^{-1} − 7.15×10^4 kg $\times$ 4.50 m s^{-1})/ 5.35×10^4 kg = 2.44 m s^{-1}		
11(c)	Use of $E_K = ½\, m\, v^2$	**(1)**	
	$E_K = 6.5 \times 10^4$ J (allow ecf from (b))	**(1)**	**2**
	<u>Example of calculation</u> Initial k.e. = $0.5 \times (7.15 \times 10^4$ kg $\times (4.50$ m s$^{-1})^2$ + 5.35×10^4 kg $\times$ (2.44 m s$^{-1})^2$) = 8.84×10^5 J Final k.e. = $0.5 \times 12.5 \times 10^4$ kg $\times$ (3.62 m s$^{-1})^2$) = 8.19×10^5 J Difference = 8.84×10^5 J − 8.19×10^5 J = 6.47×10^4 J		
	Total for question 11		**6**

Question Number	Answer	Mark
12(a)	**Either** Decrease of GPE = gain of KE. **(1)** Use of $E_k = ½\, m\, v^2$ and $\Delta E_{grav} = m\, g\, \Delta h$ **(1)** v = 3.1(m s^{-1}) **(1)** **Or** Use of trigonometry to find parallel component of g **and** distance along ramp **(1)** Use of $v^2 = u^2 + 2\, a\, s$ (or other valid *suvat* method) **(1)** v = 3.1(m s^{-1}) **(1)** (reverse calculations can score maximum 2 marks) <u>Example of calculation</u> $½\, m\, v^2 = m\, g\, \Delta h$ $½\, v^2$ = 9.81 m s^{-2} × 0.5 m $v = \sqrt{(2 \times 9.81 \text{ m s}^{-2} \times 0.5 \text{ m})}$ = 3.13 m s^{-1}	3
12(b)	Use of Pythagoras' Theorem to calculate distance along the ramp **Or** Use of trigonometry to find parallel component of g **(1)** Use of s = ½ ($u + v$) t (or other valid *suvat* method for t_{AB}) **(1)** Use of $s = u\, t$ **(1)** Total time = 1.64 s (show that value gives 1.65 s) **(1)** (may see some MPs for (b) in (a)) <u>Example of calculation</u> Distance along ramp = ($\sqrt{(2^2 + 0.5^2)}$) m = 2.06 m 2.06 m = ½ (0 + 3.13) m s^{-1} × t_{AB} t_{AB} = 2 × 2.06 m / 3.13 m s^{-1} = 1.32 s t_{BC} = 1 m / 3.13 m s^{-1} = 0.32 s Total time = 1.32 s + 0.32 s = 1.64 s	4
	Total for question 12	**7**

Question Number	Answer	Mark
13(a)(i)	Use of $\rho = m / V$ (and $U = mg$) **(1)** $U = 5.9 \times 10^7$ N **(1)** <u>Example of calculation</u> $U = \rho g V = 1.03 \times 10^3 \text{ kg m}^{-3} \times 9.81 \text{ N kg}^{-1} \times 5.83 \times 10^3 \text{ m}^3 = 5.89 \times 10^7$ N	**2**
13(a)(ii)	Weight of submarine is equal to the upthrust. **(1)** Refers to $W = m g$ to justify a mass of 6.00×10^6 kg **Or** Refers to mass calculated in (a)(i) to justify a mass of 6.00×10^6 kg **(1)** <u>Example of calculation</u> $W = U = 5.89 \times 10^7 \text{ N} = m \times 9.81 \text{ N kg}^{-1}$ $m = 5.89 \times 10^7 \text{ N} / 9.81 \text{ N kg}^{-1} = 6.00 \times 10^6$ kg	**2**
13(b)(i)	The upthrust (of the water on the submarine) is less than the weight of the submarine **(1)** A resultant force acts (downwards) on the submarine **(1)** So the submarine will (begin to) sink (dependent on MP1) **(1)**	**3**
13(b)(ii)	Use of $\rho = m/V$ **and** $W = mg$ to calculate new upthrust **(1)** Mass of water = 1×10^5 kg (pumped out) (allow ecf from (a)(i)) **(1)** <u>Example of calculation</u> Upthrust = $1.01 \times 10^3 \text{ kg m}^{-3} \times 9.81 \text{ N kg}^{-1} \times 5.83 \times 10^3 \text{ m}^3 = 5.78 \times 10^7$ N Net downward force = $5.89 \times 10^7 \text{ N} - 5.78 \times 10^7 \text{ N} = 1.14 \times 10^6$ N Mass to be lost = $1.14 \times 10^6 \text{ N} / 9.81 \text{ N kg}^{-1} = 1.17 \times 10^5$ kg	**2**
	Total for question 13	**9**

Question Number	Answer	Mark
14(a)	Resolves velocity into horizontal and vertical components. **(1)** Use of $s = u\,t$ for horizontal displacement **(1)** Use of $s = u\,t + ½\,a\,t^2$ with $a = g$ for vertical displacement **(1)** Height after 30 m = 0.91 m **(1)** **Or** decrease in height = 1.99 m Comparison and conclusion consistent with student's calculation. **(1)** A method that calculates horizontal displacement in time taken to fall 2.9 m can score full marks. *e.g.* Resolves velocity into horizontal and vertical components. **(1)** Use of *suvat* equations to calculate total time in flight **(1)** Use of $s = u\,t$ for horizontal displacement **(1)** Total distance = 32.7 m **(1)** Comparison and conclusion consistent with student's calculation. **(1)** <u>Example calculation</u> v_H = 25 m s^{-1} × cos 10° = 24.6 m s^{-1} v_V = 25 m s^{-1} × sin 10° = 4.34 m s^{-1} 30 m = 24.61 m s^{-1} × t → t = 30 m ÷ 24.6 m s^{-1} = 1.22 s s = 4.34 m s^{-1} × 1.22 s − 0.5 × 9.81 × 1.22^2 = −1.99 m Height = 2.9 m − 1.99 m = 0.91 m 0.91 m > 0.00 m ∴ success	**5**
14(b)	**Either** Use of $E_K = ½\,m\,v^2$ **(1)** Use of $\Delta W = F\Delta s$ **(1)** $F = 3.88 \times 10^2$ N **(1)** **Or** Use of $v^2 = u^2 + 2as$ or combination of *suvat* equations to find deceleration. **(1)** Use of $F = m\,a$ **(1)** $F = 3.88 \times 10^2$ N **(1)** <u>Example of calculation</u> E_K = ½ × 63 × 23^2 = 1.67 × 10^4 J 1.67 × 10^4 J = F × 43 F = 1.67 × 10^4 J / 43 = 3.88 × 10^2 N	**3**
	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 or more	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

- When the spacecraft is accelerating the astronaut accelerates at the same rate.
- The seat is applying a forward force to the astronaut so (by N3) the astronaut is applying a backward/opposite force to the seat (which compresses the seat).
- As the fuel is used up, the mass of the spacecraft decreases.
- (As the mass of the spacecraft decreases) the acceleration increases.
- The force between the seat and the astronaut increases thus further compressing the seat.
- The seat decompresses (to push the astronaut forwards) when the force (from the rocket motor) becomes zero.
  Or
  The seat decompresses when the force (from the rocket motor) is removed.
  Or
  The force from the safety strap decelerates the astronaut.

1IC **(1)**
2IC **Or** 3IC **(1)**
3IC + linkage **Or** 4IC **Or** 5IC **(1)**
4IC + linkage **Or** 5IC + linkage **Or** 6IC **(1)**
5IC + 2 × linkage **Or** 6 IC + linkage **(1)**
6IC + 2 × linkage **(1)**

Mark: **6**

	Total for question 15	**6**

Question Number	Answer	Mark
16(a)	Use of moment = $F x$ **(1)** Use of Σ(moments) = 0 **(1)** R_1 = 3.7 kN **and** R_2 = 8.6 kN **(1)** <u>Example of calculation</u> Taking moments about rear axle: $R_1 = (1.8\text{ m} \times 1.23 \times 10^4\text{ N}) / 6\text{ m} = 3.69 \times 10^3\text{ N}$ Taking moments about the front axle: $R_2 = (4.2\text{ m} \times 1.23 \times 10^4\text{ N}) / 6\text{ m} = 8.61 \times 10^3\text{ N}$	**3**
16(b)	Use of $\Sigma F = m a$ **(1)** $\Sigma F = 6.77 \times 10^4$ N **(1)** <u>Example of calculation</u> $\Sigma F = (1.23 \times 10^4\text{ N} / g) \times 5.50\text{ g} = 6.77 \times 10^4\text{ N}$	**2**
16(c)	Reference to $P = W / t$ **Or** $\Delta W = F \Delta s$ **(1)** Force decreases as velocity increases **(1)**	**2**
	Total for question 16	**7**

Question Number	Answer	Mark
17(a)	The greater the length of the rope, the greater the extension for a given force **(1)** Stiffness $k = F / \Delta x$ so stiffness decreases (if extension increases). **(1)**	**2**
17(b)(i)	Use of $E = \frac{\sigma}{\varepsilon}$ **and** $\sigma = \frac{F}{A}$ **and** $\epsilon = \frac{\Delta x}{x}$ **(1)** Use of $F = k\Delta x$ **(1)** $k = 1.35 \times 10^5$ (N m^{-1}) **(1)** <u>Example of calculation</u> 2.70×10^9 N m^{-2} = $F \times 6.00$ m ÷ (3.00×10^{-4} m^2 × ΔL) $F = (2.70 \times 10^9$ N m$^{-2} \times 3.00 \times 10^{-4}$ m^2 ÷ 6.00 m) × $\Delta L = k\,\Delta x$ $k = \frac{F}{\Delta L} = \frac{2.70 \times 10^9 \text{ N m}^{-2} \times 3.00 \times 10^{-4} \text{ m}^2}{6.00 \text{ m}}$ $= 1.35 \times 10^5$ N m^{-1}	**3**
17(b)(ii)	Correct use of factor of 2 to calculate F or Δx **(1)** Use of $\Delta F = k\Delta x$ **(1)** 1.85×10^{-2} (m) (allow ecf from (i)) **(1)** <u>Example of calculation</u> F = 5 000 N/ 2 = 2 500 N $\Delta x = \frac{F}{k} = \frac{2\,500 \text{ N}}{1.35 \times 10^5 \text{ N m}^{-1}} = 1.85 \times 10^{-2}$ m	**3**
17(b)(iii)	Use of $\Delta E_{el} = ½ F\Delta x$ **(1)** ΔE_{el} = 23.1 J (allow ecf from (ii)) **(1)** <u>Example of calculation</u> $\Delta E_{el} = 0.5 \times 2\,500 \text{ N} \times 1.85 \times 10^{-2} \text{ m} = 23.13$ J	**2**
17(c)	Use of W = $F\Delta$s (to find the work done in lifting the load) **(1)** Compares 7 500 J with their calculated value in b(iii) and draws suitable conclusion **(1)** <u>Example of calculation</u> Work done by pulley system = 5×10^3 N × 1.5 m = 7 500 J 23(.1) (J) << 7 500 (J) ∴ not significant	**2**
	Total for question 17	**12**

Question Number	Answer		Mark
18(a)	The constant maximum velocity reached by an object falling (through a fluid) When the resultant force equals zero **Or** when the drag plus the upthrust equals the weight	**(1)** **(1)**	**2**
18(b)	Use of $V = 4\pi r^3 / 3$ Use of upthrust U = weight of fluid displaced W Use of $\rho = m / V$ and $W_S = mg$ Use of $D = W - U$ $D = 0.24$ (N) <u>Example of calculation</u> $V = \frac{4}{3}\pi \times (0.0175\text{ m})^3 = 2.24 \times 10^{-5}\text{ m}^3$ $U = 2.24 \times 10^{-5}\text{ m}^3 \times 1.43 \times 10^3\text{ kg m}^{-3} \times 9.81\text{ N kg}^{-1} = 0.314\text{ N}$ $W = 2.24 \times 10^{-5}\text{ m}^3 \times 2.52 \times 10^3\text{ kg m}^{-3} \times 9.81\text{ N kg}^{-1} = 0.554\text{ N}$ $D = 0.554\text{ N} - 0.314\text{ N} = 0.240\text{ N}$ $D = W - U = (2.52 - 1.43) \times 10^3\text{ kg m}^{-3} \times 9.81\text{ N kg}^{-1} \times \frac{4}{3}\pi \times (0.0175\text{ m})^3 = 0.24\text{ N}$	**(1)** **(1)** **(1)** **(1)** **(1)**	**5**
18(c)(i)	All data points are close to the straight line through origin **Or** Best fit straight line goes through origin This consistent with Stokes' Law. Stokes' Law implies laminar flow (for the spheres).	 **(1)** **(1)** **(1)**	**3**
18(c)(ii)	Determines gradient of graph Uses large triangle. $k = 5.8$ to $6.2\text{ m}^{-1}\text{s}^{-1}$	**(1)** **(1)** **(1)**	**3**
18(c)(iii)	Use of $k = \frac{(\rho_g - \rho_s)g}{18\eta}$ $\eta = 99$ Pa s (allow ecf from (c)(ii)) <u>Example of calculation</u> $\eta = \frac{(\rho_g - \rho_s)g}{18k} = \frac{(2.52 - 1.43)\times 10^3\text{ kg m}^{-3}\times 9.81\text{N kg}^{-1}}{18 \times 6\text{ m}^{-1}\text{s}^{-1}} = 99.0\text{ Pa s}$	**(1)** **(1)**	**2**
	Total for question 18		**15**

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