Pearson Edexcel

Mark Scheme (Results)

October 2022

Pearson Edexcel International Advanced Subsidiary Level in Physics (WPH11)

Unit 1: 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.

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 may score full marks.

4.2 Some working is expected for full marks to be scored in a ‘show that’ question or an extended calculation question.

4.3 If a ‘show that’ question is worth 2 marks, then both marks will be available for a reverse working. If the question is worth 3 marks then only 2 marks will be available.

4.4 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.

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

5. Quality of Written Expression

5.1 Questions that asses the ability to show a coherent and logically structured answer are marked with an asterisk.

5.2 Marks are awarded for indicative content and for how the answer is structured.

5.3 Linkage between ideas, and fully-sustained reasoning is expected.

Question Number	Answer	Mark
1	**B is the correct answer** A is incorrect because acceleration is rate of change of velocity. C is incorrect because speed is the magnitude of velocity. D is incorrect because time taken is the x-axis variable	1
2	**C is the correct answer** A is incorrect because energy is not a vector B is incorrect because mass is not a vector D is incorrect because power is not a vector	1
3	**C is the correct answer** A is incorrect because Stokes' law does not apply to all spheres B is incorrect because Stokes' law does not apply to all spheres and applies at all viscosities D is incorrect because Stokes' law applies at all viscosities	1
4	**A is the correct answer** B is incorrect because the gradient is zero except at one point. C is incorrect because the gradient begins negative and becomes positive. D is incorrect because the positive and negative gradients are constant except at one point.	1
5	**C is the correct answer** A is incorrect because Young modulus is not the breaking stress of a material B is incorrect because Young modulus is not the density of a material. D is incorrect because Young modulus is not the elastic limit of a material	1
6	**B is the correct answer** A is incorrect because P is spurious and R is not included C is incorrect because Q is not included D is incorrect because R is not included	1
7	**C is the correct answer** A & B are incorrect because the vectors have not been added D is incorrect because the resultant is in the wrong direction	1
8	**C is the correct answer** A is incorrect because the extension is wrong and the force has been neglected B is incorrect because the force has been neglected, or the extension is wrong D is incorrect because the extension has been neglected	1
9	**A is the correct answer** B is incorrect because the electron is lighter than the proton C is incorrect because the electron is lighter than the proton D is incorrect because the velocity is not inversely proportional to mass	1
10	**C is the correct answer** A is incorrect because it gives 48% of only the power output. B is incorrect because it gives is 52% of the power output. D is incorrect because it gives is the total power input.	1
	Total for Section A	**10**

Question Number	Answer		Mark
11(a)	The (vector) sum of all forces (acting on an object) **Or** The single force that would have the same effect as all the other forces acting together [Treat "net force" as synonym for "resultant force", so no mark]	**(1)**	**1**
11(b)	Use of $F = m\,a$ [allow 3.1 kN or 5.5 kN (0.41 or 0.73 (m s^{-2}) respectively)] $a = 3.2 \times 10^{-1}$ m s^{-2} <u>Example of calculation</u> $(5.5 - 3.1) \times 10^3$ N $= 7.5 \times 10^3$ kg $\times a$ $a = 2.4 \times 10^3$ N $\div 7.5 \times 10^3$ kg $= 0.32$ m s^{-2}	**(1)** **(1)**	**2**
11(c)	Use of $P = W/t$ **and** $\Delta W = F\,\Delta x$ [allow $P = F\,v$] [allow 2.4 kN or 3.1 kN (1.2×10^4 or 1.5×10^4 (W) respectively)] $P = 2.6 \times 10^4$ W [or J s^{-1}] <u>Example of calculation</u> $P = W/t = F\,\Delta x/t = F\,v$ $= 5.5 \times 10^3$ N $\times 4.8$ m $s^{-1} = 2.64 \times 10^4$ W	**(1)** **(1)**	**2**
	Total for question 11		**5**

Question Number	Answer		Mark
12(a)	Use of $\sigma = F / A$ $\sigma = 3.8 \times 10^8$ Pa [accept N m^{-2}] **Or** $F_b = 170$ N **Or** $A_{min} = 3.6 \times 10^{-7}$ m^2 Valid comparison in consistent units and conclusion <u>Example of calculation</u> $\sigma = 150$ N $\div 3.97 \times 10^{-7}$ $m^2 = 3.78 \times 10^8$ Pa $3.78 < 4.20$ ∴ will not break	**(1)** **(1)** **(1)**	 **3**
12(b)(i)	Determine gradient of straight line section [straight line ends at 5 mm] [$\Delta x \geq 3$ mm for gradient][Allow use of tangent at origin] $k = 1.30 \times 10^4$ (N m^{-1}) [acceptable range to be determined at pre-stand] [1.27 to 1.33][need to see third s.f.] <u>Example of calculation</u> gradient = 60 / 4.6 = 13.0 gradient = k / N mm^{-1} $k = 13.0$ N $mm^{-1} = 1.30 \times 10^4$ N m^{-1}	**(1)** **(1)**	 **2**
12(b)(ii)	Use of $k = EA/x$ $E = 1.3 \times 10^{11}$ Pa [or N m^{-2}](ecf from (b)(i))[their (b)(i) $\times 1.01 \times 10^7$ + unit] <u>Example of calculation</u> $E = k\,x / A$ $E = 1.3 \times 10^4$ N $m^{-1} \times 4.00 \div 3.97 \times 10^{-7}$ m^2 $E = 1.3 \times 10^{11}$ Pa	**(1)** **(1)**	 **2**
	Total for question 12		**7**

Question Number	Answer		Mark
13(a)	Moments due to force on wheel and force on handle must be equal (magnitude about any point) Moment is force times (perpendicular) distance [accept "$F\ x$" but no other symbols unless in question or defined by candidate] [Accept for MP1 and MP2 Force × (perpendicular) distance must be same for both moments] Handle is futher from centre of gravity than wheel (so less force for equal moment) [NB independent mark]	**(1)** **(1)** **(1)**	**3**
13(b)	Uses weight = 400 N **Or** Uses x and $(1.5 - x)$ Use of moment = Fx about a stated point [accept pivot point clearly indicated on diagram] Use of principle of moments $x = 0.3$ m <u>Example calculation</u> Weight = 320 + 80 = 400 N Taking moments about line of action of 320 N force 400 N × x = 80 N × 1.5 m x = 120 Nm ÷ 400 N = 0.30 m	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 13		**7**

Question Number	Answer		Mark
14(a)	Use of upthrust = weight of fluid displaced Use of $\rho = m / V$ [accept use to calculate density of balloon, 0.184 (kg m^{-3})] [Correct use of $\rho_{air}gV$ to find resultant can score MP1 and MP2] Use of $W = mg$ Resultant force = 0.5 N <u>Example of calculation</u> Upthrust $U = 0.05\ \text{m}^3 \times 1.20\ \text{kg m}^{-3} \times 9.81\text{N kg}^{-1} = 0.589\ \text{N}$ Weight $W = 9.20 \times 10^{-3}\ \text{kg} \times 9.81\text{N kg}^{-1} = 0.090\ \text{N}$ Resultant force = $U - W = 0.589\ \text{N} - 0.090\ \text{N} = 0.498\ \text{N}$	**(1)** **(1)** **(1)** **(1)**	**4**

14(b)*	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

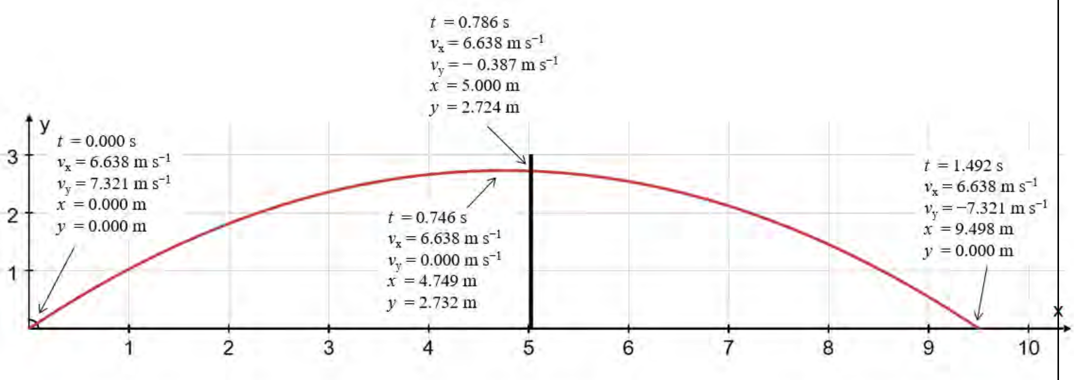
Indicative content:

[Allow "net force" as synonym for "resultant force", accept U, W for upthrust and weight]

- Initially there is a resultant upward force
  Or
  Upthrust is greater than weight and initially there is no air resistance [accept "drag"]
- Balloon accelerates (upwards)
  Or
  Balloon moves (up) with increasing velocity/speed
- (Downward) air resistance force, (initially zero) increases as velocity/speed increases. (U and W are constant.)
- Resultant (upward) force decreases so acceleration decreases
- (Eventually) resultant force is zero
  Or
  (Eventually) upthrust = weight + drag
  Or
  (Eventually) the forces (on the balloon) are balanced
- Balloon moves continues to move (upwards) at constant velocity
  Or
  balloon moves (upwards) with terminal velocity/speed

Mark: **6**

	Total for question 14	**10**

Question Number	Answer		Mark
15(a)	Use of correct trigonometry to calculate horizontal component [9.7 cos 49° or 9.7 sin 41° seen] Use of $s = u\,t + ½\,a\,t^2$ with $a = 0$ [*i.e.* use of $s = v\,t$] $t = 0.79$ (s) [NB reverse argument scores 2 marks (Rule 4.2)] <u>Example of calculation</u> $v_H = 9.70 \text{ m s}^{-1} \times \cos 49° = 6.36 \text{ m s}^{-1}$ $t = 5.00 \text{ m} \div 6.36 \text{ m s}^{-1} = 0.786 \text{ s}$	(1) (1) (1)	3
15(b)	Use of correct trigonometry to calculate vertical component [9.7 sin 49° or 9.7 cos 41° seen] Use of $s = u\,t + ½\,a\,t^2$ $s = 2.7$ m (ecf from (a)) ["show that" value also gives 2.72 m] Correct conclusion from valid comparison using student's calculated value **Or** Use of $v^2 = u^2 + 2\,a\,s$ Max height = 2.7 m [no ecf] Correct conclusion from valid comparison using student's calculated value [allow any valid *suvat* method, allow ecf if method involves t from (a)] <u>Example of calculation</u> $v_V = 9.70 \text{ m s}^{-1} \times \sin 49° = 7.32 \text{ m s}^{-1}$ $s = 7.32 \text{m s}^{-1} \times 0.79 \text{ s} - 0.5 \times 9.81 \text{ m s}^{-2} \times (0.79 \text{ s})^2 = 2.72 \text{ m}$ 2.72 m < 3.00 m so ball does not go over the wall [Significant moments …  	(1) (1) (1) (1) (1) (1) (1)	4
	Total for question 15		**7**

<table>
<tr><th>Question Number</th><th>Answer</th><th></th><th>Mark</th></tr>
<tr><td>16(a)</td><td>Sum of momenta before (collision) = sum of momenta after (collision)
Or
Total momentum before (a collision) = total momentum after (a collision)
Or
Total momentum remains constant
Or
The momentum of a system remains constant

Provided no external/unbalanced/resultant force acts (on the system)
Or
in a closed/isolated system</td><td>(1)

(1)</td><td>2</td></tr>
<tr><td>16(b)</td><td>Use of $p = m v$

Momentum before collision = 810 N s and after collision = 780 N s
Or Expected velocity = 6.5 m s^{-1}

Correct conclusion based on comparison of candidate's momenta/speeds

<u>Example of calculation</u>
Momentum before collision:
65 kg × 5.5 m s^{-1} + 60 kg × 7.5 m s^{-1} = 807.5 N s
Momentum after collision:
(65 + 60) kg × 6.2 m s^{-1} = 775.0 N s
775 ≠ 808 ∴ momentum not conserved</td><td>(1)

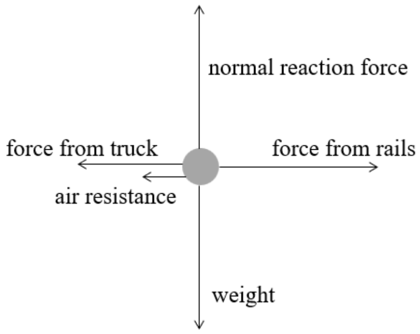
(1)

(1)</td><td>3</td></tr>
<tr><td>16(c)</td><td><u>Forces</u> acted between skaters (during the collision)
Or
External forces [accept friction (between skates and ice)] act on the skaters (during the collision)

<u>Work</u> done (by forces) during the collision was not recovered
Or
<u>Work</u> done (by forces) during the collision was dissipated
Or
<u>Work</u> done (by forces) transfers (kinetic) energy to thermal energy [accept "heat"]</td><td>(1)

(1)</td><td>2</td></tr>
<tr><td></td><td>Total for question 16</td><td></td><td>7</td></tr>
</table>

Question Number	Answer		Mark
17(a)(i)	Use of $W = m\,g$ Use of Newton first law 6.9×10^{-8} (N) <u>Example of calculation</u> $W = 1.15 \times 10^{-8}$ kg $\times$ 9.81 N kg^{-1} = 1.13×10^{-7} N $D = W - U$ = 1.13×10^{-7} N $-$ 4.37×10^{-8} N = 6.91×10^{-8} N	**(1)** **(1)** **(1)**	**3**
17(a)(ii)	Use of $F = 6\,\pi\,\eta\,r\,v$ [allow diameter for radius] Terminal velocity = 5.7×10^{-3} m s^{-1} (ecf from (a)(i)) ["show that" value gives 5.73×10^{-3} m s^{-1}] <u>Example of calculation</u> $D = 6\pi \times 1.41 \times 10^{-3}$ Pa s $\times\ 4.6 \times 10^{-4}$ m $\times\ v = 6.91 \times 10^{-8}$ N $v = 6.91 \times 10^{-8}$ N $\div$ ($6\pi \times 1.41 \times 10^{-3}$ Pa s $\times\ 4.6 \times 10^{-4}$ m) $= 5.65 \times 10^{-3}$ m s^{-1}	**(1)** **(1)**	**2**
17(b)	Viscosity increases (with lower temperature) so <u>drag</u> force increases (for given velocity) **OR** Viscosity increases (with lower temperature) so (terminal) velocity slower for given <u>drag</u> force [allow reference to $F = 6\pi\,\eta\,\rho\,v$] Density increases (with increasing depth) so <u>upthrust</u> increases [ignore "upthrust is constant"] Weight remains constant [do not accept "mass"] Terminal velocity reduces (with increasing depth) (dependent on MP1 or MP2) [accept "constant" velocity]	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 17		**9**

Question Number	Answer		Mark
18(a)	Force from truck to the left [accept 1.2×10^5 (N)] Air resistance to the left [accept 3.0×10^4 (N)][do not accept "viscous drag"] Force from rails to the right [accept 1.5×10^5 (N)] [withhold one mark if more forces than three][if magnitudes used ignore names of forces] Total length of arrows towards the left equals length of arrow to the right [to within 2 mm using measuring tool][dependent on any three horizontal forces, do not check unless lengths look close by eye] 	(1) (1) (1) (1)	4
18(b)	A Newton's third law pair of forces • Forces of equal magnitude that act in opposite directions [do not accept "equal and opposite reaction"][accept act for equal times] • Same type of force • (Acting on) different bodies These two forces both act on the engine [accept "on the same body"] One force is gravitational [do not accept "weight"]and the other is a contact force	(1) (1) (1) (1) (1)	5
	Total for question 18		**9**

Question Number	Answer		Mark
19(a)	Use of $\Delta W = F\,\Delta x$ [allow any dimensionally correct variation, *e.g.* involving trig] $\Delta W = 3.2 \times 10^4$ (J) [do not allow if cos 4° used in MP1, gives 3.217].] <u>Example of calculation</u> $\Delta W = 150\text{ N} \times 215\text{ m} = 3.23 \times 10^4\text{ J}$	(1) (1)	2
19(b)(i)	Use of correct trigonometry to calculate Δh **Or** Use of correct trigonometry to calculate component of g along slope, [61.6 (N)] Use of $\Delta E_{grav} = m\,g\,\Delta h$ [$\Delta E_{grav} = 90\text{ kg} \times 9.81 \times 215\text{ m} \times \sin 4.0°$ scores MP1&2] Total work done = work done against gravity + work done against air resistance Work against air resistance = 2.0×10^4 J (allow ecf from (a)) ["show that" value gives 1.68×10^4 J] <u>Example of calculation</u> $\Delta h = 215\text{ m} \times \sin 4.0° = 15.0\text{ m}$ $\Delta E_{grav} = 90\text{ kg} \times 9.81 \times 15.0 = 1.32 \times 10^4\text{ J}$ $W = 3.20 \times 10^4\text{ J} - 1.32 \times 10^4\text{ J} = 1.88 \times 10^4\text{ J}$	(1) (1) (1) (1)	4
19(b)(ii)	Force of gravity and air resistance are the only significant forces acting (to oppose the motion of the bicycle) **Or** Frictional forces (in the bearings of the bicycle) are negligible [accept zero, do not accept friction between bicycle and slope/ground] **Or** Work done against frictional forces (in the bearings of the bicycle) is negligible [accept zero]	(1)	1
19(c)	No work done against (force of) gravity **Or** All work done against air resistance **Or** No backward force due to gravity so resultant force acts Speed increases [MP2 dependent on MP1]	(1) (1)	2
	Total for question 19		**9**

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