Pearson Edexcel

Mark Scheme (Final)

Summer 2023

Pearson Edexcel International Advanced Subsidiary Level In Physics (WPH11)
Paper 01
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 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.

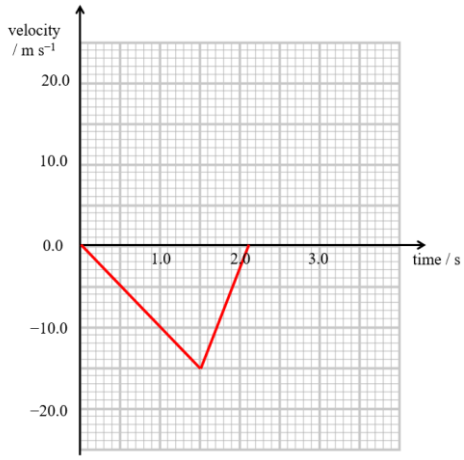
6.3 A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale e.g. multiples of 3, 7 etc.

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	**D is the correct answer** A is incorrect because efficiency is not a vector quantity B is incorrect because energy is not a vector quantity C is incorrect because power is not a vector quantity	**1**
2	**B is the correct answer** A is incorrect because the force is not acting in the direction of motion D is incorrect because tan 40° does not give parallel component of force C is incorrect because sin 40° does not give parallel component of force	**1**
3	**C is the correct answer** A is incorrect because shorter wire gives less extension B is incorrect because shorter and thicker wire gives less extension D is incorrect because thicker wire gives less extension	**1**
4	**B is the correct answer** Ais incorrect because area under graph is not a rectangle B is incorrect because work done is not the gradient of the graph C is incorrect because work done is not the gradient^{-1} of the graph	**1**
5	**A is the correct answer** B is incorrect because N3 pairs must have the same magnitude C is incorrect because N3 pairs must act at the same time D is incorrect because N3 pairs must be of the same type	**1**
6	**B is the correct answer** A is incorrect because the gradient gives a quarter of the acceleration C is incorrect because the gradient gives the wrong units D is incorrect because the gradient gives the wrong units	**1**
7	**D is the correct answer** A is incorrect because 15 is not the time taken B is incorrect because 2 ×15 is not the time taken C is incorrect because the displacement has not been doubled	**1**
8	**C is the correct answer** Because KE gained is GPE lost and the height lost is 20 m × sin 23°	**1**
9	**B is the correct answer** A is incorrect because viscosity decreases C is incorrect because viscosity decreases D is incorrect because weight of the ball bearing is constant	**1**
10	**D is the correct answer** A is incorrect because it would give a result in mm N^{-1} B is incorrect because two such springs in series would give an extension of 60 mm for a tension of 45 N, not 15 mm C is incorrect because it would give a result in mm N^{-1}	**1**

Question Number	Answer	Mark
11	Use of $v^2 = u^2 + 2\,a\,s$ with $u = 0$ **(1)** Substitutes $a = 0.38\,g$ **(1)** $\frac{v_M}{v_E} = 0.62$ **(1)** Example calculation $v_M{}^2 = 0 + 2 \times 0.38\,g\,\,s$ $v_E{}^2 = 0 + 2 \times g\,\,s$ $\left(\frac{v_M}{v_E}\right)^2 = \frac{0.38gs}{gs} = 0.38$ $\frac{v_M}{v_E} = \sqrt{0.38} = 0.62$	**3**
	Total for question 11	**3**

Question Number	Answer	Mark
12(a)(i)	(Initial) gradient = 0 **Or** Tangent horizontal (at $t = 0$) **(1)**	**1**
12(a)(ii)	**EITHER** Draws tangent at (1.5, 0.0) **(1)** (−)14 ± 1 m s^{-1} by graphical method **(1)** **OR** *suvat* method using quantities read from the graph and/or $a = \pm g$. **(1)** Correct answer from *suvat* calculation **(1)**	**2**
12(b)	Straight line from 0 to (1.5, − [magnitude from (a)(ii)]) **(1)** Second straight line from end of first line to (2.1, 0.0) **(1)** [Ignore lines beyond 2.1 s] 	**2**
	Total for question 12	**5**

Question Number	Answer	Mark
13(a)	Use of $E_k = ½ m v^2$ **(1)** $E_k = 2.1 \times 10^9$ (J) **(1)** Example calculation $E_k = 0.5 \times 7.2 \times 10^5$ kg $\times$ (76 m s^{-1})^2 = 2.08×10^9 J	**2**
13(b)	Use of $P = W / t$ **(1)** $D = 8.0 \times 10^8$ J (ecf from (a)) **(1)** Example calculation $W = 16 \times 10^6$ W $\times$ 180 s = 2.9×10^9 J $D = 2.9 \times 10^9$ J – 2.1×10^9 J = 8.0×10^8 J	**2**
	Total for question 13	**4**

Question Number	Answer	Mark
14	Resolves horizontal and vertical component of velocity **(1)** Use of $s = u t + ½ a t^2$ with $a = -g$ and $u = u_v$ **(1)** Use of $s = u t + ½ a t^2$ with $a = 0$ and $u = u_h$ **(1)** Horizontal distance = 130 m **(1)** Example calculation $u_v = 37$ m s^{-1} $\times$ sin 53° = 29.5 m s^{-1} $t = 2 \times 29.5$ m s^{-1} $\div$ 9.81 = 6.02 s $u_h = 37$ m s^{-1} $\times$ cos 53° = 22.3 m s^{-1} $s_h = 22.3$ m s^{-1} $\times$ 6.02 s = 134.1 m	**4**
	Total for question 14	**4**

Question Number	Answer		Mark
15(a)	Total momentum is conserved (because no external forces act) **Or** Total momentum before is equal to total momentum after (because no external forces act) **Or** Momentum of system is conserved (because no external forces act)	**(1)**	
	Total/system/initial momentum is zero	**(1)**	
	(Final momentum of machine is not zero because) final ball momentum is not zero **Or** Machine and ball have (equal but) opposite momenta	**(1)**	**3**
15(b)	Use of $p = mv$	**(1)**	
	Use of conservation of momentum	**(1)**	
	Velocity of machine = (−)0.087 m s^{-1}	**(1)**	**3**
	Example calculation 2.9 kg × v + 0.056 kg × 4.5 m s^{-1} = 0 v = −0.252 m kg s^{-1} ÷ 2.9 kg = −0.0869 m s^{-1}		
	Total for question 15		**6**

Question Number	Answer	Mark
16(a)	Flow (around sphere must be) laminar **Or** Flow (around sphere is) not turbulent **(1)**	**1**
16(b)(i)	Use of upthrust = weight of displaced fluid **(1)** $U = 5.2 \times 10^{-7}$ (N) **(1)** Example calculation $U = 5.3 \times 10^{-11}\ m^3 \times 998\ kg\ m^{-3} \times 9.81\ N\ kg^{-1}$ $= 5.19 \times 10^{-7}$ N	**2**
16(b)(ii)	Use of $V = \frac{4}{3}\pi r^3$ **(1)** Use of $F = 6\pi\eta r v$ **(1)** $F = 1.5 \times 10^{-7}$ N **Or** Required $v = 0.12\ m\ s^{-1}$ **Or** Required $V = 2.4 \times 10^{-9}\ m^3$ **Or** Required $r = 8.3 \times 10^{-4}$ m **and** $r = 2.3 \times 10^{-4}$ m **Or** Required $\eta = 3.4 \times 10^{-3}$ Pa s **(1)** Valid conclusion by comparison of relevant student values (ecf from (b)(i)) **(1)** Example calculation $5.3 \times 10^{-11}\ m^3 = \frac{4}{3}\pi r^3$ $r = \sqrt[3]{\frac{3 \times 5.3 \times 10^{-11}\ m^3}{4\pi}} = 2.33 \times 10^{-4}$ m If Stokes' law applies, $F = U$ $F = 6\pi \times 9.5 \times 10^{-4}\ Pa\ s \times 2.33 \times 10^{-4}\ m \times 3.50 \times 10^{-2}\ m\ s^{-1}$ $= 1.46 \times 10^{-7}\ N \neq 5.19 \times 10^{-7}\ N$ $\therefore$ Stokes' law does not apply	**4**
	Total for question 16	**7**

Question Number	Answer		Mark
17(a)(i)	Equates horizontal component with force from current	**(1)**	
	F = 480 (N)	**(1)**	**2**
	Example calculation F sin 33° = 260 N F = 260 N ÷ sin 33° = 477 N		
17(a)(ii)	Resolves vertical component of F	**(1)**	
	Equates vertical forces	**(1)**	
	Weight of buoy = 2500 N (ecf from (a)(i))	**(1)**	**3**
	Example calculation 477 N cos 33° = 400 N 400 N + Weight of buoy = 2.9×10^3 N Weight of buoy = 2900 N − 400 N = 2500 N		
17(b)	**EITHER** Horizontal component of F increases (to maintain equilibrium) **and** Vertical component of F remains the same (because vertical forces do not change, upthrust and weight are constant)	**(1)**	
	$F^2 = F_h^2 + F_v^2$ so F increases [dependent on MP1]	**(1)**	
	tan $\theta = F_h/F_v$ so θ increases [dependent on MP1]	**(1)**	
	OR Horizontal component of F increases (to maintain equilibrium) **and** Vertical component of F remains the same (because vertical forces do not change, upthrust and weight are constant)	**(1)**	
	$F^2 = F_h^2 + F_v^2$ so F increases [dependent on MP1] **Or** tan $\theta = F_h/F_v$ so θ increases [dependent on MP1]	**(1)**	
	F cos θ is constant so increase in either F or θ implies an increase in the other [dependent on MP2]	**(1)**	**3**
	Total for question 17		**8**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>*18</td><td>
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.

<table>
<tr><th>IC points</th><th>IC mark</th><th>Max linkage mark available</th><th>Max final mark</th></tr>
<tr><td>6</td><td>4</td><td>2</td><td>6</td></tr>
<tr><td>5</td><td>3</td><td>2</td><td>5</td></tr>
<tr><td>4</td><td>3</td><td>1</td><td>4</td></tr>
<tr><td>3</td><td>2</td><td>1</td><td>3</td></tr>
<tr><td>2</td><td>2</td><td>0</td><td>2</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td></tr>
</table>
<table>
<tr><th></th><th>Marks</th></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table>
Indicative content:

IC1 Balloon exerts a (backwards) force on the air

IC2 By N3 the air exerts an opposite (forwards) force on balloon

IC3 The forward force on the balloon is greater than resistive forces

IC4 By N2 the resultant force causes acceleration

IC5 As speed increases forces change until resistive force equals forward force

IC6 By N1 resultant force equals zero so acceleration equals zero (at maximum speed)
</td><td>6</td></tr>
<tr><td></td><td>Total for question 18</td><td>6</td></tr>
</table>

Question Number	Answer	Mark
19(a)	Use of $\Delta W = F\,\Delta x$ **or** $\Delta E_{grav} = mg\Delta h$ **(1)** Use of $P = W / t$ **(1)** Use of efficiency = useful power output / total power input **Or** Use of efficiency = useful energy output / total energy input **(1)** Total power input = 2.0×10^4 W **(1)** <u>Example of calculation</u> $\Delta W = 4.4 \times 10^4 \times 15$ m $= 6.6 \times 10^5$ J Output power = 6.6×10^5 J ÷ 70 s = 9.4×10^3 W Efficiency = $\frac{9.4\times10^3\ \text{W}}{\text{Total power input}} = 0.47$ Total power input = $\frac{9.4 \times 10^3\ W}{0.47} = 2.0 \times 10^4$ W	**4**
19(b)(i)	Total clockwise must balance total anticlockwise moment (about tower) **Or** Net/resultant/total moment (about tower) must be zero. **(1)** Total anticlockwise moment is due to counterweight **and** Total clockwise moment is due to sum of moment from beam and load **(1)** Increasing the distance of the load increases the (cw) moment (distance of CoG remains the same) **(1)** Distance of counterweight needs to be increased [dependent on MP3] **(1)**	**4**

19(b)(ii)	Use of moment = $F\,x$ **(1)** Position of centre of mass of beam identified **(1)** Use of principle of moments **(1)** Maximum distance of load = 15 m **Or, for load at 22 m …** CW moment =1.18×10^6 Nm **and** max ASW moment = 8.8×10^5 Nm **Or** Required distance of counterweight = 11 m **Or** Required counterweight = 1.5×10^5 N **Or** Maximum load = 3.0×10^4 N **Or** Required distance to CoG = 2.9 m **Or** Required weight of beam = 1.3×10^4 N **Or** Resultant moment = 3.0×10^5 Nm (cw) **(1)** Valid conclusion by comparison of relevant student values **(1)** <u>Example of calculation</u> For equilibrium: 3.0×10^4 N × 7.0 m + 4.4×10^4 N × x = 1.1×10^5 N × 8.0 m where x is the maximum distance of the load from the tower. x = (8.8×10^5 Nm − 2.1×10^5 Nm) ÷ 4.4×10^4 N = 6.7×10^5 Nm ÷ 4.4×10^4 N = 15.2 m 15.2 m < 22.0 m so crane would topple if load moved to end of beam	**5**
	Total for question 19	**13**

Question Number	Answer	Mark
20(a)	Stress (or strain) value at/beyond which a material/object undergoes a sudden or large plastic deformation **(1)**	**1**
20(b)(i)	The force/tension from/in the cable (on the actor) is greater than the weight of the actor **(1)** (So) there is a resultant/net/unbalanced force (upwards) **(1)**	**2**

20(b)(ii)	Use of $W = m\,g$ **(1)** Use of $\Sigma F = m\,a$ **(1)** Tension = 917 (N) **(1)** Example calculation $W = 77\text{ kg} \times 9.81\text{ N kg}^{-1} = 755\text{ N}$ $T - 755\text{ N} = 77\text{ kg} \times 2.1\text{ m s}^{-2}$ $T = 162\text{ N} + 755\text{ N} = 917\text{ N}$	**3**
20(b)(iii)	Use of $A = \pi r^2$ **(1)** Use of $\sigma = F \div A$ (ecf from (b)(ii)) **(1)** Allowed stress (15% yield stress of steel) = 3.8×10^7 Pa **and** $\sigma = 2.0 \times 10^7$ Pa **Or** $(15\%)^{-1}$ of cable stress = 1.3×10^8 Pa **Or** Max safe tension = 1.7×10^3 N **Or** Min safe diameter = 5.6×10^{-3} m **Or** Percentage of yield stress = 8% **Or** Max safe acceleration = 12.3 m s^{-2} **(1)** Valid conclusion by comparison of relevant student values **(1)** Example calculation $A = \frac{\pi d^2}{4} = \frac{\pi \times (7.6 \times 10^{-3}\text{m})^2}{4} = 4.54 \times 10^{-5}\text{ m}^2$ $\sigma = \frac{917\text{ N}}{4.54 \times 10^{-5}\text{m}^2} = 2.02 \times 10^7\text{ Pa}$ (show that value gives 2.03×10^7 Pa) $0.15 \times 2.5 \times 10^8\text{ Pa} = 3.75 \times 10^7\text{ Pa}$ $2.03 \times 10^7\text{ Pa} < 3.75 \times 10^7\text{ Pa}$ so it is safe.	**4**
20(c)	New cable has a greater cross sectional area, (but same breaking stress) so a greater force is required **(1)** Because new cable has smaller Young modulus, there is a greater strain for the same stress **(1)** So (at breaking stress) there will be a greater extension (because cables are the same length) [dependent on MP2] **Or** Smaller Young modulus implies greater extension (at breaking stress, because cables are the same length) [independent mark] **(1)** (And as) force and extension both increase, work done to break the new cable is greater than that for the original cable [independent mark] **(1)**	**4**
	Total for question 20	**14**

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