Pearson Edexcel

Mark Scheme (Results)

October 2020

Pearson Edexcel International Advanced Subsidiary/Advanced Level
In Physics (WPH011)
Paper 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.

For example:

(iii) Horizontal force of hinge on table top

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

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. 'resonance'
   - 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] **3**

Example of answer:

80 cm × 50 cm × 1.8 cm = 7200 cm^3

7200 cm^3 × 0.70 g cm^{-3} = 5040 g

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	**C is the correct answer** A is not the correct answer as joules are used for energy, a scalar B is not the correct answer as metres are used for distance, a scalar D is not the correct answer as watts are used for power, a scalar	**(1)**
2	**B is the correct answer** A is not the correct answer as *D* has corresponding force on the air C is not the correct answer as *W* has corresponding force on the planet and *D* has corresponding force on the air D is not the correct answer as *W* has corresponding force on the planet	**(1)**
3	**D is the correct answer** A is not the correct answer as would be difference in velocities of cars descending to ground from standing starts at P and Q and is out by factor of √2 B is not the correct answer as would be difference in velocities of cars descending to ground from standing starts at P and Q C is not the correct answer as is out by a factor of √2	**(1)**
4	**B is the correct answer** A is not the correct answer as this would give a final velocity of 80 m s^{-1} N C is not the correct answer as this would give a final velocity of 120 m s^{-1} N D is not the correct answer as this would give a final velocity of 20 m s^{-1} S	**(1)**
5	**D is the correct answer** A is not the correct answer as *R* has the wrong direction B is not the correct answer as *R* has the wrong direction C is not the correct answer as *R* is along the wrong diagonal	**(1)**
6	**D is the correct answer** A is not the correct answer as spurious factor of 100 and 0.68 multiplies B is not the correct answer as this gives a lower input than output C is not the correct answer as there is a spurious factor of 100	**(1)**
7	**B is the correct answer** A is not the correct answer as a velocity requires two measurements C is not the correct answer as a velocity requires two measurements D is not the correct answer as a velocity requires two measurements	**(1)**
8	**C is the correct answer** A is not the correct answer as $\sigma \div A$ does not give force B is not the correct answer as $\sigma \div A$ does not give force Δx squared D is not the correct answer as Δx squared	**(1)**
9	**B is the correct answer** A is not the correct answer as areas above and below time axis not equal C is not the correct answer as graph starts from zero D is not the correct answer as graph starts from zero	**(1)**

10	**C is the correct answer** A is not the correct answer as no indication in Q9 of extremely high velocity required to change displacement apparently instantly B is not the correct answer as lines straight, indicating no change in velocity D is not the correct answer as lines straight, indicating no change in velocity	**(1)**

Question Number	Answer		Mark
11(a)	• Use of Power = $\frac{\text{energy}}{\text{time}}$ • P = 72 (kW) <u>Example of calculation</u> $P = \frac{32 \times 10^6 \text{ J l}^{-1} \times 65 \text{ l}}{8 \text{ h} \times 3600 \text{ s}}$ = 72.2 kW	**(1)** **(1)**	**2**
11(b)	• Use of $\Delta W = F\Delta s$ • Use of power = $\frac{\text{energy}}{\text{time}}$ • Average power output of engine = 53 (kW) <u>Example of calculation</u> $W = 2.1 \times 10^3 \text{ N} \times 730 \times 10^3 \text{ m} = 1.53 \times 10^6 \text{ J}$ $P = \frac{2100 \text{ N} \times 730 \times 10^3 \text{ m}}{8 \text{ h} \times 3600 \text{ s}}$ = 53.2 kW	**(1)** **(1)** **(1)**	**3**
11(c)	• Use of efficiency = $\frac{\text{useful power output}}{\text{total power input}}$ • Efficiency = 0.74 or 74 % (ECF from (a) and (b)) <u>Example of calculation</u> $E = \frac{53.2 \times 10^3 \text{ W}}{72.2 \times 10^3 \text{ W}}$ = 0.74	**(1)** **(1)**	**2**
	Total for question 11		**7**

Question Number	Answer	Mark
12(a)	• States that *W* is the weight of the rider (and unicycle) and *R* is the push/reaction force (from the ground) (1) • *R* and *W* are different types of force (1) **Or** *R* and *W* act on the same object **Or** *R* and *W* are not equal. • They are **not** a N3 pair of forces (1) MP3 conditional on MP2	**3**
12(b)	• The resultant force acting in the vertical direction is zero so the unicycle will remain at that height (1) **Or** The resultant force acting in the vertical direction is zero so zero acceleration in the vertical direction (1) • The unicycle moves at a constant (forward) speed because the resultant horizontal force is zero or horizontal forces are balanced (because forward frictional force balances backward drag forces)	**2**
	Total for question 12	**5**

Question Number	Answer		Mark
13(a)	• X is the force (or pull or tension) of the <u>wire</u> (on the flagpole) (accept tension in the wire) • Y is force (or reaction or push, ignore "normal") of the <u>hinge</u> (or <u>wall</u>) (on the flagpole). • Z is weight or force of gravity (of/on the flagpole)	(1) (1) (1)	**3**
13(b)	• Use of moment of a force = *Fx* • Use of the principle of moments • *T* = 323 (N) < 350 (N) so wire will not break **Or** Moment of weight about hinge = 88.3 (Nm) < 95.8 (Nm), max poss from wire **Or** Correct conclusion based on comparison of student's value with 350 N or 95.8 Nm MP3 depends on MP1 and MP2 being seen <u>Example of calculation</u> (15 kg × 9.81 N kg $^{-1}$ × 0.6 m) – (*T* sin 20° × ⅔ × 1.2 m) = 0 *T* = (15 kg × 9.81 N kg $^{-1}$ × 0.6 m) ÷ (0.8 m × sin 20°) = 88.29 Nm ÷ 0.2736 *T* = 322.7 N max available moment = 350 N × 0.8 m × sin 20° = 95.77 Nm > 88.29 Nm	(1) (1) (1)	**3**
	Total for question 13		**6**

Question Number	Answer	Mark
*14	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

Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points	Linkage marks available
6	4	2
5	3	2
4	3	1
3	2	1
2	2	0
1	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

Total marks awarded is the sum of marks for indicative content and the marks for structure and lines of reasoning

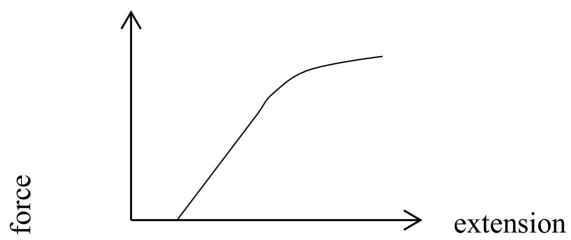
Indicative content

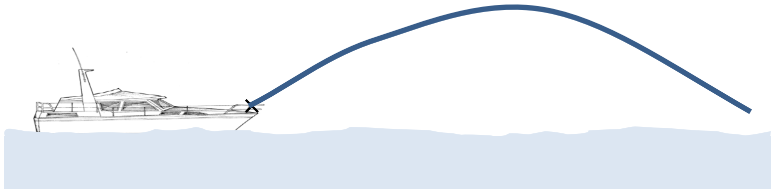
- Acceleration is maximum (or acceleration = g) initially
- As velocity increases the air resistance increases
- Resultant force decreases until it becomes zero and diver reaches terminal velocity
  Or
  (Eventually) forces balance and the diver reaches terminal velocity
- At t_1 the air resistance increases or is greater then the weight
- Skydiver decelerates or the resultant force is now upwards/negative
- Second terminal velocity is lower because air resistance = weight at a lower velocity.

Ignore mention of upthrust.

	Total for question 14	**6**

Question Number	Answer	Mark
15(a)(i)	• The sphere will be accelerating (in the oil) initially (1) **Or** Sphere needs time/distance to accelerate • The sphere falls a distance (through the oil) before reaching constant/terminal velocity (1) **Or** Sphere needs to reach terminal velocity before timing begins	**2**
15(a)(ii)	**Either** • Adding a rubber band enables more than one distance to be timed (for the sphere to fall) (1) • An average/mean value for the time/speed can then be calculated (1) **Or** • Can compare times/velocities for more than one distance (1) • To detemine whether terminal velocity achieved (1)	**2**
15(b)(i)	Weight of (solid) sphere (1)	**1**
15(b)(ii)	Weight of oil displaced (by the sphere) **Or** upthrust (1)	**1**
15(b)(iii)	Viscous drag or viscous force (1)	**1**
15(b)(iv)	The temperature (of the oil) was greater than 24 °C/had increased - do not accept temperature of the room. **Or** the measured diameter of the sphere was less than true value **Or** the time measured (to determine the terminal velocity) was less than true value (1) **Or** the meaured distance between bands was greater than true value Do not accept sphere too close to the edge of cylinder or the flow around the sphere is turbulent or densities used were incorrect	**1**
	Total for question 15	**8**

Question Number	Answer		Mark
16(a)(i)	• Point K is the limit of proportionality **Or** beyond K, the force is no longer proportional to the extension **Or** Hooke's Law no longer obeyed **Or** before K the force is proportional to the extension **Or** Hooke's Law obeyed	(1)	**1**
16(a)(ii)	• Beyond point L the spring will behave plastically • Beyond L, the spring will no longer return to its original length (once the deforming force is removed)/spring will be permanently deformed **Or** below L, the spring will return to its original length (once the deforming force is removed)	(1) (1)	**2**
16(a)(iii)	• The spring constant/stiffness (not Young modulus) is smaller or has changed (do not allow greater stiffness)	(1)	**1**
16(b)	• Same shape graph but starting from an extension > 0 	(1)	**1**
16(c)	• Same force acts through both springs • Both springs have the same extension • In this combination the (total) extension will be doubled **Or** Force required for same (total) extension is halved • Reference to $F = k\Delta x$ e.g. k is proportional to $1/\Delta x$ so k is halved	(1) (1) (1) (1)	**4**
	Total for question 16		**9**

Question Number	Answer	Mark
17(a)(i)	• Initial angle at approximately 30° (by eye) with approximately parabolic shape. **(1)** 	**1**
17(a)(ii)	• Use of $v^2 = u^2 + 2as$ (with u and v the correct way around) **(1)** **Or** Loss of KE = gain of GPE (i.e. $u_V^2 = 2gh$) • See u sin 30° for initial vertical component of velocity u_V **(1)** • $u = 57$ (m s^{-1}) **(1)** <u>Example of calculation</u> $0^2 = (u \sin 30°)^2 + (2\times -9.81\ \text{N kg}^{-1} \times 42\ \text{m})$ $u_V = u \sin 30° = 28.7\ \text{m s}^{-1}$ $u = 57.4\ \text{m s}^{-1}$	**3**
17(a)(iii)	• Use of trig to determine the horizontal component of the initial velocity **(1)** <u>METHOD 1</u> • Use of suitable equation(s) of motion to determine the time of flight **(1)** • Use of $v = s/t$ to determine the horizontal distance travelled by the flare **(1)** • Comparison of distance to boat to distance flare travelled with conclusion consistent with student's value **(1)** e.g. 7.9 km is less than 8.0 km so the flare can be seen. <u>Example of calculation</u> $0 = (57.4\ \text{m s}^{-1} \times \sin 30° \times t) - (0.5\times 9.81\ \text{N kg}^{-1}\times t^2)$ $t = 5.85$ s $s = (57.4\ \text{m s}^{-1}\times \cos 30° \times 5.85\ \text{s}) = 49.7\ \text{m s}^{-1} \times 5.85\ \text{s} = 291\ \text{m}$	**4**

	METHOD 2 • Use of $v = s/t$ to determine the time to reach 200 m • Use of $s = ut + ½at^2$ to find height reached after 200 m travel • Explains conclusion consistent with student's value e.g. flare above the sea and in range so visible	
17(b)	• Air resistance/drag is ignored **Or** air resistance/drag is **(**presumed to be) negligible **(1)**	**1**
	Total for question 17	**9**

Question Number	Answer	Mark
18(a)	• Use of $p = mv$ (1) • Use of conservation of momentum (1) • $v = 6.3\ \text{m s}^{-1}$ (1) <u>Example of calculation</u> Before: $p_{\text{mallet}} = 0.17\ \text{kg} \times 1.6\ \text{m s}^{-1} = 0.272\ \text{kg m s}^{-1}$ After: $p_{\text{mallet}} = 0.17\ \text{kg} \times 0.3\ \text{m s}^{-1} = 0.051\ \text{kg m s}^{-1}$ $0.272\ \text{kg m s}^{-1} = 0.051\ \text{kg m s}^{-1} + (0.035\ \text{kg} \times v)$ $v = 6.3\ \text{m s}^{-1}$	**3**
18(b)	<u>METHOD 1</u> • Use of $E_k = ½mv^2$ (1) • Use of sin 30° to determine vertical height moved by disc (1) • Use of $E_{grav} = mgh$ (1) • Use of $W = Fd$ (1) • Use of conservation of energy e.g. $E_k = E_{grav} + W$ (1) • $F_F = 6.6$ N (1) <u>Example of calculation</u> $E_k = ½ \times 0.035\ \text{kg} \times (5.0\ \text{m s}^{-1})^2 = 0.44\ \text{J}$ $E_{grav} = 0.035\ \text{kg} \times 9.81\ \text{N kg}^{-1} \times 0.065\ \text{m} \times \sin 30° = 1.12 \times 10^{-2}\ \text{J}$ $0.44\ \text{J} = 1.12 \times 10^{-2}\ \text{J} + (F_F \times 0.065\ \text{m})$ $0.44\ \text{J} - 0.0112\ \text{J} = 0.43\ \text{J}$ $F_F = 6.56\ \text{N}$ <u>METHOD 2</u> • Use of $v^2 = u^2 + 2as$ to determine deceleration along ramp • $v = 0$ and a negative • Use of sin 30° to determine component of weight of disc down slope • Use of $\Sigma F = m\,a$ to determine resultant force along ramp • Subtraction of weight component from resultant force. • $F_F = 6.6$ N	**6**
	Total for question 18	**9**

<table>
<tr><th>Question Number</th><th>Answer</th><th></th><th>Mark</th></tr>
<tr><td>19(a)(i)</td><td>The distance between pylons Or length of cable Or the weight/mass/density of the cable/material</td><td>(1)</td><td>1</td></tr>
<tr><td>19(a)(ii)</td><td>See $Mg = 2T \sin \theta$ Or weight (or W or Mg) is proportional to $T \sin \theta$
as the sag increases, θ (or $\sin \theta$) increases (for a constant weight)
(as the sag increases) $\sin\theta$ increases hence T decreases</td><td>(1)
(1)
(1)</td><td>3</td></tr>
<tr><td>19(b)(i)</td><td>Use of region of graph 0 to 300 MPa to determine the gradient Or tangent from origin
$E_{steel} = 1.5 \times 10^{11}$ (Pa) to 1.8×10^{11} (Pa)
<u>Example of calculation</u>
$E_{steel} = \frac{200 \times 10^6 \ Pa}{0.0013} = 1.53 \times 10^{11}$ Pa</td><td>(1)
(1)</td><td>2</td></tr>
<tr><td>19(b)(ii)</td><td>Use of $\sigma = \frac{F}{A}$ to obtain the stress
stress = 73 MPa
<u>Example of calculations</u>
$F = 0.62 \text{ N m}^{-1} \times 270 \text{ m} = 167.4 \text{ N}$
$\sigma = \frac{0.62 \text{ N m}^{-1} \times 270 \text{ m}}{2.3 \times 10^{-6} \text{ m}^2}$
$\sigma = 72.8$ MPa</td><td>(1)
(1)</td><td>2</td></tr>
<tr><td>19(b)(iii)</td><td><u>METHOD 1</u>
Use of graph to obtain the strain in steel
Or use of Young Modulus
Use of $\varepsilon = \frac{\Delta e}{l}$ (for steel $\Delta e = 0.14$ m)
Comparison of the two extensions/strains
e.g. the extension/strain of aluminium is larger than that of steel, so steel is used to reduce the (total) extension/sag
Or
Comparison of two strains/extensions e.g. lower strain for steel so stiffness of cable increased to reduce (total) extension/sag</td><td>(1)
(1)
(1)</td><td>3</td></tr>
</table>

	<u>METHOD 2</u> • Use of $\varepsilon = \frac{\Delta e}{l}$ to find strain (for extension of 0.95 m) • Use of graph to obtain the stress in aluminium and steel. • Comparison of two stresses (e.g. greater stress required for steel) so stiffness of cable increased to reduce (total) extension/sag <u>Example of calculation</u> Read off strain (when stress is 70 MPa) on Steel graph (0.0005) For Steel, Δe = 0.0005 × 270 m = 0.14 m	
	Total for question 19	**11**

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