Pearson Edexcel

Mark Scheme (Results)

October 2019

Pearson Edexcel International Advanced 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) Horizontal force of hinge on table top

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. '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	**A is the correct answer** B is not correct as both the micro and centi columns are incorrect. C is not correct as the micro column is incorrect. D is not correct as the centi column is incorrect.	**(1)**
2	**B is the correct answer** A is not correct as they are the units for force. C is not correct as they are the units for momentum. D is not correct as they are the units for power.	**(1)**
3	**C is the correct answer** A is not correct as diameter is being used for radius. B is not correct as diameter is being used for radius. D is not correct as the anomalous point (1.36) has not been ignored.	**(1)**
4	**D is the correct answer** This is because the area under a stress-strain graph is the work done per unit volume, but the area under the other 3 graphs represents work done.	**(1)**
5	**B is the correct answer** This is because the horizontal component is calculated using the equation $v_{\mathrm{H}} = \sqrt{v^2 - v_{\mathrm{V}}^2} = \sqrt{0.5^2 - 0.3^2} = 0.4$	**(1)**
6	**C is the correct answer** This is because W_c should have been drawn in the centre of the cube.	**(1)**
7	**C is the correct answer** A is not correct as it ignores the weight of the table. B is a correct equation since $R_c = W_c$, but it is not an instance of the third law. D is a correct equation but it is not an instance of the third law.	**(1)**
8	**C is the correct answer** This is because the power needed is equal to the gravitational energy supplied per second (mgh) plus the kinetic energy given to the water per second ($\frac{1}{2}mv^2$).	**(1)**
9	**C is the correct answer** This is because $s=\frac{1}{2}gt^2$. So if in one unit of time the sphere has fallen one unit of distance, i.e. from image 1 to image 2, then in 2 units of time it will have fallen 4 units of distance, i.e. from image 1 to R.	**(1)**
10	**B is the correct answer** This is because the force is given by $F=kx$. So if k is doubled but x remains the same, F will be doubled.	**(1)**

Question Number	Answer		Mark
11	Horizontal force/component = $F\cos\theta$	(1)	
	Work done = $F_H \times s$ **Or** Work done = $F\cos\theta \times s$	(1)	
	As θ increases, $\cos\theta$ / F_H / $F\cos\theta$ decreases so work done decreases. **Or** As θ decreases, $\cos\theta$ / F_H / $F\cos\theta$ increases so work done increases.	(1)	**(3)**
	Total for question 11		**3**

Question Number	Answer		Mark
12(a)	Use of $(\Delta)E_{grav} = Fd$ **Or** Use of $E_k = (\Delta)E_{grav}$ **AND** Use of $v^2=u^2+2as$ with $a = -\frac{F}{m}$	(1)	
	Gradient = $\frac{mg}{F}$ **Or** $\frac{d}{h} = \frac{mg}{F}$	(1)	**(2)**
	<u>Example of calculation</u> $mgh = Fd$ $\frac{d}{h} = \frac{mg}{F}$		
12(b)	$u = \sqrt{2gh}$ (Do not allow if suvat used with $a=g$)	(1)	
	Use of $p = mv$	(1)	
	$m_1u = (m_1 + m_2)v$ (either seen or used) (Do not allow if there is an m_2u term unless $u=0$)	(1)	
	Some working leading to the correct expression **AND** statement that the student is correct.	(1)	**(4)**
	<u>Example of calculation</u> $mgh = \frac{1}{2}mv^2$ $v = \sqrt{2gh}$ $m\sqrt{2gh} = 2mv$ $v = \frac{\sqrt{2gh}}{2} = \sqrt{\frac{gh}{2}}$		
	Total for question 12		**6**

Question Number	Answer	Mark
13(a)	**<u>Method 1</u> – Calculate the vertical displacement at 102 m.** See (u_v =) 33sin28 **Or** 15 to 16 (m s^{-1}) **Or** (u_h =) 33cos28 **Or** 29 (m s^{-1}) (1) Use of v = s/t with s = 102 m for the time of flight needed **Or** Use of v = s/t with s = 10 m for the extra time of flight needed (1) Use of equation(s) to determine the vertical displacement at the time calculated (1) Vertical displacement = (–) 5.8 to 6.0 m (1) Comparison with required height **AND** height is insufficient (1) (Allow correct conclusion based on the calculated height) **<u>Method 2</u> – Calculate the horizontal displacement for a height of 4.5 m.** See (u_v =) 33sin28 **Or** 15 to 16 (m s^{-1}) **Or** (u_h =) 33cos28 **Or** 29 (m s^{-1}) (1) Use of vertical equation(s) with s = (−)4.5 m to determine the actual time of flight **Or** to determine the time beyond 92 m (1) Use of v = s/t to determine the range **Or** Use of v = s/t for the extra displacement beyond 92 m (1) Horizontal displacement = 98 to 101 m **Or** extra displacement = 7.7 to 7.9 m (1) Comparison with required displacement **AND** height is insufficient **Or** Comparison of extra displacement **AND** height is insufficient (1) (Allow correct conclusion based on the calculated distance) **<u>Method 3</u> – Calculate the actual time of flight and that needed for 102 m** See (u_v =) 33sin28 **Or** 15 to 16 (m s^{-1}) **Or** (u_h =) 33cos28 **Or** 29 (m s^{-1}) (1) Use of v = s/t with s = 102 m for the time of flight needed (1) Use of vertical equation(s) to determine the actual time of flight (1) Time of flight needed = 3.5 s **AND** actual time of flight = 3.4 s (1) Time needed > actual time **AND** height is insufficient (1) (Allow correct conclusion based on the calculated times) <u>Example of calculation</u> $u_v = (33\text{m s}^{-1})\sin 28° = 15.5\text{ m s}^{-1}$ $u_h = (33\text{ m s}^{-1})\cos 28° = 29.1\text{m s}^{-1}$ $t = \frac{102\text{ m}}{29.1\text{ m s}^{-1}}$ t = 3.50 s $s = (15.5\text{ m s}^{-1} \times 3.50\text{ s}) + (½ \times (-9.81\text{ N kg}^{-1}) \times (3.50\text{ s})^2)$ s = – 5.87 m	**(5)**

***13(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**

	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

Indicative content
With air resistance:
Vertical motion

- When moving up weight and (vertical component of) air resistance are acting.
  Or When moving up air resistance increases the resultant force.
- (When moving up,) downwards/vertical acceleration/deceleration increases
  Or upward velocity decreases more quickly.
- (So maximum) height is lower.

Horizontal motion

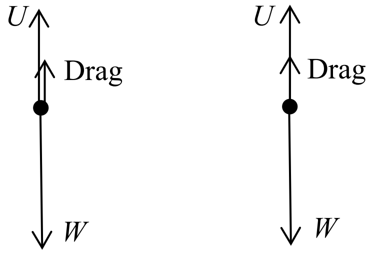
- There is a horizontal deceleration/force (due to air resistance).
- (So the average) horizontal velocity is lower.
- The (ball travels a) shorter (total) distance.

(6)

	Total for question 13	**11**

Question Number	Answer	Mark
14(a)(i)	(This moment) causes an anti-clockwise rotation/motion (about G) **Or** This moment is anti-clockwise (about G) (1) Returning/maintaining the boat to/in an upright/initial position **Or** Reducing the tilt of the boat **Or** opposing/balancing the moment caused by the wind (1)	**(2)**
14(a)(ii)	The distance *d* is reduced **Or** *W*/G moves to the right of *U*/X (1) The (anti-clockwise) moment is reduced **Or** The moment becomes/is clockwise (1) The boat would be less stable **Or** The boat will tilt further **Or** The boat could turn over (1)	**(3)**
14(b)(i)	When filled with water/ballast, the weight/mass (of the boat) increases (1) Upthrust equals the weight (of the boat) (because the boat is floating) **Or** Upthrust increases (because the boat is floating) (1) Boat moves downwards in the water **Or** The volume/amount of displaced water increases (1) Centre of gravity of displaced water is lower (1)	**(4)**
14(b)(ii)	Greater (surface) area of boat in contact with water **Or** greater cross-sectional area in water (in direction of travel) (1) There a greater resistance/drag/friction (on the boat). (1) (ignore references to greater risk of flooding)	**(2)**
	Total for question 14	**11**

Question Number	Answer	Mark
15(a)(i)	Place two or more rubber bands or markers (on the cylinder) (accept markers correctly placed and labelled on diagram) (1) The top band should be far enough below the surface for terminal velocity to have been reached **Or** have more than 2 markers and check velocity is constant. (1) Measure time for the sphere to fall a given distance (using the stopwatch) **and** measure distance fallen (using the metre rule) (1) **Either** Reference to repeated measurements and averaging (1) $(\text{terminal velocity} =) \dfrac{\text{distance between markers}}{\text{(average) time between markers}}$ (1) **Or** measure the times for different distances (1) (terminal velocity =) gradient of graph of distance against time (1)	**(5)**
15(a)(ii)	A larger sphere would have a greater (terminal) velocity (1) Weight is greater **Or** terminal velocity is proportional to r^2 **Or** takes more time to reach terminal velocity (1) The time of falling would be less (1) The (absolute) uncertainty in the time is the same **Or** Resolution of the stopwatch is the same **Or** Reaction time is the same (or they are a greater proportion of the (measured) time) (1)	**(4)**

15(b) (i)	Upthrust/U up (1) Drag/friction/D up (1) Weight/W/mg down (1) (−1 for each extra force over 3) (−1 if any arrow does not touch the dot) (−1 if any arrow is not close to vertical) (Accept single line up with two labelled arrow heads. Ignore the length of the arrows.) Examples:  	**(3)**
15(b) (ii)	Weight = (upthrust +) drag with indication that W=3.5×10^{-2} N (1) Use of upthrust = $\rho_l Vg$ (1) Use of drag = $6\pi r\eta v$ (1) η = 2.1 (Pa s) (1) <u>Example of calculation</u> $V = \frac{4}{3}\pi(4.8 \times 10^{-3}\text{ m})^3 = 4.63 \times 10^{-7}\text{ m}^3$ Upthrust = $1.1 \times 10^3\text{ kg m}^{-3} \times 4.63 \times 10^{-7}\text{ m}^3 \times 9.81\text{ N kg}^{-1} = 5.00 \times 10^{-3}\text{ N}$ $3.5 \times 10^{-2}\text{ N} = 5.0 \times 10^{-3}\text{ N} + 6\pi(4.8 \times 10^{-3}\text{ m} \times \eta \times 0.160\text{ m s}^{-1})$ η = 2.07 Pa s	**(4)**
	Total for question 15	**16**

Question Number	Answer		Mark
16(a)	Compares ≈40 (MPa) (compression) with ≈10 (MPa) (tension) Breaking/fracture/ultimate stress/force (much) greater under compression **Or** Breaking/fracture/ultimate stress is 40 MPa under compression, and 10 MPa under tension. **Or** Breaking/fracture/ultimate stress is 30 MPa greater under compression. (If no other mark scored, allow 1 mark for greater energy absorbed/stored under compression)	(1) (1)	**(2)**
16(b)	Breaking stress = 5.00 to 5.10 ($\times 10^8$ Pa) Use of $\sigma = F/A$ $F = 8.0/8.1 \times 10^5$ N <u>Example of calculation</u> $A = \pi \times (2.25 \times 10^{-2}\ \text{m})^2 = 1.59 \times 10^{-3}\ \text{m}^2$ $F = 1.59 \times 10^{-3}\ \text{m}^2 \times 5.05 \times 10^8\ \text{Pa} = 8.03 \times 10^5$ N	(1) (1) (1)	**(3)**
16(c)(i)	Concrete can withstand high(er) stress/force under compression **Or** Concrete is strong(er) under compression The concrete remains under compression when tensile force applied. **Or** Applied/tensile force first has to overcome the compression **Or** When tensile force applied, concrete is still under compression The steel/rods take (some of) the force/stress **Or** The force/stress causes deformation of the steel Steel can withstand a large(r) tensile force/stress **Or** Steel is strong(er) under tension **Or** Ultimate tensile stress of steel is large(r)	(1) (1) (1) (1)	**(4)**
16(c)(ii)	(When force removed) the rod will not return to its original length/shape **Or** The rod will be permanently/plastically deformed the concrete will not compress (as much) **Or** The compression force will be less/zero	 (1) (1)	**(2)**
	Total for question 16		**11**

Question Number	Answer	Mark
17(a)(i)	The graph is less steep **Or** The gradient is smaller **(1)**	**(1)**
17(a)(ii)	Use of $a = \frac{v-u}{t}$ **Or** Use of a = gradient **(1)** a_2 = 0.96 to 1.3 m s^{-2} **(1)** <u>Example of calculation</u> $a_2 = \frac{13.2 \text{ m s}^{-1} - 6.8 \text{ m s}^{-1}}{(10.5-4)\text{s}}$ = 0.98 m s^{-2}	**(2)**
17(a)(iii)	Velocity is large(r) (in higher gears) **(1)** so force (of the engine) will be smaller. **(1)**	**(2)**
17(b)(i)	Conversion of mph to m s^{-1} **(1)** Use of acceleration values for first and second gears only. **(1)** Use of a = $\frac{v-u}{t}$ to determine a time **(1)** total time = 13.0 to 14.0 s **(1)** <u>Example of calculation</u> Velocity conversion = $\frac{60 \text{ mph} \times 1600 \text{ m}}{3600}$ = 26.7 m s^{-1} 2.9 m s^{-2} = $\frac{18 \text{ m s}^{-1} - 0}{t_1}$ t_1 = 6.21 s 1.2 m s^{-2} = $\frac{26.7 \text{ m s}^{-1} - 18 \text{ m s}^{-1}}{t}$ t_2 = 7.22 s Total time = 6.21 s + 7.22 s = 13.4 s	**(4)**
17(b)(ii)	As velocity increases the air resistance increases **(1)** (When) frictional forces are equal to the (driving) force of engine/car **(1)** There is no resultant/net/unbalanced force **and** no acceleration **(1)**	**(3)**
	Total for question 17	**12**