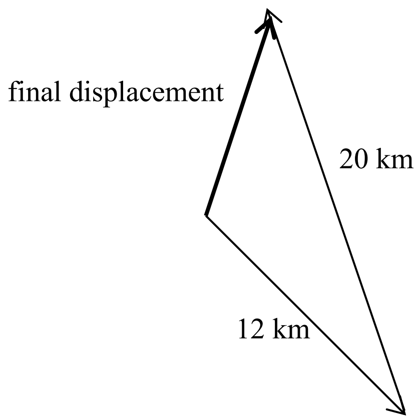
Mark Scheme (Results)

June 2019

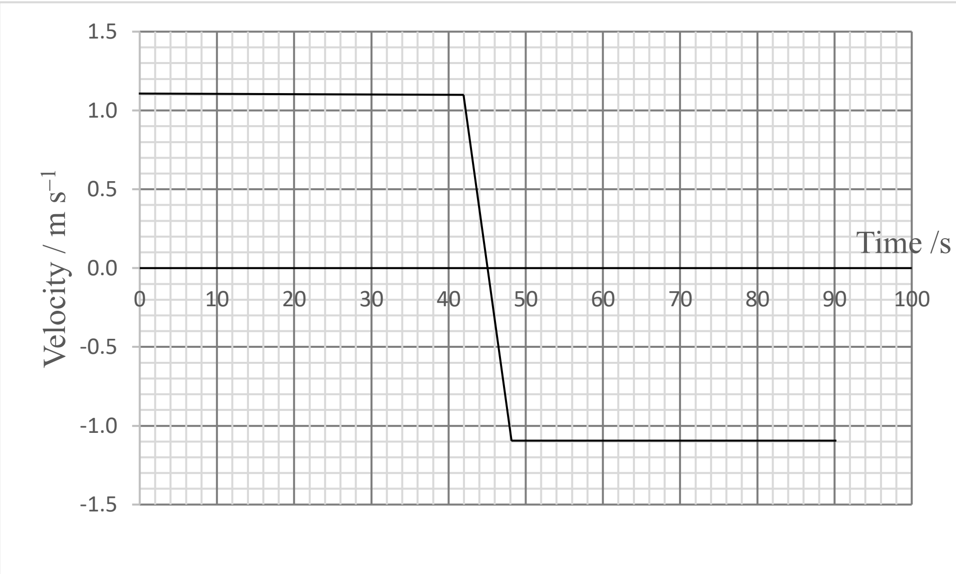
Pearson Edexcel International Advanced Subsidiary Level
In Physics (WPH11)
Paper 01 Mechanics and Materials

Question Number	Answer	Mark
1	**The only correct answer is D** because kg m^{-3} is the unit for density (scalar) **A** *is not the correct answer as m s^{-1} is the unit for velocity (vector) and speed (scalar)* **B** *is not the correct answer as m s^{-2} is the unit for acceleration (vector)* **C** *is not the correct answer as kg m s^{-2} is the unit for force (vector)*	**(1)**
2	**The only correct answer is C** as the velocity is changing (due to the direction changing) and N2 describes a resultant force (due to the gravitational force of the earth) causing a change in velocity **A** *is not the correct answer as the velocity is changing* **B** *is not the correct answer as the velocity is changing and N2 describes a changing velocity due to unbalanced forces* **D** *is not the correct answer as N2 describes a changing velocity due to unbalanced forces*	**(1)**
3	**The only correct answer is B** because Upthrust is equal to weight of sphere (2.5 N). Weight of displaced water if half sphere submerged = 2.5 N Weight of displaced water if all of sphere submerged = 5.0 N Total upwards force acting on sphere when completely submerged = 5.0 N Total downwards force on sphere if completely submerged (and stationary) = 5.0 N F must be equal to 2.5 N **A** *is not the correct answer as F = 2.5 N* **C** *is not the correct answer as F = 2.5 N* **D** *is not the correct answer as F = 2.5 N*	**(1)**
4	**The only correct answer is B** as $s = vt$ and $s = 1.2 \times 0.9$ **A** *is not the correct answer as* $s = vt$ *and* $s = 1.2 \times 0.9$ **C** *is not the correct answer as* $s = vt$ *and* $s = 1.2 \times 0.9$ **D** *is not the correct answer as* $s = vt$ *and* $s = 1.2 \times 0.9$	**(1)**
5	**The only correct answer is D** **A** *is not the correct answer as smaller particles of sand have a lower terminal velocity so take longer to reach the bottom of the beaker* **B** *is not the correct answer as a lower temperature would increase the viscosity and increase the time taken for the particles to reach the bottom of the beaker (lower terminal velocity)* **C** *is not the correct answer as the sand particles take longer to reach the bottom of the beaker with a smaller terminal velocity*	**(1)**
6	**The only correct answer is C** **A** *is not the correct answer as it has a high elastic limit* **B** *is not the correct answer as it has a high elastic limit and a small region of plastic deformation* **D** *is not the correct answer as it has a small region of plastic deformation*	**(1)**

7	**The only correct answer is B** as power output = kinetic energy per second of the ejected water. $P = \frac{\frac{1}{2} \times 0.2\ kg \times (3\ m\ s^{-1})^2}{1\ second} = \frac{0.2\ \times 3^{\ 2}}{2}$ **A** *is not the correct answer because the mass has not been converted into kg which is required for a power in watts.* **C** *is not the correct answer because the mass is in g and the velocity has not been squared* **D** *is not the correct answer because the velocity has not been squared*	**(1)**
8	**The only correct answer is C** as the acceleration is positive while the fuel is still burning. It then becomes negative, while still travelling upwards, as the only forces acting on it are downwards (weight and drag). **A** *is not the correct answer because the acceleration should be constant as there is a constant upwards thrust from the fuel.* **B** *is not the correct answer because the acceleration should be constant as there is a constant upwards thrust from the fuel. The acceleration should become negative before T.* **D** *is not the correct answer because the acceleration becomes negative as the fuel runs out and not at the maximum height.*	**(1)**
9	**The only correct answer is B**  **A** *is not the correct answer as the length and direction of the line are incorrect* **C** *is not the correct answer as the length and direction of the line are incorrect* **D** *is not the correct answer as the length and direction of the line are incorrect*	**(1)**
10	**The only correct answer is C** because taking upwards as positive, force of floor of lift on student – weight of student = mass × acceleration $800 - 70g = 70a$ **A** *is not the correct answer because the force of the lift on the student was omitted and the direction of the weight is incorrect* **B** *is not the correct answer because the weight of the student has been omitted* **D** *is not the correct answer because the weight and the force of the lift on the student are in the wrong direction*	**(1)**

Question Number	Answer	Mark
11	**Max 4** • Initial momentum (of the child, ball and skateboard/total) is zero (1) • Due to conservation of momentum, the total momentum before the ball is thrown = total momentum after the ball is thrown (so final total momentum is zero) (1) • The momentum of the child/skateboard is equal to the momentum of the ball (1) • The momentum of the child/skateboard is opposite in direction to the momentum of the ball (1) • As the mass of the child/skateboard greater (than the mass of ball), the velocity (of the child/skateboard) will be lower (1) (all symbols to be defined, '*mv*' to be defined if used for momentum) (MP3 accept to the right/positive for forwards)	**4**
	Total for question 11	**4**

Question Number	Answer	Mark
12	**Either** (1) • Use of $\sin\theta = \frac{2.0}{15}$ **Or** use of $\theta = 7.7°$ (1) • Use of Work done = $F\Delta s$ **Or** use of $E_{grav} = mg\Delta h$ (1) • Use of efficiency = $\frac{\text{useful energy output}}{\text{total energy input}}$ (× 100 %) (1) • Efficiency = 83 or 84 % so less than 90 % (MP4 dependent on scoring all points MP1& 2 &3) <u>Example of calculation</u> (1) $\sin^{-1}\left(\frac{2.0}{15}\right) = 7.7°$ (1) $W_{50} = 50\text{ kg} \times 9.81\text{ N kg}^{-1} \times 2.0\text{ m} \times \frac{2.0}{15} = 130.8\text{ J}$ (1) $W_{8} = 8.0\text{ kg} \times 9.81\text{ N kg}^{-1} \times 2.0\text{ m} = 157.0\text{ J}$ (1) Efficiency = $\frac{130.8\text{ J}}{157.0\text{ J}} \times 100\ \% = 83\ \%$	4
	Total for question 12	**4**

Question Number	Answer		Mark
13(a)	• Use of $v = s/t$ **Or** use of gradient	(1)	
	• $v = (\pm)$ 1.1 to 1.2 (m s^{-1})	(1)	
	• Scaling of the velocity axis so that the graph covers at least 50% of the paper above and below the axes. (A minimum of 1 number on each axis required e.g. 1 and −1)	(1)	
	• A positive constant velocity from 0 to 42 s and the same negative constant velocity from 48 s to 90 s with connecting line/curve (tolerance of ± 1 s)	(1)	4
	<u>Example of calculation</u>		
	Initial velocity = $\frac{46\text{ m}}{40\text{ s}} = 1.15\text{ m s}^{-1}$		
			
13(b)(i)	The graph should be a curve initially	(1)	
	with a decreasing gradient up to 15 m (by eye) (ignore any part of the graph above 15 m)	(1)	2

<table>
<tr><td>13(b)(ii)</td><td>1 mark for a simplification (1)

1 mark for a corresponding explanation (1)

<table>
<tr><td>Simplification</td><td>Explanation</td></tr>
<tr><td>Velocity constant
Or velocity doesn’t change
Or velocity is an average
Or no regions of acceleration/deceleration</td><td>• Variation in velocity during each stroke
• The force applied to the swimmer/water varies (within the stroke)
• As the swimmer moves above/below water to breathe, the velocity changes
• The speed would change as they went from gliding to swimming</td></tr>
<tr><td>The velocity of the swimmer has the same magnitude in both parts of the race</td><td>The swimmer may have tired and this could be less for the second half of the race</td></tr>
<tr><td>The initial velocity after the turn would be greater</td><td>The swimmer would probably glide (underwater) after the turn</td></tr>
<tr><td>Gradient should initially increase from zero</td><td>Swimmer initially pushes off from starting block/turn</td></tr>
</table>
Treat references to drag as neutral.</td><td>2</td></tr>
<tr><td></td><td>Total for question 13</td><td>8</td></tr>
</table>

<table>
<tr><th>Question Number</th><th>Answer</th><th></th><th>Mark</th></tr>
<tr><td>14(a)(i)</td><td>• Use of equation(s) of motion to determine u_v
Or Use of $E_k = E_{grav}$

• $u_v = 83$ (m s^{-1})
(for mp2 must have used $v = 0$ and $-g$)

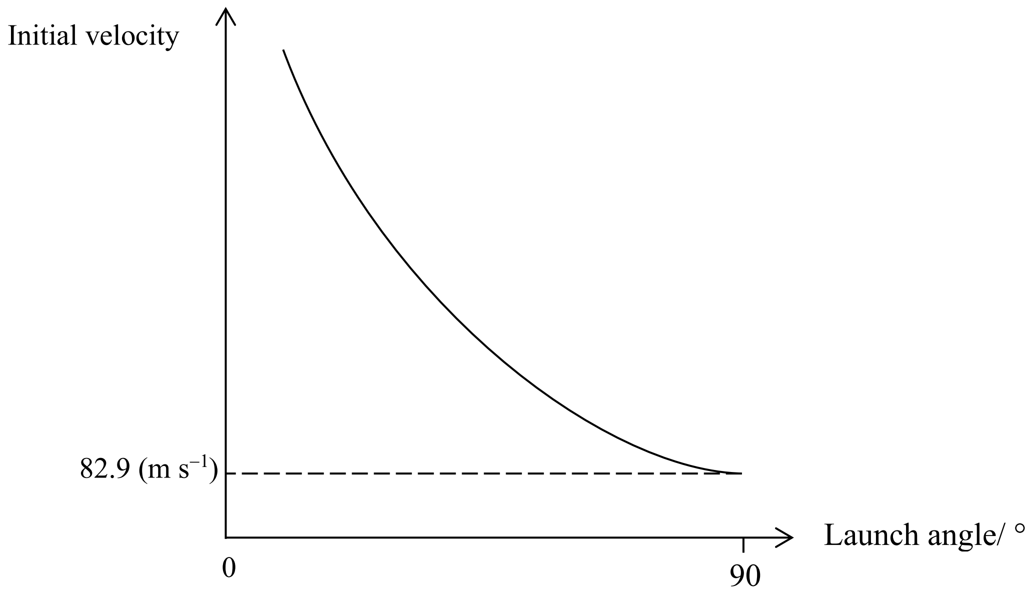
<u>Example of calculation</u>
$0^2 = u^2 + 2(-9.81 \text{ m s}^{-2})(350 \text{ m})$
$u = 82.9 \text{ m s}^{-1}$</td><td>(1)

(1)</td><td>2</td></tr>
<tr><td>14(a)(ii)</td><td>• Launch angle increasing as initial velocity decreases (i.e. negative gradient)

• Curve drawn

• Minimum initial velocity marked, and graph passes through (90, 82.9/80)
Or other correct pair of points labelled and plotted

• Initial velocity axis asymptotic


</td><td>(1)

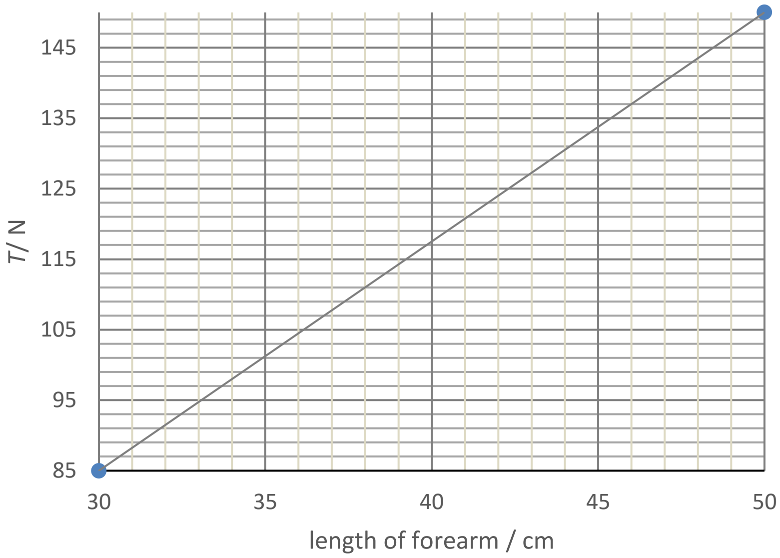
(1)

(1)

(1)</td><td>4</td></tr>
<tr><td>14(b)</td><td>(Perpendicular) distance to firework= time (counted) × speed of sound

Diameter of firework = 2 × distance × tan (ϕ/2)
(allow Diameter of firework = distance × tan (ϕ/2))</td><td>(1)

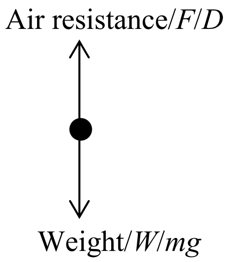
(1)</td><td>2</td></tr>
<tr><td></td><td>Total for question 14</td><td></td><td>8</td></tr>
</table>

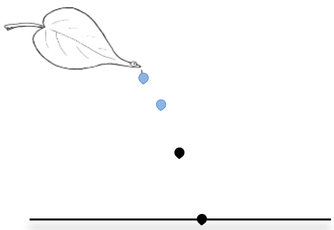
Question Number	Answer	Mark
15(a)	• Estimate of length of forearm 30 – 50 (cm) (1) • Use of trig to determine the perpendicular component of the tension **Or** see $T\sin 70$ **Or** see $T\cos 20$ (1) • Use of moment = Fx with a corresponding force and distance (1) • Use of the principle of moments (1) • Value for T in range 85 N to 150 N (l = 30 cm, T = 85 N and l = 50 cm, T = 150 N) (1) <u>Example of calculation</u> (for l = 0.40 m) $(0.04\text{ m} \times T \times \sin 70) = (0.31\text{ m} \times 4.5\text{ N}) + (0.20\text{ m} \times 15\text{ N})$ T = 117 N  	5
15(b)	• The forearm is not uniform/symmetrical (1) • The centre of gravity is not in the middle (1)	2
	Total for question 15	**7**

Question Number	Answer	Mark
16(a)	• Use a micrometer (screw gauge) **Or** (vernier)digital calipers (1) • At different orientations **and/or** positions along the wire (1) • Calculate/determine/take/find a mean/average value (1)	**3**
16(b)	• Use of $A = \pi\left(\frac{d}{2}\right)^2$ (1) • Calculate gradient of linear section (up to 3×10^{-3} m, 6.8 N) of graph **Or** use of a corresponding pair of points for F and Δx from the linear region of the graph (1) • Use of $\sigma = \frac{F}{A}$ and $\varepsilon = \frac{\Delta x}{l}$ **Or** use of $E = \frac{Fl}{A\Delta x}$ **Or** Use of $E =$ gradient $\times \frac{l}{A}$ (1) • $E = (1.2 - 1.3) \times 10^{11}$ Pa (1) (MP4 conditional on scoring MP1 & MP2 & MP3) <u>Example of calculation using gradient</u> $A = \pi\left(\frac{2.3 \times 10^{-4}\text{ m}}{2}\right)^2 = 4.15 \times 10^{-8}\text{ m}^2$ Gradient $= \frac{6.5\text{ N}}{2.9 \times 10^{-3}\text{ m}} = 2.2 \times 10^3\text{ N m}^{-1}$ $E = 2.2 \times 10^3\text{ N m}^{-1} \times \frac{2.4\text{ m}}{4.15 \times 10^{-8}\text{m}^2} = 1.27 \times 10^{11}$ Pa	**4**

*16(c)	• 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. Number of indicative marking points seen in answer → Number of marks awarded for indicative marking points: 6 → 4 5–4 → 3 3–2 → 2 1 → 1 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 (a minimum of at least 5 IC points including: IC1 and IC2/IC5 **and** IC3 and IC4/IC5 Answer is partially structured with some linkages and lines of reasoning → 1 (a minimum of 3 IC points including: **either** IC1 and IC2/IC5 **Or** IC3 and IC4/IC5) 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** • For long(er) wire, the extension will be large(r) • (For the same load) extension is proportional to the original length **Or** $\frac{\text{extension}}{\text{original length}} = \text{constant}$ • For a thin(ner) wire, the extension will be large(r) • (For the same load) extension is inversely proportional to cross-sectional area (may be explained in terms of E, σ and ε) • The percentage uncertainty in the extension/length will be lower (although this will be greater for the cross-sectional area) • A small(er) load can be used with a long/thin wire	6
	Total for question 16	**13**

Question Number	Answer	Mark
17(a)(i)	Use of fall factor = $\frac{\text{height fallen before the rope begins to stretch}}{\text{total unstretched length of rope}}$ **(1)** Use of $\varepsilon = \frac{\Delta x}{x}$ with $x = 15.0$ m **(1)** Use of $E_{grav} = mg\Delta h$ **(1)** Use of $E_{grav} = E_{el}$ with their Δx **(1)** F_{max} = 14 000 (N) **(1)** <u>Example of calculation</u> Height fallen = 15.0 m × 0.8 = 12 m Δx = 0.09 × 15.0 m = 1.35 m E_{grav} = 71 kg × 9.81 N kg^{-1}× 12 m = 8358 J (from fall) E_{grav} = 71 kg × 9.81 N kg^{-1}× 1.35 m = 940.3 J (from extension) 8358 J + 940.3 J = ½ × F_{max} × 1.35 m F_{max} = 13 775 N	5
17(a)(ii)	• This would not be a good idea, as the climber would reach a higher velocity (just before the rope stretches) **(1)** • (Hence) the climber's deceleration/force (as the rope stretches) would be greater **(1)**	2
17(b)	**Max 6** • Use of area under the graph to determine the stored energy **(1)** • Energy = 800 J (new) **(1)** • Energy = 700 J (old) **(1)** • The old rope would absorb/store less energy **(1)** • Use of $F = k\Delta x$ to determine k (accept gradient of a tangent) **(1)** • Calculation of k for both ropes at same applied force **(1)** • The old rope is not as stiff as the new rope **Or** The old rope extends more **(1)** • The old rope would break at a smaller applied force/stress **(1)**	6
	Total for question 17	**13**

Question Number	Answer	Mark
18(a)(i)	Explanation • Terminal velocity is the constant/maximum velocity the rain reaches **Or** terminal velocity is the velocity when acceleration = 0 (1) • When weight = Drag (+ upthrust) **Or** when forces is equilibrium **Or** when resultant force = 0 (accept when the total upward force = total downward force) (1) Diagram • Weight and air resistance (and upthrust) only drawn with correct directions (arrowed lines must touch dot, and labels included) (1) • Arrow lengths of weight and air resistance same length (if upthrust drawn, upthrust line + drag line = weight line) (MP4 dependent on MP3) (1) 	**4**

18(a)(ii)	• Use of $A = \pi r^2$ **and** $V = \frac{4}{3}\pi r^3$ • Use of $\rho = \frac{m}{V}$ **and** $W = mg$ • Use of $W = F$ • $v = 6.5 – 7.0\ \mathrm{m\ s^{-1}}$ <u>Example of calculation</u> $A = \pi \times (0.002)^2 = 1.26 \times 10^{-5}\ \mathrm{m^2}$ $V = \frac{4}{3}\pi \times (0.002\ \mathrm{m})^3 = 3.35 \times 10^{-8}\ \mathrm{m^3}$ $m = 1000\ \mathrm{kg\ m^{-3}} \times 3.35 \times 10^{-8}\ \mathrm{m^3} = 3.35 \times 10^{-5}\ \mathrm{kg}$ $W = 3.35 \times 10^{-5}\ \mathrm{kg} \times 9.81\ \mathrm{N\ kg^{-1}} = 3.29 \times 10^{-4}\ \mathrm{N}$ $3.29 \times 10^{-4}\ \mathrm{N} = 0.45 \times 1.2\ \mathrm{kg\ m^{-3}} \times 1.26 \times 10^{-5}\ \mathrm{m^2} \times v^2$ $3.29 \times 10^{-4}\ \mathrm{N} = 6.80 \times 10^{-6} \times v^2$ $v = 6.96\ \mathrm{m\ s^{-1}}$	(1) (1) (1) (1)	**4**
18(b)(i)	• Vertical displacement increasing • Horizontal displacement constant (same as first two drops) (Mark all added drops but there must be a minimum of 2 additional drops to award MP1 &2) 	(1) (1)	**2**
18(b)(ii)	• Use of $s = ut + ½ at^2$ with $u = 0$ (accept use of t = 0.2 s, 0.25 s, 0.75 s, 1.0 s) • See 0.8 s for the time since the drop left the leaf • $s = 3.1\ \mathrm{m}$ <u>Example of calculation</u> $s = ½ \times 9.81\ \mathrm{N\ kg^{-1}} \times (0.8\ \mathrm{s})^2 = 3.14\ \mathrm{m}$	(1) (1) (1)	**3**
	Total for question 18		**13**