



Mark Scheme (Results)

October 2021

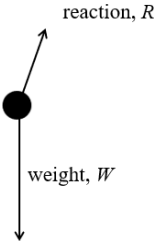
Pearson Edexcel International Advanced
Subsidiary Level in Physics (WPH11)
Paper 01 Mechanics and Materials

Question Number	Answer	Mark
1	<p>B is the correct answer</p> <p>A is incorrect because gradient is velocity, not acceleration</p> <p>C is incorrect because gradient is rate of change of acceleration, not velocity</p> <p>D is incorrect because gradient is rate of change of acceleration, not displacement</p>	1
2	<p>C is the correct answer</p> <p>A is incorrect because magnitudes are equal</p> <p>B is incorrect because magnitudes are equal and directions are opposite</p> <p>D is incorrect because directions are opposite</p>	1
3	<p>C is the correct answer</p> <p>A is incorrect because reducing the extension reduces the stored energy</p> <p>B is incorrect because reducing the extension reduces the stored energy and increasing the force increases the stored energy</p> <p>D is incorrect because increasing the force increases the stored energy</p>	1
4	<p>C is the correct answer</p> <p>A is incorrect because $13.2/\text{answer} = \cos 22.6^\circ$, not $\sin 22.6^\circ$</p> <p>B is incorrect because $13.2/\text{answer} = \cos 22.6^\circ$, not $\sin 22.6^\circ$, and the equation has also been incorrectly transposed.</p> <p>D is incorrect because although $5.5/\text{answer} = \sin 22.6^\circ$ the equation has been incorrectly transposed.</p>	1
5	<p>B is the correct answer</p> <p>A is incorrect because the CW moment of the force could balance the ACW moment of the weight</p> <p>C is incorrect because the CW moment of the force could balance the ACW moment of the weight</p> <p>D is incorrect because the CW moment of the force could balance the ACW moment of the weight</p>	1

6	A is the correct answer B is incorrect because N is in the wrong direction C is incorrect because the wrong diagonal has been used D is incorrect because the wrong diagonal has been used	1
7	A is the correct answer B is incorrect because the distance has not been doubled and the time has not been squared C is incorrect because the distance is in the wrong unit D is incorrect because the distance is in the wrong unit, has not been doubled and the time has not been squared	1
8	B is the correct answer A is incorrect because the factor $9.81 = g / (\text{N kg}^{-1})$ is not needed since it is already included in the weight, $\Delta E_{\text{grav}} = mg\Delta h = W\Delta h$ C is incorrect because dividing by 9.81 removes g from the calculation D is incorrect because dividing by 9.81 removes g and the factor $25 = \Delta h / \text{m}$ is missing from the calculation	1
9	A is the correct answer B is incorrect because low viscosity is not a condition C is incorrect because cylindrical object is not a condition D is incorrect because neither cylindrical object nor low viscosity are conditions	1
10	D is the correct answer A is incorrect because mg has the wrong direction B is incorrect because mg and ma have the wrong directions C is incorrect because ma has the wrong direction	1
Total for Section A		10

Question Number	Answer	Mark
11(a)	Use of $E_k = \frac{1}{2} m v^2$ (1) $E_k = 0.54 \text{ J}$ (1) <u>Example of calculation</u> $E_k = 0.5 \times 0.16 \text{ kg} \times (2.6 \text{ m s}^{-1})^2 = 0.541 \text{ J}$	2
11(b)	Use of $E_{\text{grav}} = m g \Delta h$ (1) $\Delta h = 0.51 \text{ m}$ (1) (allow ecf from (a)) <u>Example of calculation</u> Decrease in GPE = $0.54 \text{ J} + 0.26 \text{ J} = 0.8 \text{ J}$ $\Delta h = 0.8 \text{ J} / (0.16 \text{ kg} \times 9.81 \text{ m s}^{-2}) = 0.51 \text{ m}$	2
	Total for question 11	4

Question Number	Answer	Mark
12(a)	<p>the total momentum before (a collision) = the total momentum after (a collision)</p> <p>Or</p> <p>Sum of momentum values before (collision) = sum of momentum values after (collision)</p> <p>Or</p> <p>total momentum remains constant</p> <p>Or (1)</p> <p>the momentum of a system remains constant</p> <p>Provided no external/unbalanced/resultant force acts (on the system)</p> <p>Or (1)</p> <p>in a closed/isolated system</p>	2
12(b)	<p>Use of $p = m v$ (1)</p> <p>Uses conservation of momentum (1)</p> <p>Velocity = -4.6 m s^{-1} (1)</p> <p><u>Example of calculation</u></p> <p>$2.7 \text{ kg} \times 10 \text{ m s}^{-1} = 2.7 \text{ kg} \times v + 7.9 \text{ kg} \times 5.0 \text{ m s}^{-1}$</p> <p>$v = (27.0 - 39.5) \text{ kg m s}^{-1} \div 2.7 \text{ kg} = -4.6(3) \text{ m s}^{-1}$</p>	3
	Total for question 12	5

Question Number	Answer	Mark
13(a)	<p>Vertical downwards force labelled "weight", or W. (1) Force perpendicular to slope labelled "reaction", "(normal) contact", or R or N. (1)</p> 	2
13(b)(i)	<p>Resolves acceleration along slope. (1) Acceleration = 1.2 m s^{-2} (1)</p> <p><u>Example of calculation</u> $a = 9.81 \text{ m s}^{-2} \times \sin 6.9^\circ = 1.18 \text{ m s}^{-2}$</p>	2
13(b)(ii)	<p>Either</p> <p>Use of $v^2 = u^2 + 2 a s$ (1) Final speed = 12 m s^{-1} (ecf from (i)) (1)</p> <p>Or</p> <p>Use of $E_k = \frac{1}{2}mv^2$ and $\Delta E_{\text{grav}} = mg\Delta h$ (1) Final speed = 12 m s^{-1} (ecf from (i)) (1)</p> <p><u>Example of calculation</u> $v^2 = 0^2 + 2 \times 1.18 \text{ m s}^{-2} \times 60 \text{ m}$ $v = \sqrt{0 + 2 a s} = \sqrt{2 \times 1.18 \text{ m s}^{-2} \times 60 \text{ m}} = 11.9 \text{ m s}^{-1}$</p>	2
13(b)(iii)	<p>Use of $v = u + a t$ or another valid <i>suvat</i> equation (1) Time = 10 s (ecf from (ii)) (ecf from (i)) (1)</p> <p><u>Example of calculation</u> $v = u + a t, u = 0$ $11.9 = 0 + 1.18 \text{ m s}^{-2} \times t$ $t = 11.9 \text{ m s}^{-1} \div 1.18 \text{ m s}^{-2} = 10.1 \text{ s}$</p>	2
Total for question 13		8

Question Number	Answer	Mark
14(a)	<p>Maximum value of weight/force for which weight/force is proportional to extension</p> <p>Or</p> <p>Point beyond which Hooke's Law no longer applies</p> <p>Or</p> <p>Point beyond which graph line ceases to be straight</p> <p>Or</p> <p>Point beyond which weight/force is no longer proportional to extension (1)</p>	1
14(b)(i)	<p>Use of large triangle to determine gradient (1)</p> <p>Gradient = 18 500 (N m⁻¹) (sf range 18 - 19, no ue) (1)</p> <p><u>Example of calculation</u></p> <p>gradient = 37 N ÷ (2 × 10⁻³ m) = 18 500 (N m⁻¹)</p>	2
14(b)(ii)	<p>Rearranges $E = \text{stress} / \text{strain}$ to get $E = \text{gradient} \times \frac{x}{A}$</p> <p>Or Rearranges $E = \text{stress} / \text{strain}$ to get gradient = $\frac{A}{x} E$ (1)</p> <p>Use of $A = \pi r^2$ (1)</p> <p>Young modulus = 2 × 10¹¹ Pa (1)</p> <p>(allow ecf from (b)(i))</p> <p><u>Example of calculation</u></p> <p>$A = \pi \times (2.8 \times 10^{-4})^2 = 2.46 \times 10^{-7} \text{ m}^2$</p> <p>$E = 1.85 \times 10^4 \text{ N m}^{-1} \times 2.6 \text{ m} \div 2.46 \times 10^{-7} \text{ m}^2 = 1.95 \times 10^{11} \text{ Pa}$</p>	3
14(c)	<p>Use of $\sigma = \frac{F}{A}$ (1)</p> <p>Determines maximum safe load</p> <p>Or</p> <p>Determines maximum stress</p> <p>Or</p> <p>Determines minimum cross section (1)</p> <p>Valid conclusion by comparison with student's calculation (1)</p> <p><u>Example of calculation</u></p> <p>$\sigma_{\text{max}} = \frac{W_{\text{max}}}{A}$</p> <p>$4.80 \times 10^8 \text{ Pa} = \frac{W_{\text{max}}}{2.46 \times 10^{-7} \text{ m}^2}$</p> <p>$W_{\text{max}} = 480 \times 10^6 \text{ Pa} \times 2.46 \times 10^{-7} \text{ m}^2 = 118 \text{ N} > 100 \text{ N}$ so yes</p>	3
	Total for question 14	9

Question Number	Answer	Mark																																						
15(a)*	<p>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.</p> <p>The following table shows how the marks should be awarded for indicative content and lines of reasoning.</p> <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><td></td><td>Marks</td></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></table> <p>Indicative content:</p> <ol style="list-style-type: none">1. There is a (backward) force/friction on floor from wheels/car2. Newton's Third Law implies forward/opposite force from floor3. Compression/deformation of spring reduces (as car moves forward)4. (Resultant) force is proportional to compression/deformation of spring <p>Or</p> <p>Reference to Hooke's law.</p> <ol style="list-style-type: none">5. Acceleration is proportional to resultant force <p>Or</p> <p>Reference to $F = ma$</p> <ol style="list-style-type: none">6. Acceleration reduces (as distance travelled increases) <p>Or</p> <p>Acceleration is zero once spring has returned to original state</p> <p>Accept "resultant force" for "acceleration" in IC6</p>	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	6
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																																							
Total for question 15		6																																						

Question Number	Answer	Mark
16(a)	<p>Resolves velocity to find vertical component (1) Use of $v = u + at$ (1) Time to max height = 3.3 (s) (1)</p> <p><u>Example of calculation</u> $u_v = 50 \text{ m s}^{-1} \sin (40^\circ) = 32.1 \text{ m s}^{-1}$ $v = u + at$ with $v = 0$ $t = 32.1 \text{ m s}^{-1} \div 9.81 \text{ m s}^{-2} = 3.28 \text{ s}$</p>	3
16(b)	<p>Use of $v_H = v \cos \theta$ (1) Use of $s = ut$ to calculate horizontal distance (1) Use of $s = ut + \frac{1}{2}at^2$ to calculate maximum height or other <i>suvat</i> equation (1) Maximum height = 53 m (allow ecf from (a)) (1) Use of $\tan \theta$ to calculate vertical height of hill (1) Compares height of hill with maximum height (accept conclusion based on candidate's values).</p> <p>Or</p> <p>Use of $v_H = v \cos \theta$ (1) Use of $s = ut$ to calculate horizontal distance (1) Use of $s = ut + \frac{1}{2}at^2$ to calculate maximum height or other <i>suvat</i> equation (1) Maximum height = 53 m (allow ecf from (a)) (1) Use of $\tan \theta$ to calculate minimum angle of hill for a hit (1) Compares angle of hill with minimum angle (accept conclusion based on candidate's values).</p> <p>Or (1) (1) Use of $v_H = v \cos \theta$ (1) Use of $s = ut$ to calculate horizontal distance (1) Use of $s = ut + \frac{1}{2}at^2$ to calculate maximum height or other <i>suvat</i> equation (1) Maximum height = 53 m (allow ecf from (a)) (1) Use of $\tan \theta$ to calculate horizontal distance to 52.6 m height along hill Compares horizontal distances (accept conclusion based on candidate's values).</p> <p><u>Example of calculation</u> $v_H = 50 \text{ m s}^{-1} \times \cos (40^\circ) = 38.3 \text{ m s}^{-1}$ $s_H = v_H \times t$ $s_H = 38.3 \text{ m s}^{-1} \times 3.28 \text{ s} = 125 \text{ m}$ maximum height of rock = $s_v = u_v t + \frac{1}{2}at^2$ with $a = -g$</p>	6

	$s_v = 32.1 \text{ m s}^{-1} \times 3.28 \text{ s} - \frac{1}{2} \times 9.81 \text{ m s}^{-2} \times (3.28 \text{ s})^2 = 52.6 \text{ m}$ vertical height of hill at horizontal distance of 125 m = $125 \text{ m} \times \tan(20^\circ)$ = 45.7 m 45.7 m < 52.6 m, so no	
	Total for question 16	9

Question Number	Answer	Mark
17(a)(i)	The layers of fluid flow past each other without mixing Or <u>Velocity</u> at a fixed point (relative to the drop) remains constant (1)	1
17(a)(ii)	Resultant force is zero Or Sum of the vertical forces is zero (1) (Accept $W - U = D$ or $W = U + D$ with terms defined)	1
17(b)(i)	Use of $\rho = \frac{m}{V}$ (1) Use of $W = mg$ (1) Weight = 3.3×10^{-4} N (1) <u>Example of calculation</u> $1.00 \times 10^3 \text{ kg m}^{-3} = m \div 3.35 \times 10^{-8} \text{ m}^3$ $m = 1.00 \times 10^3 \text{ kg m}^{-3} \times 3.35 \times 10^{-8} \text{ m}^3 = 3.35 \times 10^{-5} \text{ kg}$ $W = mg = 3.35 \times 10^{-5} \text{ m}^3 \times 9.81 \text{ N kg}^{-1} = 3.29 \times 10^{-4} \text{ N}$	3
17(b)(ii)	Use of upthrust = weight of fluid displaced (1) Upthrust = 3.1×10^{-4} (N) (1) <u>Example of calculation</u> $0.94 \times 10^3 \text{ kg m}^{-3} = m \div 3.35 \times 10^{-8} \text{ m}^3$ $m = 0.94 \times 10^3 \text{ kg m}^{-3} \times 3.35 \times 10^{-8} \text{ m}^3 = 3.15 \times 10^{-5} \text{ kg}$ $U = mg = 3.15 \times 10^{-5} \text{ m}^3 \times 9.81 \text{ N kg}^{-1} = 3.09 \times 10^{-4} \text{ N}$	2
17(b)(iii)	Uses upthrust and weight to determine the viscous force F (1) Use of $V = \frac{4}{3} \pi r^3$ to determine r (1) Use of $F = 6\pi\eta rv$ (1) $v = 4.8 \times 10^{-3} \text{ m s}^{-1}$ (ecf from (b)(i) and (b)(ii)) (1) <u>Example of calculation</u> $W = U + 6\pi\eta rv \rightarrow W - U = 6\pi\eta rv$ $W - U = (3.29 - 3.09) \times 10^{-4} \text{ N} = 2.0 \times 10^{-5} \text{ N}$ $r = \sqrt[3]{\frac{3}{4} \times 3.35 \times 10^{-8} \text{ m}^3 \div \pi} = 2.0 \times 10^{-3} \text{ m}$ $2.0 \times 10^{-5} \text{ N} = 6\pi \times 0.11 \text{ Pa s} \times 2.0 \times 10^{-3} \text{ m} \times v$ $v = 2.0 \times 10^{-5} \text{ N} \div (6\pi \times 0.11 \text{ Pa s} \times 2.0 \times 10^{-3} \text{ m}) = 4.82 \times 10^{-3} \text{ m s}^{-1}$	4
	Total for question 17	11

Question Number	Answer	Mark
18(a)	Use of $P = W / t$ and $\Delta W = F \Delta s$ (1) Force = 13.9 (kN) (1) <u>Example of calculation</u> In 1 second $W = 6250$ J and distance travelled = 0.450 m $F = 6250 \text{ W} \div 0.450 \text{ m s}^{-1} = 13.9 \text{ kN}$	2
18(b)	Use of $\Delta W = F \Delta s$ (1) Use of $\Delta s = 4.35 / \sin 6.0^\circ$ (1) Total work = 5.8×10^5 J (allow ecf from (a)) (1) <u>Example of calculation</u> $\Delta W = 13.9 \times 10^3 \text{ N} \times 4.35 \text{ m} \div \sin 6.0^\circ = 578 \text{ kJ}$	3
18(c)	Use of $\Delta E_{\text{grav}} = m g \Delta h$ (1) Useful work done = 89.6 (kJ) (1) <u>Example of calculation</u> $\Delta E_{\text{grav}} = 2.10 \times 10^3 \text{ kg} \times 9.81 \text{ N kg}^{-1} \times 4.35 \text{ m} = 89.6 \text{ kJ}$	2
18(d)	Use of $\varepsilon = \text{useful energy output} / \text{total energy input}$ (1) Efficiency = 0.16 (allow ecf from (b) and (c)) (1) <u>Example of calculation</u> $\varepsilon = 89.6 \text{ kJ} \div 578 \text{ kJ} = 0.155$	2
	Total for question 18	9

Question Number	Answer	Mark
19(a)	<p>Use of moment = $F \times$ (1)</p> <p>Anticlockwise moment = 25.2 (Nm)</p> <p>and (maximum) clockwise moment = 24.2 (Nm) (1)</p> <p>As angle to the ground increases, clockwise moment from the weight decreases</p> <p>Or (1)</p> <p>If line of action of weight moves outside base cannot regain equilibrium. (1)</p> <p>$25.2 > 24.2 \therefore$ blows over</p> <p><u>Example of calculation</u></p> <p>moment from wind = $14 \text{ N} \times 1.8 \text{ m} = 25.2 \text{ N m}$</p> <p>moment from weight = $110 \text{ N} \times 0.22 \text{ m} = 24.2 \text{ N m}$</p> <p>$25.2 > 24.2 \therefore$ blows over</p>	4
19(b)	<p>Horizontal component = $T \times \sin 44^\circ$</p> <p>Or</p> <p>Distance to line of action of $T = 1.5 \times \sin 44^\circ$ (1)</p> <p>Equates clockwise to anticlockwise moments about centre of base to determine T (1)</p> <p>Use of trigonometry to calculate vertical component of tension (1)</p> <p>Adds weight to vertical component</p> <p>Force exerted on the ground = 141 N (1)</p> <p>(1)</p> <p><u>Example of calculation</u></p> <p>Horizontal component of tension = $T \times \sin 44^\circ$</p> <p>CWM = $1.5 \text{ m} \times T \times \sin 44^\circ = 1.04 \text{ m} \times T$</p> <p>ACWM = $25 \text{ N} \times 1.8 \text{ m} = 45.0 \text{ N m}$</p> <p>$1.04 \text{ m} \times T = 45.0 \text{ N m}$</p> <p>$T = 45.0 \text{ N m} \div 1.04 \text{ m} = 43.2 \text{ N}$</p> <p>Vertical component of $T = 43.2 \text{ N} \times \cos 44^\circ = 31.1 \text{ N}$</p> <p>Total downward force = $110 \text{ N} + 31.1 \text{ N} = 141.1 \text{ N}$</p>	5
	Total for question 19	9