Mark Scheme (Results)

October 2021

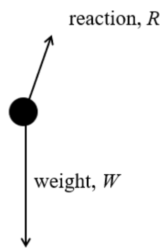
Pearson Edexcel International Advanced Subsidiary Level in Physics (WPH11)
Paper 01 Mechanics and Materials

Question Number	Answer	Mark
1	**B is the correct answer** A is incorrect because gradient is velocity, not acceleration C is incorrect because gradient is rate of change of acceleration,not velocity D is incorrect because gradient is rate of change of acceleration, not displacement	**1**
2	**C is the correct answer** A is incorrect because magnitudes are equal B is incorrect because magnitudes are equal and directions areopposite D is incorrect because directions are opposite	**1**
3	**C is the correct answer** A is incorrect because reducing the extension reduces the storedenergy B is incorrect because reducing the extension reduces the storedenergy and increasing the force increases the stored energy D isincorrect because increasing the force increases the stored energy	**1**
4	**C is the correct answer** A is incorrect because 13.2/answer = cos 22.6°, not sin 22.6° B is incorrect because 13.2/answer = cos 22.6°, not sin 22.6°, andthe equation has slo been incorrectly transposed. D is incorrect because although 5.5/answer = sin 22.6° the equation has been incorrectly transposed.	**1**
5	**B is the correct answer** A is incorrect because the CW moment of the force could balancethe ACW moment of the weight C is incorrect because the CW moment of the force could balance theACW moment of the weight D is incorrect because the CW moment of the force could balance the ACW moment of the weight	**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 / (N kg^{-1}) is not needed since it is already included in the weight, $\Delta E_{grav} = mg\Delta h = W\Delta h$ 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 = Δh / 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 $E_k = ½ m v^2$ **(1)** $E_k = 0.54$ J **(1)** <u>Example of calculation</u> $E_k = 0.5 \times 0.16 \text{ kg} \times (2.6 \text{ m s}^{-1})^2 = 0.541$ J	**2**
11(b)	Use of $E_{grav} = m g \Delta h$ **(1)** $\Delta h = 0.51$ m **(1)** (allow ecf from (a)) <u>Example of calculation</u> Decrease in GPE = 0.54 J + 0.26 J = 0.8 J $\Delta h = 0.8 \text{ J} / (0.16 \text{ kg} \times 9.81 \text{ m s}^{-2}) = 0.51$ m	**2**
	Total for question 11	**4**

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

Question Number	Answer		Mark
13(a)	Vertical downwards force labelled "weight", or *W*. Force perpendicular to slope labelled "reaction", "(normal) contact", or *R* or *N*.  	**(1)** **(1)**	**2**
13(b)(i)	Resolves acceleration along slope. Acceleration = 1.2 (m s^{-2}) <u>Example of calculation</u> a = 9.81 m s^{-2} × sin 6.9° = 1.18 m s^{-2}	**(1)** **(1)**	**2**
13(b)(ii)	**Either** Use of $v^2 = u^2 + 2\,a\,s$ Final speed = 12 m s^{-1} (ecf from (i)) **Or** Use of $E_k = ½mv^2$ and $\Delta E_{grav} = mg\Delta h$ Final speed = 12 m s^{-1} (ecf from (i)) <u>Example of calculation</u> $v^2 = 0^2 + 2 \times 1.18$ m s^{-2} × 60 m $v = \sqrt{(0 + 2\,a\,s\,)} = \sqrt{(2 \times 1.18}$ m s^{-2} × 60 m) = 11.9 m s^{-1}	**(1)** **(1)** **(1)** **(1)**	**2**
13(b)(iii)	Use of $v = u + a\,t$ or another valid *suvat* equation Time = 10 s (ecf from (ii)) (ecf from (i)) <u>Example of calculation</u> $v = u + a\,t$, $u = 0$ 11.9 = 0 + 1.18 m s^{-2} × t t = 11.9 m s^{-1} ÷ 1.18 m s^{-2} = 10.1 s	**(1)** **(1)**	**2**
	Total for question 13		**8**

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

Question Number	Answer	Mark
15(a)*	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**

	Mark s
Answer shows a coherent and logical structure withlinkages and fully sustained lines of reasoning demonstrated throughout.	2
Answer is partially structured with some linkages and lines of reasoning	1

Indicative content:

1. There is a (backward) force/friction on floor from wheels/car
2. Newton's Third Law implies forward/opposite force from floor
3. Compression/deformation of spring reduces (as car moves forward)
4. (Resultant) force is proportional to compression/deformation of spring
   Or
   Reference to Hooke's law.
5. Acceleration is proportional to resultant force
   Or
   Reference to $F = ma$
6. Acceleration reduces (as distance travelled increases)
   Or
   Acceleration is zero once spring has returned to original state

Accept "resultant force" for "acceleration" in IC6

6

	Total for question 15	**6**

Question Number	Answer		Mark
16(a)	Resolves velocity to find vertical component Use of $v = u + a\,t$ Time to max height = 3.3 (s) <u>Example of calculation</u> $u_V = 50 \text{ m s}^{-1} \sin(40°) = 32.1 \text{ m s}^{-1}$ $v = u + a\,t$ with $v = 0$ $t = 32.1 \text{ m s}^{-1} \div 9.81 \text{ m s}^{-2} = 3.28 \text{ s}$	**(1)** **(1)** **(1)**	**3**
16(b)	Use of $v_H = v \cos\theta$ Use of $s = u\,t$ to calculate horizontal distance Use of $s = u\,t + ½\,a\,t^2$ to calculate maximum height or other *suvat* equation Maximum height = 53 m (allow ecf from (a)) Use of tan θ to calculate vertical height of hill Compares height of hill with maximum height (accept conclusion based on candidate's values). **Or** Use of $v_H = v \cos\theta$ Use of $s = u\,t$ to calculate horizontal distance Use of $s = u\,t + ½\,a\,t^2$ to calculate maximum height or other *suvat* equation Maximum height = 53 m (allow ecf from (a)) Use of tan θ to calculate minimum angle of hill for a hit Compares angle of hill with minimum angle (accept conclusion based on candidate's values). **Or** Use of $v_H = v \cos\theta$ Use of $s = u\,t$ to calculate horizontal distance Use of $s = u\,t + ½\,a\,t^2$ to calculate maximum height or other *suvat* equation Maximum height = 53 m (allow ecf from (a)) Use of tan θ to calculate horizontal distance to 52.6 m height along hill Compares horizontal distances (accept conclusion based on candidate's values). <u>Example of calculation</u> $v_H = 50 \text{ m s}^{-1} \times \cos(40°) = 38.3 \text{ m s}^{-1}$ $s_H = v_H \times t$ $s_H = 38.3 \text{ m s}^{-1} \times 3.28 \text{ s} = 125 \text{ m}$ maximum height of rock = $s_V = u_V\,t + ½\,a\,t^2$ with $a = -g$	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**6**

	$s_V = 32.1\ \text{m s}^{-1} \times 3.28\ \text{s} - ½ \times 9.81\ \text{m s}^{-2} \times (3.28\ \text{s})^2 = 52.6\ \text{m}$ vertical height of hill at horizontal distance of 125 m = 125 m × tan (20°) = 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 (Accept $W - U = D$ or $W = U + D$ with terms defined)	**(1)**	**1**
17(b)(i)	Use of $\rho = \frac{m}{V}$ Use of $W = mg$ Weight = 3.3×10^{-4} N <u>Example of calculation</u> 1.00×10^{3} kg m^{-3} = $m \div 3.35 \times 10^{-8}$ m^{3} $m = 1.00 \times 10^{3}$ kg m^{-3} $\times 3.35 \times 10^{-8}$ m^{3} = 3.35×10^{-5} kg $W = m\,g = 3.35 \times 10^{-5}$ m^{3} $\times$ 9.81 N kg^{-1} = 3.29×10^{-4} N	**(1)** **(1)** **(1)**	**3**
17(b)(ii)	Use of upthrust = weight of fluid displaced Upthrust = 3.1×10^{-4} (N) <u>Example of calculation</u> 0.94×10^{3} kg m^{-3} = $m \div 3.35 \times 10^{-8}$ m^{3} $m = 0.94 \times 10^{3}$ kg m^{-3} $\times 3.35 \times 10^{-8}$ m^{3} = 3.15×10^{-5} kg $U = m\,g = 3.15 \times 10^{-5}$ m^{3} $\times$ 9.81 N kg^{-1} = 3.09×10^{-4} N	**(1)** **(1)**	**2**
17(b)(iii)	Uses upthrust and weight to determine the viscous force F Use of $V = 4/3\,\pi r^{3}$ to determine r Use of $F = 6\pi\eta r v$ $v = 4.8 \times 10^{-3}$ m s^{-1} (ecf from (b)(i) and (b)(ii)) <u>Example of calculation</u> $W = U + 6\pi\eta r v \rightarrow W - U = 6\pi\eta r v$ $W - U = (3.29 - 3.09) \times 10^{-4}$ N = 2.0×10^{-5} N $r = \sqrt[3]{(3/4 \times 3.35 \times 10^{-8}\text{ m}^{3} \div \pi)} = 2.0 \times 10^{-3}$ m 2.0×10^{-5} N = $6\pi \times 0.11$ Pa s $\times 2.0 \times 10^{-3}$ m $\times v$ $v = 2.0 \times 10^{-5}$ N $\div (6\pi \times 0.11$ Pa s $\times 2.0 \times 10^{-3}$ m$) = 4.82 \times 10^{-3}$ m s^{-1}	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 17		**11**

Question Number	Answer		Mark
18(a)	Use of $P = W / t$ and $\Delta W = F \Delta s$ Force = 13.9 (kN) <u>Example of calculation</u> In 1 second W = 6250 J and distance travelled = 0.450 m F = 6 250 W ÷ 0.450 m s^{-1} = 13.9 kN	**(1)** **(1)**	**2**
18(b)	Use of $\Delta W = F \Delta s$ Use of Δs = 4.35 / sin 6.0° Total work = 5.8 × 10^5 J (allow ecf from (a)) <u>Example of calculation</u> ΔW = 13.9 × 10^3 N × 4.35 m ÷ sin 6.0° = 578 kJ	**(1)** **(1)** **(1)**	**3**
18(c)	Use of $\Delta E_{\text{grav}} = m g \Delta h$ Useful work done = 89.6 (kJ) <u>Example of calculation</u> ΔE_{grav} = 2.10 × 10^3 kg × 9.81 N kg^{-1} × 4.35 m = 89.6 kJ	**(1)** **(1)**	**2**
18(d)	Use of ε = useful energy output / total energy unput Efficiency = 0.16 (allow ecf from (b) and (c)) <u>Example of calculation</u> ε = 89.6 kJ ÷ 578 kJ = 0.155	**(1)** **(1)**	**2**
	Total for question 18		**9**

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