Mark Scheme (Results)

Summer 2021

Pearson Edexcel International Advanced Subsidiary Level In Physics (WPH11)

Paper 01 Mechanics and Materials

Question Number	Answer	Mark
1	**D is the correct answer** A is incorrect because weight is a force, which is a vector B is incorrect because momentum is a vector C is incorrect because velocity is a vector	**(1)**
2	**C is the correct answer** A is incorrect because it give units of $m^3\ kg^{-1}$ B is incorrect because it give units of $m^3\ kg\ N^{-2}$ D is incorrect because it give units of $N^2\ kg^{-1}\ m^{-3}$	**(1)**
3	**C is the correct answer** A is incorrect because the frictional force from the road is the driving force B is incorrect because a drag force is also acting D is incorrect because the frictional force from the road is the driving force	**(1)**
4	**B is the correct answer** A is incorrect because it gives units of J C is incorrect because it gives an input power less than the output power D is incorrect because it gives units of J	**(1)**
5	**D is the correct answer** A is incorrect because the units are inconsistent B is incorrect because it gives a greater length, and *F* is a compressive force C is incorrect because the units are inconsistent	**(1)**
6	**B is the correct answer** A is incorrect because it gives units of $J\ m \neq N$ C is incorrect because it gives units of $W\ m\ s^{-1} \neq N$ D is incorrect because it gives units of $m\ s\ W^{-1} \neq N$	**(1)**
7	**B is the correct answer** A is incorrect because the acceleration is g which has constant magnitude and direction C is incorrect because the objects gain the same k.e. for the same drop height D is incorrect because both objects start with the same k.e. and gain the same k.e.	**(1)**
8	**C is the correct answer** A is incorrect because the acceleration does not reach zero B is incorrect because the acceleration does not reach zero D is incorrect because the acceleration does not reach zero	**(1)**
9	**D is the correct answer** A is incorrect because the fracture point is at the extreme end of the graph B is incorrect because proportionality ends before point X is reached C is incorrect because point X is not the highest point reached by the graph	**(1)**
10	**C is the correct answer** A is incorrect because R is in the wrong direction B is incorrect because R is the wrong diagonal D is incorrect because R is the wrong diagonal	**(1)**

Question Number	Answer	Mark
11(a)	Use of $p = mv$ **(1)** $p = 4.53 \times 10^5$ (kg m s^{-1}) **(1)** (reverse calculation can gain both marks) <u>Example of calculation</u> $p = mv$ $p = (7.15 + 5.35) \times 10^4$ kg $\times$ 3.62 m s^{-1} = 4.53×10^5 kg m s^{-1}	**2**
11(b)	Equates the initial with the final momentum. **(1)** v = 2.44 m s^{-1} (allow ecf from (a)) **(1)** <u>Example of calculation</u> 5.35×10^4 kg $\times v +$ 7.15×10^4 kg $\times$ 4.50 m s^{-1} = 4.53×10^5 kg m s^{-1} v = (4.53×10^5 kg m s^{-1} − 7.15×10^4 kg $\times$ 4.50 m s^{-1})/ 5.35×10^4 kg = 2.44 m s^{-1}	**2**
11(c)	Use of $E_K = \frac{1}{2} m v^2$ **(1)** $E_K = 6.5 \times 10^4$ J (allow ecf from (b)) **(1)** <u>Example of calculation</u> Initial k.e. = 0.5 $\times$(7.15×10^4 kg $\times$(4.50 m s^{-1})^2 + 5.35×10^4 kg $\times$ (2.44 m s^{-1})^2) = 8.84×10^5 J Final k.e. = 0.5$\times$12.5 $\times 10^4$ kg $\times$ (3.62 m s^{-1})^2) = 8.19×10^5 J Difference = 8.84×10^5 J − 8.19×10^5 J = 6.47×10^4 J	**2**
	Total for question 11	**6**

Question Number	Answer		Mark
12(a)	**Either**		
	Decrease of GPE = gain of KE.	**(1)**	
	Use of $E_k = ½\, m\, v^2$ and $\Delta E_{grav} = m\, g\, \Delta h$	**(1)**	
	$v = 3.1(\text{ m s}^{-1})$	**(1)**	
	Or		
	Use of trigonometry to find parallel component of g **and** distance along ramp	**(1)**	
	Use of $v^2 = u^2 + 2\, a\, s$ (or other valid *suvat* method)	**(1)**	
	$v = 3.1(\text{ m s}^{-1})$	**(1)**	**3**
	(reverse calculations can score maximum 2 marks)		
	<u>Example of calculation</u> $½\, m\, v^2 = m\, g\, \Delta h$ $½\, v^2 = 9.81 \text{ m s}^{-2} \times 0.5 \text{ m}$ $v = \sqrt{(2 \times 9.81 \text{ m s}^{-2} \times 0.5 \text{ m})} = 3.13 \text{ m s}^{-1}$		
12(b)	Use of Pythagoras' Theorem to calculate distance along the ramp **Or** Use of trigonometry to find parallel component of g	**(1)**	
	Use of $s = ½\, (u + v)\, t$ (or other valid *suvat* method for t_{AB})	**(1)**	
	Use of $s = u\, t$	**(1)**	
	Total time = 1.64 s (show that value gives 1.65 s)	**(1)**	**4**
	(may see some MPs for (b) in (a))		
	<u>Example of calculation</u> Distance along ramp $= (\sqrt{(2^2 + 0.5^2)}) \text{ m} = 2.06 \text{ m}$ $2.06 \text{ m} = ½\, (0 + 3.13) \text{ m s}^{-1} \times t_{AB}$ $t_{AB} = 2 \times 2.06 \text{ m} / 3.13 \text{ m s}^{-1} = 1.32 \text{ s}$ $t_{BC} = 1 \text{ m} / 3.13 \text{ m s}^{-1} = 0.32 \text{ s}$ Total time = 1.32 s + 0.32 s = 1.64 s		
	Total for question 12		**7**

Question Number	Answer		Mark
13(a)(i)	Use of $\rho = m / V$ (and $U = mg$)	**(1)**	
	$U = 5.9 \times 10^7$ N	**(1)**	**2**
	<u>Example of calculation</u> $U = \rho g V = 1.03 \times 10^3$ kg m$^{-3} \times 9.81$ N kg$^{-1} \times 5.83 \times 10^3$ m$^3 = 5.89 \times 10^7$ N		
13(a)(ii)	Weight of submarine is equal to the upthrust.	**(1)**	
	Refers to $W = m g$ to justify a mass of 6.00×10^6 kg **Or** Refers to mass calculated in (a)(i) to justify a mass of 6.00×10^6 kg	**(1)**	**2**
	<u>Example of calculation</u> $W = U = 5.89 \times 10^7$ N $= m \times 9.81$ N kg^{-1} $m = 5.89 \times 10^7$ N / 9.81 N kg$^{-1} = 6.00 \times 10^6$ kg		
13(b)(i)	The upthrust (of the water on the submarine) is less than the weight of the submarine	**(1)**	
	A resultant force acts (downwards) on the submarine	**(1)**	
	So the submarine will (begin to) sink (dependent on MP1)	**(1)**	**3**
13(b)(ii)	Use of $\rho = m/V$ **and** $W = mg$ to calculate new upthrust	**(1)**	
	Mass of water = 1×10^5 kg (pumped out) (allow ecf from (a)(i))	**(1)**	**2**
	<u>Example of calculation</u> Upthrust = 1.01×10^3 kg m$^{-3} \times 9.81$ N kg$^{-1} \times 5.83 \times 10^3$ m$^3 = 5.78 \times 10^7$ N Net downward force = 5.89×10^7 N – 5.78×10^7 N = 1.14×10^6 N Mass to be lost = 1.14×10^6 N / 9.81 N kg$^{-1} = 1.17 \times 10^5$ kg		
	Total for question 13		**9**

Question Number	Answer	Mark
14(a)	Resolves velocity into horizontal and vertical components. **(1)** Use of $s = u\,t$ for horizontal displacement **(1)** Use of $s = u\,t + ½\,a\,t^2$ with $a = g$ for vertical displacement **(1)** Height after 30 m = 0.91 m **(1)** **Or** decrease in height = 1.99 m Comparison and conclusion consistent with student's calculation. **(1)** A method that calculates horizontal displacement in time taken to fall 2.9 m can score full marks. *e.g.* Resolves velocity into horizontal and vertical components. **(1)** Use of *suvat* equations to calculate total time in flight **(1)** Use of $s = u\,t$ for horizontal displacement **(1)** Total distance = 32.7 m **(1)** Comparison and conclusion consistent with student's calculation. **(1)** <u>Example calculation</u> $v_H = 25 \text{ m s}^{-1} \times \cos 10° = 24.6 \text{ m s}^{-1}$ $v_V = 25 \text{ m s}^{-1} \times \sin 10° = 4.34 \text{ m s}^{-1}$ $30 \text{ m} = 24.61 \text{ m s}^{-1} \times t$ $\rightarrow t = 30 \text{ m} \div 24.6 \text{ m s}^{-1} = 1.22 \text{ s}$ $s = 4.34 \text{ m s}^{-1} \times 1.22 \text{ s} - 0.5 \times 9.81 \times 1.22^2 = -1.99 \text{ m}$ Height = 2.9 m − 1.99 m = 0.91 m 0.91 m > 0.00 m ∴ success	5
14(b)	**Either** Use of $E_K = ½\,m\,v^2$ **(1)** Use of $\Delta W = F\Delta s$ **(1)** $F = 3.88 \times 10^2$ N **(1)** **Or** Use of $v^2 = u^2 + 2as$ or combination of *suvat* equations to find deceleration. **(1)** Use of $F = m\,a$ **(1)** $F = 3.88 \times 10^2$ N **(1)** <u>Example of calculation</u> $E_K = ½ \times 63 \times 23^2 = 1.67 \times 10^4$ J $1.67 \times 10^4 \text{ J} = F \times 43$ $F = 1.67 \times 10^4 \text{ J} / 43 = 3.88 \times 10^2$ N	3
	Total for question 14	**8**

Question Number	Answer	Mark
*15	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 or more	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
Answer has no linkages between points and is unstructured	0

Indicative content

- When the spacecraft is accelerating the astronaut accelerates at the same rate.
- The seat is applying a forward force to the astronaut so (by N3) the astronaut is applying a backward/opposite force to the seat (which compresses the seat).
- As the fuel is used up, the mass of the spacecraft decreases.
- (As the mass of the spacecraft decreases) the acceleration increases.
- The force between the seat and the astronaut increases thus further compressing the seat.
- The seat decompresses (to push the astronaut forwards) when the force (from the rocket motor) becomes zero.
  Or
  The seat decompresses when the force (from the rocket motor) is removed.
  Or
  The force from the safety strap decelerates the astronaut.

1IC	**(1)**	
2IC **Or** 3IC	**(1)**	
3IC + linkage **Or** 4IC **Or** 5IC	**(1)**	**6**
4IC + linkage **Or** 5IC + linkage **Or** 6IC	**(1)**	
5IC + 2 × linkage **Or** 6 IC + linkage	**(1)**	
6IC + 2 × linkage	**(1)**	

	Total for question 15	**6**

Question Number	Answer		Mark
16(a)	Use of moment = $F\,x$ Use of Σ(moments) = 0 $R_1 = 3.7$ kN **and** $R_2 = 8.6$ kN <u>Example of calculation</u> Taking moments about rear axle: $R_1 = (1.8\text{ m} \times 1.23 \times 10^4\text{ N}) / 6\text{ m} = 3.69 \times 10^3\text{ N}$ Taking moments about the front axle: $R_2 = (4.2\text{ m} \times 1.23 \times 10^4\text{ N}) / 6\text{ m} = 8.61 \times 10^3\text{ N}$	**(1)** **(1)** **(1)**	**3**
16(b)	Use of $\Sigma F = m\,a$ $\Sigma F = 6.77 \times 10^4$ N <u>Example of calculation</u> $\Sigma F = (1.23 \times 10^4\text{ N} / g) \times 5.50\text{ g} = 6.77 \times 10^4\text{ N}$	**(1)** **(1)**	**2**
16(c)	Reference to $P = W / t$ **Or** $\Delta W = F\,\Delta s$ Force decreases as velocity increases	**(1)** **(1)**	**2**
	Total for question 16		**7**

Question Number	Answer	Mark
17(a)	The greater the length of the rope, the greater the extension for a given force **(1)** Stiffness $k = F / \Delta x$ so stiffness decreases (if extension increases). **(1)**	**2**
17(b)(i)	Use of $E = \frac{\sigma}{\varepsilon}$ **and** $\sigma = \frac{F}{A}$ **and** $\epsilon = \frac{\Delta x}{x}$ **(1)** Use of $F = k\Delta x$ **(1)** $k = 1.35 \times 10^5$ (N m^{-1}) **(1)** <u>Example of calculation</u> 2.70×10^9 N m^{-2} = $F \times 6.00$ m ÷ (3.00×10^{-4} m^2 × ΔL) $F = (2.70 \times 10^9 \text{ N m}^{-2} \times 3.00 \times 10^{-4} \text{ m}^2 \div 6.00 \text{ m}) \times \Delta L = k\,\Delta x$ $k = \frac{F}{\Delta L} = \frac{2.70 \times 10^9 \text{ N m}^{-2} \times 3.00 \times 10^{-4} \text{ m}^2}{6.00 \text{ m}}$ $= 1.35 \times 10^5$ N m^{-1}	**3**
17(b)(ii)	Correct use of factor of 2 to calculate F or Δx **(1)** Use of $\Delta F = k\Delta x$ **(1)** 1.85×10^{-2} (m) (allow ecf from (i)) **(1)** <u>Example of calculation</u> F = 5 000 N/ 2 = 2 500 N $\Delta x = \frac{F}{k} = \frac{2\,500 \text{ N}}{1.35 \times 10^5 \text{ N m}^{-1}} = 1.85 \times 10^{-2}$ m	**3**
17(b)(iii)	Use of $\Delta E_{el} = \frac{1}{2} F\Delta x$ **(1)** ΔE_{el} = 23.1 J (allow ecf from (ii)) **(1)** <u>Example of calculation</u> $\Delta E_{el} = 0.5 \times 2\,500 \text{ N} \times 1.85 \times 10^{-2} \text{ m} = 23.13$ J	**2**
17(c)	Use of W = $F\Delta$s (to find the work done in lifting the load) **(1)** Compares 7 500 J with their calculated value in b(iii) and draws suitable conclusion **(1)** <u>Example of calculation</u> Work done by pulley system = 5×10^3 N × 1.5 m = 7 500 J 23(.1) (J) << 7 500 (J) ∴ not significant	**2**
	Total for question 17	**12**

Question Number	Answer		Mark
18(a)	The constant maximum velocity reached by an object falling (through a fluid) When the resultant force equals zero **Or** when the drag plus the upthrust equals the weight	**(1)** **(1)**	**2**
18(b)	Use of $V = 4\pi r^3 / 3$ Use of upthrust U = weight of fluid displaced W Use of $\rho = m / V$ and $W_S = mg$ Use of $D = W - U$ $D = 0.24$ (N) <u>Example of calculation</u> $V = \frac{4}{3}\pi \times (0.0175\text{ m})^3 = 2.24 \times 10^{-5}\text{ m}^3$ $U = 2.24 \times 10^{-5}\text{ m}^3 \times 1.43 \times 10^3\text{ kg m}^{-3} \times 9.81\text{ N kg}^{-1} = 0.314\text{ N}$ $W = 2.24 \times 10^{-5}\text{ m}^3 \times 2.52 \times 10^3\text{ kg m}^{-3} \times 9.81\text{ N kg}^{-1} = 0.554\text{ N}$ $D = 0.554\text{ N} - 0.314\text{ N} = 0.240\text{ N}$ $D = W - U = (2.52 - 1.43) \times 10^3\text{ kg m}^{-3} \times 9.81\text{ N kg}^{-1} \times \frac{4}{3}\pi \times (0.0175\text{ m})^3 = 0.24\text{ N}$	**(1)** **(1)** **(1)** **(1)** **(1)**	**5**
18(c)(i)	All data points are close to the straight line through origin **Or** Best fit straight line goes through origin This consistent with Stokes' Law. Stokes' Law implies laminar flow (for the spheres).	 **(1)** **(1)** **(1)**	**3**
18(c)(ii)	Determines gradient of graph Uses large triangle. $k = 5.8$ to $6.2\text{ m}^{-1}\text{s}^{-1}$	**(1)** **(1)** **(1)**	**3**
18(c)(iii)	Use of $k = \frac{(\rho_g - \rho_s)g}{18\eta}$ $\eta = 99$ Pa s (allow ecf from (c)(ii)) <u>Example of calculation</u> $\eta = \frac{(\rho_g - \rho_s)g}{18k} = \frac{(2.52 - 1.43) \times 10^3\text{ kg m}^{-3} \times 9.81\text{N kg}^{-1}}{18 \times 6\text{ m}^{-1}\text{s}^{-1}} = 99.0\text{ Pa s}$	**(1)** **(1)**	**2**
	Total for question 18		**15**