Mark Scheme (Results)

January 2026

Pearson Edexcel International Advanced Subsidiary level
In Physics
Mechanics and Materials
WPH11/01A

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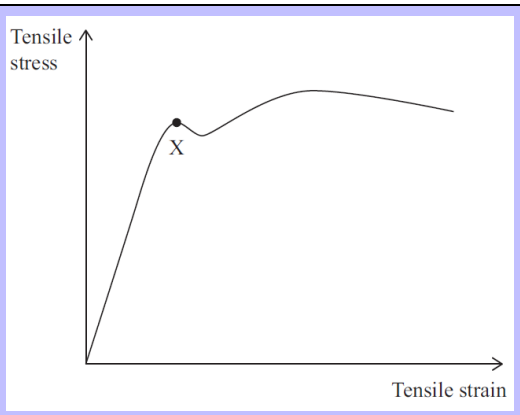
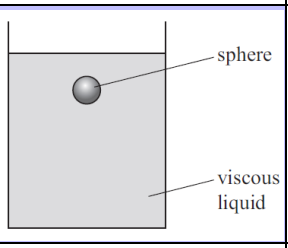
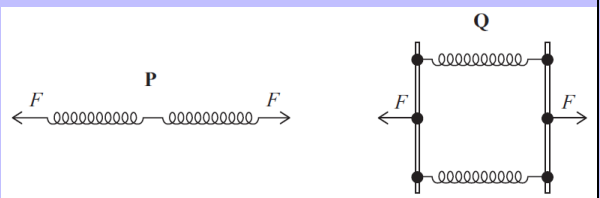
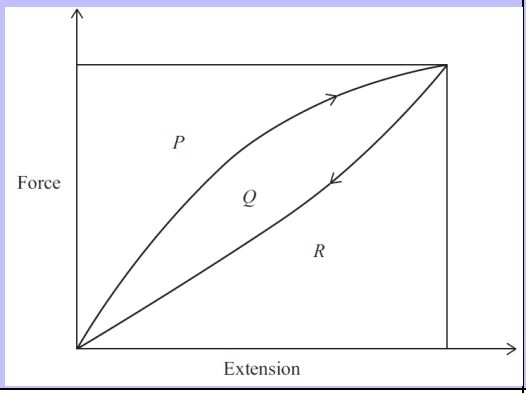
January 2026
Question Paper Log Number P87631A
Publication Code WPH11_01A_2601_MS

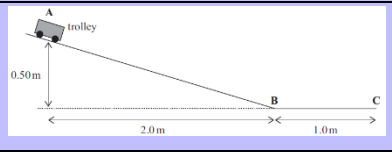
General Marking Guidance

- 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.

Question Number	Answer	Mark
	Which of the following is a scalar quantity?	
1	**The only correct answer is D** (work) A is incorrect because force is a vector B is incorrect because momentum is a vector C is incorrect because velocity is a vector	**1**
	Two forces, X and Y, act at a point. **Which of the following vector diagrams shows the magnitude and direction of the resultant of the two forces?**	
2	**The only correct answer is C** (vectors X and Y drawn tip-to-tail and resultant force vector drawn in direction from start of X to end of Y) A is incorrect because the vectors have not been added B is incorrect because the vectors have not been added D is incorrect because the resultant is in the wrong direction	**1**
	A copper rod was placed under tensile stress and the tensile strain in the rod was measured. **The graph shows how the tensile stress required to cause a tensile strain in the rod depends upon the tensile strain.** **What does point X represent?**  	
3	**The only correct answer is D** (the yield point of copper) 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**
	A tractor pulls a trailer a distance *s* in time *t*. The useful power output of the tractor is *P*. **Which of the following equations gives the force *F* of the tractor on the trailer?**	
4	**The only correct answer is B** $\left(F = \frac{Pt}{s}\right)$ 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**
	A cylinder of aluminium has a weight of 35.0 N and a volume of 1.32 × 10^{-3} m^3. **Which of the following calculations gives the density of aluminium in kg m^{-3}?**	
5	**The only correct answer is C** $\left(\frac{35.0}{9.81 \times 1.32 \times 10^{-3}}\right)$ A is incorrect because it gives units of m^3 kg^{-1} B is incorrect because it gives units of m^3 kg N^{-2} D is incorrect because it gives units of N^2 kg^{-1} m^{-3}	**1**

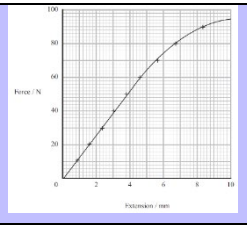
	An object on the Moon falls a vertical distance of 0.32 m, from rest, in a time of 0.63 s. **Which of the following expressions gives the acceleration due to gravity on the Moon in m s^{-2}?**	
6	**The only correct answer is C** $\left(\frac{2\times0.32}{0.63^2}\right)$ A is incorrect because the 2 should be above the line, and the 0.63 should be squared B is incorrect because the 2 should be above the line D is incorrect because he 0.63 should be squared	**1**
	A sphere falls through a viscous liquid as shown. **Which row of the table describes the upthrust and the viscous drag on the sphere as it accelerates downwards?**  	
7	**The only correct answer is B** (Upthrust constant and viscous drag increasing) A is incorrect because the upthrust is constant C is incorrect because the upthrust is constant and the viscous drag is increasing D is incorrect because the viscous drag is increasing	**1**
	Two arrangements, P and Q, of identical springs are subjected to the same tensile force *F*, as shown. **When one spring is subjected to a tensile force *F*, the elastic strain energy for the spring is *E*.** **Which row of the table gives the total elastic strain energy for each arrangement?**  	
8	**The only correct answer is D** (P: 2E; Q: ½ E) A is incorrect because springs in series increase the extension and springs in parallel decrease the extension for the same force B is incorrect because springs in series increase the extension for the same force C is incorrect because springs in parallel decrease the extension for the same force	**1**

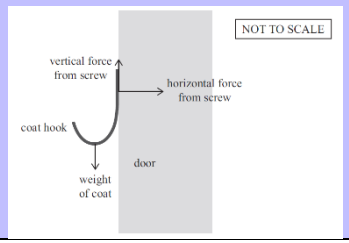
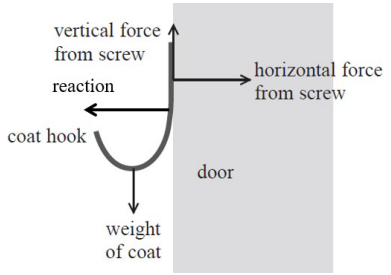
	A rubber band is initially stretched by an increasing force. When the force is gradually decreased, the rubber band returns to its original length. The force-extension graph for the rubber band is shown. **P, Q and R represent different areas of the graph.** **Which of the following gives the work done in stretching the rubber band up to its maximum extension?** 	**1**
9	**The only correct answer is B** ($Q + R$) A is incorrect because P is spurious and R is not included C is incorrect because Q is not included D is incorrect because R is not included	**1**
	A person is pushing a trolley at a constant velocity. **The floor exerts a force *W* on the person. The person exerts a force *X* on the trolley.** **The trolley exerts a force *Y* on the person and the total drag force on the trolley is *Z*.** **Which pair of forces is a Newton's Third Law pair?** 	
10	**The only correct answer is B** (X and Y) A is incorrect because force W and Y act on the same object C is incorrect because force X and Z act on the same object D is incorrect because forces W and Z are not the same type of force.	**1**

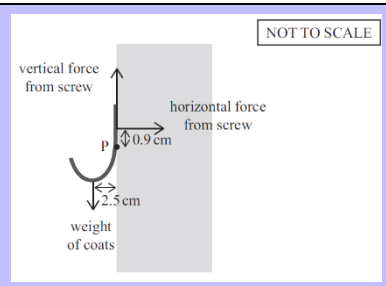
Question Number	Answer	Additional Guidance	Mark
	A trolley accelerates from rest at point A, down a straight track to point B. The trolley then continues along a horizontal track to point C, as shown. The effects of air resistance are negligible (a) Show that the trolley reaches point B with a speed of about 3 m s^{-1}.		.

11(a)	Use of $\Delta E_{\text{grav}} = mg\Delta h$ Use of $E_{\text{k}} = \frac{1}{2}mv^2$ $v = 3.1\ \text{m s}^{-1}$ (to at least 2 significant figures) **OR** Use of appropriate trigonometry to determine *s* and *a* **Or** Use of Pythagoras to determine *s* and *a* **Or** Use of appropriate trigonometry and Pythagoras to determine *s* and *a* Use of appropriate equation(s) of motion to determine v $v = 3.1\ \text{m s}^{-1}$ (to at least 2 significant figures) (dependent on MP1)	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	Example of calculation $m \times 9.81\ \text{m s}^{-2} \times 0.5\ \text{m} = 0.5 \times m \times v^2$ $v = \sqrt{\frac{9.81\ \text{m s}^{-2} \times 0.5\ \text{m}}{0.5}} = 3.13\ \text{m s}^{-1}$ Example of calculation $\theta = \tan^{-1}\left(\frac{0.5}{2.0}\right) = 14°$ $a = 9.81\ \text{m s}^{-2} \times \sin(14°) = 2.37\ \text{m s}^{-2}$ $s = \sqrt{2^2 + 0.5^2} = 2.06\ \text{m}$ $v^2 = 0^2 + 2 \times 2.37\ \text{m s}^{-2} \times 2.06\ \text{m} = 9.76\ \text{m}^2\ \text{s}^{-2}$ $v = \sqrt{9.76\ \text{m}^2\ \text{s}^{-2}} = 3.12\ \text{m s}^{-1}$	**3**
11(b)	Use of Pythagoras' Theorem to calculate distance along the ramp **Or** Use of appropriate trigonometry to determine distance along ramp **Or** Use of appropriate trigonometry to determine acceleration along ramp Use of appropriate equation(s) of motion to determine time taken to move down ramp with a non-zero (component of) *a* Use of $s = ut + \frac{1}{2}at^2$ with *a* = 0 (to determine time on horizontal track) Total time = 1.7 s (ecf from 11(a)) Note: they may end up with 1.64 s depending on rounding, so final answer may be 1.6 s (Show that value gives 1.7)	**(1)** **(1)** **(1)** **(1)**	Example of calculation $s = \sqrt{(2.0\ \text{m})^2 + (0.50\ \text{m})^2} = 2.06\ \text{m}$ $2.06\ \text{m} = \frac{0 + 3.1\ \text{m s}^{-1}}{2} \times t_{\text{ramp}}$ $t_{\text{ramp}} = \frac{2.06\ \text{m} \times 2}{3.1\ \text{m s}^{-1}} = 1.33\ \text{s}$ $t_{\text{horizontal}} = \frac{1.0\ \text{m}}{3.1\ \text{s}} = 0.32\ \text{s}$ $t_{\text{total}} = 1.33\ \text{s} + 0.32\ \text{s} = 1.65\ \text{s}$	**4**
	Total for question 11			**7**

Question Number	Answer	Additional Guidance	Mark
	A student carried out an experiment to determine the Young modulus of constantan. **The student had a constantan wire with cross-sectional area *A* of $3.97 \times 10^{-7}\ m^2$.** **The unstretched length *x* of the wire was 4.00 m.** **(a) The student had enough slotted masses to apply a weight of up to 150 N to the wire.** **The breaking stress for constantan is about 420 MPa.** **Deduce whether the wire could support a weight of 150 N.**		
12(a)	Use of $\sigma = \frac{F}{A}$ **(1)** $\sigma = 378$ MPa **(1)** Comparison of calculated stress with 420 (MPa) and consistent conclusion **(1)** For MP2 and 3 *F =167* N; Comparison of calculated force with 150 (N) and consistent conclusion **Or** $A = 3.57 \times 10^{-7} m^2$; Comparison of calculated area with $3.97 \times 10^{-7} (m^2)$ and consistent conclusion	Example of calculation $\frac{150\ N}{3.97 \times 10^{-7}\ m^2} = 378$ MPa 378 MPa < 420 MPa so yes, it can support the weight	**3**

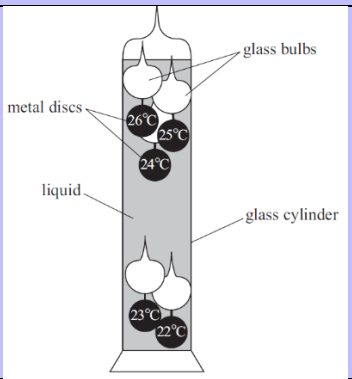
	The student added slotted masses to the wire and determined the corresponding extensions. The student plotted a graph of force against extension, as shown. **(i) Show that the stiffness of the wire is about 1.3×10^4 N m^{-1}.** 			
12(b)(i)	Determines gradient of straight line section with an extension of $\leq$ 5.0 mm and force $\leq$ 64 N **Or** Use of $\Delta F = k\Delta x$ with an extension of $\leq$ 5 mm **(1)** $k = 1.30 \times 10^4$ (N m^{-1}) to at least 3 significant figures **(1)**		allow a tolerance of $\pm$ half a small square allow a value consistent with their valid readings MP2 dependent on MP1 <u>Example of calculation</u> $k = \frac{60 \text{ N}}{4.6 \times 10^{-3} \text{m}} = 1.304 \times 10^4 \text{ N m}^{-1}$	**2**
	The relationship between the stiffness *k* of the wire and the Young modulus *E* is given by $k = \frac{EA}{x}$ **where *x* is the unstretched length of the wire and *A* is the cross-sectional area of the wire.** **Determine a value for the Young modulus of constantan using the student's data.**			
12(b)(ii)	Use of $k = \frac{EA}{x}$ **(1)** $E = 1.3 \times 10^{11}$ Pa (ecf from (b)(i)) **(1)**		<u>Example of calculation</u> $E = \frac{1.3 \times 10^4 \text{ N m}^{-1} \times 4.00 \text{ m}}{3.97 \times 10^{-7} \text{ m}^2}$ $E = 1.31 \times 10^{11}$ Pa	**2**
	Total for question 12			**7**

Question Number	Answer	Additional Guidance	Mark
	A coat hook is attached to a smooth door by a screw, as shown.  The diagram below shows three of the forces that act on the coat hook when a coat is hung from it. The weight of the coat hook may be neglected.  Add a labelled arrow to the diagram in the answer book to show the additional force required for the coat hook to be in equilibrium.		
13(a)	Horizontal arrow starting at wall and pointing to the left labelled normal contact force **(1)** Horizontal force arrow drawn starting at wall below screw and not lower than last point of contact between hook and door. **(1)**	Acceptable labels include Reaction force, *R*, Normal contact force, *N*, Force from door/wall, *F*, additional force. If more than one arrow drawn, MP1 cannot be scored <u>Example of diagram</u> 	**2**

	If too many coats are hung on the coat hook, the hook will rotate and pull the screw out of the door. Point P is the position of the pivot as shown. **The maximum horizontal force from the screw is 150 N.** **The mass of one coat is 2.6 kg.** **Deduce whether a person could hang more than two of these coats from the hook.**			
13(b)	Use of moment of force = $F\,x$ **(1)** Use of principle of moments **(1)** Use of $W = m\,g$ **(1)** 2.1 (coats) > 2 (coats) so yes **(1)** **Or** 2.1 (coats) < 3 (coats) so no **Or**(Horizontal force needed from screw for exactly 2 coats) 141.7 (N) < 150 (N) so yes **Or** (Distance from screw to pivot for exactly 2 coats) 0.85 (cm) < 0.9 (cm) so yes **Or** (Distance of hook from wall for exactly 2 coats is) 2.646 (cm) > 2.5 (cm) so yes **Or** (maximum mass that the hook can support) 5.5 (kg) > 5.2 (kg) so yes **Or** (maximum weight that the hook can support) 54 (N) > 51 (N) so yes **Or** (Maximum mass of one coat would be) 2.75 (kg) > 2.6 (kg) so yes **Or**(Maximum weight of one coat would be) 27 (N) >25.5 (N) so yes. **Or** (moment caused by weight of 2 coats) 1.28 (Nm) < 1.35 (Nm) so yes **NOTE that other comparisons may also be valid**	Allow an answer that calculates the clockwise moment and calculates the anticlockwise moment caused by the weight of 2 or 3 coats. Example of calculation $0.9\text{ cm} \times 150\text{ N} = 2.5\text{ cm} \times F$ $F = \dfrac{0.9\text{ cm} \times 150\text{ N}}{2.5\text{ cm}} = 54\text{ N}$ $2.6\text{ kg} \times 9.81\text{ N kg}^{-1} = 25.5\text{ N}$ $\dfrac{54\text{ N}}{25.5\text{ N}} = 2.12\text{ coats}$ 2.12 > 2 so yes	**4**
	Total for question 13			**6**

Question Number	Answer	Additional Guidance	Mark
	A small sphere is moving horizontally through a viscous liquid. **(a) Stokes' law can be used to calculate the drag force on an object.** **State the conditions that must apply for Stokes' law to be valid.**		
14(a)	Small, spherical object **Or** Spherical object with low speed **(1)** Laminar flow **(1)**	Allow an absence of turbulent flow	**2**
	There is a constant force of 2.3×10^{-5} N acting horizontally on the sphere in the same direction that the sphere is moving. **diameter of sphere = 4.5×10^{-3} m** **viscosity of liquid = 7.1×10^{-2} Pa s** **(i) At one instant, the speed of the sphere is 5.2×10^{-3} m s^{-1}.** **Calculate the resultant horizontal force on the sphere.**		
14(b)(i)	Use of $F = 6\pi\,\eta\,r\,v$ with $r = \frac{d}{2}$ **(1)** Calculates ΣF **(1)** Resultant force = 7×10^{-6} N **(1)**	Example of calculation $F_{\text{drag}} = 6 \times \pi \times 7.1 \times 10^{-2}\ \text{Pa s} \times \frac{4.5 \times 10^{-3}\ \text{m}}{2} \times 5.2 \times 10^{-3}\ \text{m s}^{-1}$ $F_{\text{drag}} = 1.57 \times 10^{-5}\ \text{N}$ $\Sigma F = 2.3 \times 10^{-5}\ \text{N} - 1.57 \times 10^{-5}\ \text{N} = 7.3 \times 10^{-6}\ \text{N}$	**3**

	Calculate the maximum speed of the sphere in the horizontal direction.			
14(b)(ii)	Use of $F = 6\pi \eta r v$ with $F = 2.3 \times 10^{-5}$ N $v = 7.6 \times 10^{-3}$ m s^{-1}	**(1)** **(1)**	May use diameter instead of radius in this question part and still score MP1 Example of calculation $2.30 \times 10^{-5}\text{N} = 6 \times \pi \times 7.10 \times 10^{-2}\ \text{Pa s} \times 2.25 \times 10^{-3}\ \text{m} \times v$ $v = \dfrac{2.30 \times 10^{-5}\text{N}}{6 \times \pi \times 7.10 \times 10^{-2}\ \text{Pa s} \times 2.25 \times 10^{-3}\ \text{m}}$ $v = 7.6 \times 10^{-3}\ \text{m s}^{-1}$	**2**
	Total for question 14			**7**

Question Number	Answer	Additional Guidance	Mark
	A Galilean thermometer consists of a closed glass cylinder containing a liquid. In the liquid there are several identical sealed glass bulbs, as shown. Attached to each bulb is a metal disc labelled with a temperature. Each disc has a different mass. As the temperature increases, the density of the liquid decreases. This can cause the bulbs to move within the liquid. Explain why a particular bulb will float until the temperature of the liquid exceeds a certain value.		

***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.

IC points	IC mark	Max linkage mark	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

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
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

Indicative content

IC1 Upthrust equals weight of liquid displaced.

IC2 When upthrust ≥ weight of bulb / disc, bulb floats

IC3 As temperature increases, upthrust decreases (because density of liquid decreases)
Or
As temperature increases, weight of liquid displaced decreases (because density of liquid decreases)

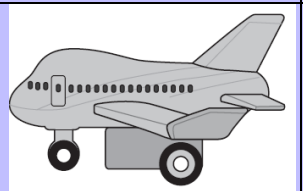
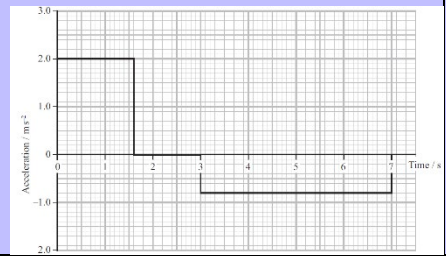
IC4 Until weight of a bulb / disc > upthrust

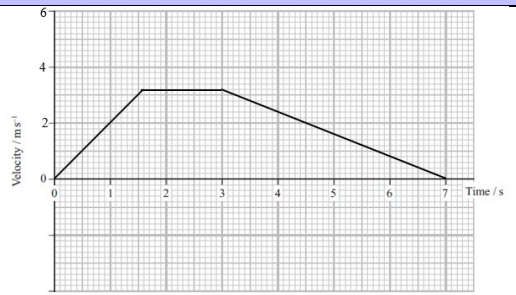
IC5 So there is a resultant force downwards on the bulb

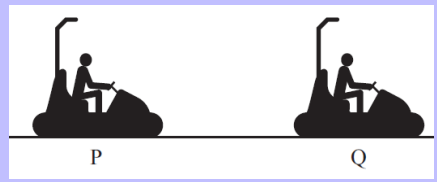
IC6 So the bulb accelerates downwards

6

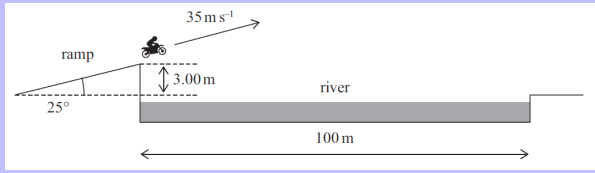
Total for question 15 **6**

Question Number	Answer	Additional Guidance	Mark
	The toy aeroplane in the diagram has a spring mechanism connected to the wheels. When the aeroplane is pulled backwards, the wheels rotate backwards and a spring is compressed. When the aeroplane is released, the force from the spring propels the aeroplane forwards.  The aeroplane is pulled backwards and released from rest. The aeroplane then moves forward in a straight line along a flat surface. The simplified acceleration–time graph for the forward motion of the aeroplane is shown. Show that the maximum velocity of the aeroplane is about 3 m s^{-1}.  		

16(a)	Use of $v = u + at$ **Or** Determines area under the graph **(1)** v = 3.2 (m s^{-1}) (to 2 significant figures) **(1)**	Example of calculation $v = 0 + 2.0\ \text{m s}^{-2} \times 1.6\ \text{s} = 3.2\ \text{m s}^{-1}$ Note: watch out for $0.8\ \text{m s}^{-2} \times 4.0\ \text{s} = 3.2\ \text{m s}^{-1}$ which is also a valid method.	**2**
	On the axes in the answer book, draw the corresponding velocity–time graph for the aeroplane.		
16(b)	Straight line from origin to (3.2 m s^{-1}, 1.6 s) (ecf from 16(a)) **(1)** Line parallel to x-axis between 1.6 s and 3.0 s, at maximum velocity **(1)** Straight line from maximum velocity at 3.0 s to (0 m s^{-1}, 7.0 s) **(1)**		**3**
	Calculate the total distance travelled by the aeroplane after release.		
16(c)	Calculates areas under their graph from 0 s to 1.6s **And** Calculates areas under their graph from 1.6 s to 3.0 s **(1)** **And** Calculates areas under their graph from 3.0 s to 7.0 s. **(1)** Adds areas together **(1)** s = 13 m (ecf from 16(a) and / or 16(b)) (show that value gives 12.6 m) **OR** Time at maximum velocity determined from their graph **And** total time determined from their graph **(1)** Determines area of trapezium **(1)** s = 13 m (ecf from 16(a) and / or 16(b)) (show that value gives 12.6 m) **(1)**	Example of calculation $\frac{1}{2} \times 3.2\ \text{m s}^{-1} \times 1.6\ \text{s} = 2.56\ \text{m}$ $3.2\ \text{m s}^{-1} \times 1.4\ \text{s} = 4.48\ \text{m}$ $\frac{1}{2} \times 3.2\ \text{m s}^{-1} \times 4.0\ \text{s} = 6.40\ \text{m}$ $s = 2.56\ \text{m} + 4.48\ \text{m} + 6.40\ \text{m} = 13.44\ \text{m}$	**3**
	Total for question 16		**8**

Question Number	Answer	Additional Guidance	Mark
	The diagram shows two bumper cars, P and Q, at an amusement park. Q was stationary. P was moving at a speed of 2.10 m s^{-1} towards Q. P collided with Q. After the collision, P and Q moved off in the same direction. P moved with a speed of 1.15 m s^{-1}. Q moved with a speed of 1.57 m s^{-1}. **(a) (i) Show that the total mass of Q was about 150 kg.** **total mass of P = 250 kg** 		
17(a)(i)	Use of $p = mv$ **(1)** Use of conservation of momentum **(1)** m = 151 (kg) (to at least 3 significant figures) **(1)**	Example of calculation $250\ \text{kg} \times 2.10\ \text{m s}^{-1} = 250\ \text{kg} \times 1.15\ \text{m s}^{-1} + m_{\text{Q}} \times 1.57\ \text{m s}^{-1}$ $m_{\text{Q}} = \dfrac{525\ \text{kg m s}^{-1} - 287.5\ \text{kg m s}^{-1}}{1.57\ \text{m s}^{-1}} = 151.3\ \text{kg}$	**3**
	State one assumption you made in your calculation in (a)(i).		
17(a)(ii)	No external forces acted (during the collision) **Or** it is a closed system **(1)**	Allow there is no friction / drag (during the collision)	**1**
	The collision lasted a total time of 1.35 s. Calculate the average horizontal force on Q during the collision.		
17(a)(iii)	Use of $a = \frac{v-u}{t}$ **(1)** Use of $\Sigma F = ma$ **(1)** ΣF = 176 N (ecf from (a)(i)) (show that value gives 174 N) **(1)** **OR** Use of $\Delta p = m\Delta v$ **(1)** Use of $F = \frac{\Delta p}{\Delta t}$ **(1)** ΣF = 176 N (ecf from (a)(i)) **(1)**	Example of calculation $a = \dfrac{1.57\ \text{m s}^{-1}}{1.35\ s} = 1.163\ \text{m s}^{-2}$ $F = 151\ \text{kg} \times 1.163\text{m s}^{-2} = 175.6\ \text{N}$ Example of calculation $\Delta p_Q = 151\ \text{kg} \times 1.57\ \text{m s}^{-1} = 237.1\ \text{kg m s}^{-1}$ $F = \dfrac{237.1\ \text{kg m s}^{-1}}{1.35\ s} = 175.6\ \text{N}$	**3**

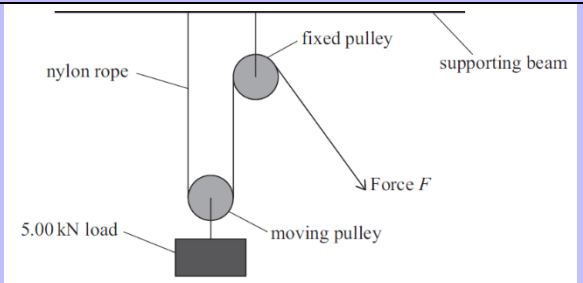
	(show that value gives 174 N)		
	Explain why P decelerates during the collision. Your answer should make reference to Newton's laws of motion.		
17(b)	P exerts a force on Q so Q exerts a force on P **(1)** By Newton's third law, forces are equal (magnitude) and opposite (in direction) **(1)** Resultant force on P opposite to direction of motion so Newton's first / second law applies (and P decelerates) **(1)**	Dependent on MP1 Allow Resultant force on P is to the left / backwards so Newton's first / second law applies (and P decelerates)	**3**
	Total for question 17		**10**

Question Number	Answer	Additional Guidance	Mark
	A stunt motorcyclist wants to jump across a river to land on the other side. The diagram shows the motorcyclist driving off a ramp at the edge of a river.  The ramp is at an angle of 25° to the horizontal and the height at the end of the ramp is 3.0 m. The width of the river is 100 m. The initial velocity of the motorcyclist is 35 m s–1. (a) Calculate the horizontal and vertical components of the motorcycle's initial velocity as it leaves the ramp.		

18(a)	$v_h = 31.7 \text{ m s}^{-1}$ **(1)** $v_v = 14.8 \text{ m s}^{-1}$ **(1)**	Max 1 mark if no unit seen If no other mark scored allow **1** mark for $v_h = 35 \times \cos(25°)$ **and** $v_v = 35 \times \sin(25°)$	**2**
	Deduce whether the rider lands on the other side of the river. **The effects of air resistance can be ignored.**		
18(b)	Use of appropriate equation of motion for vertical motion with $a = (-)9.81 \text{ m s}^{-2}$ **(1)** Use of $s = ut + \frac{1}{2}at^2$ for horizontal motion with $a = 0$ **(1)** Horizontal distance = 102 m **Or** Decrease in height = 2.1 m **Or** Time taken for change in height of −3.0 m = 3.21 s **Or** Speed needed to travel 100m and decrease in height by 3.0 m = 34.7 m/s **(1)** Comparison of calculated value with (value needed to travel) 100 (m) and consistent conclusion **(1)**	Must be using vertical (components of) velocity, displacement, acceleration Must use horizontal (components of) velocity, displacement, acceleration ecf from 18(a)) Examples for MP3 and MP4: 2.1 (m) < 3.0 (m) so yes 102 (m) > 100 (m) so yes 3.21 (s) > 3.15 (s) so yes 34.7 (m s^{-1}) < 35 (m s^{-1}) so yes <u>Example of calculation</u> $-3 \text{ m} = 14.8 \text{ m s}^{-1} \times t + \frac{1}{2} \times (-9.81 \text{ m s}^{-2}) \times t^2$ $t = 3.21 \text{ s}$ $s = 31.7 \text{ m s}^{-1} \times 3.21 \text{ s} = 101.8 \text{ m}$ 101.8 m > 100 m so yes, the rider lands on the other side	**4**

	Explain how air resistance would affect the jump.			
18(c)	Air resistance opposes the motion (of the motorcyclist)	**(1)**	Allow drag for air resistance Allow there is a (resultant) force to the left (on the motorbike) Allow there is a backwards force (on the motorbike)	
	There is deceleration in the horizontal direction **Or** Horizontal (component of) velocity / speed would decrease **Or** The vertical acceleration is not 9.81 m s^{-2}	**(1)**		
	(Horizontal) distance travelled would decrease **Or** The (maximum) height reached by the motorcyclist would decrease **Or** the motorcyclist falls through a greater height in (a horizontal distance of 100m)	**(1)**	Allow so the rider may not reach the other side (of the river) Allow the (maximum) height of the jump would decrease MP3 dependent on MP1 or MP2	
	OR Work is done by air resistance	**(1)**		
	The kinetic energy of the motorbike decreases **Or** The maximum gravitational potential energy of the motorbike decreases	**(1)**		
	(Horizontal) distance travelled would decrease **Or** The (maximum) height reached by the motorcyclist would decrease **Or** the motorcyclist falls through a greater height in (a horizontal distance of 100m)	**(1)**	MP3 dependent on MP1 or MP2	**3**

	Total for question 18		9

Question Number	Answer	Additional Guidance	Mark
	A pulley system is used to lift a 5.00 kN load. The system consists of one fixed pulley and one pulley that can move. The pulleys are connected by a nylon rope, as shown. The nylon rope will stretch when it is used in this way. The weight of the pulleys and the rope can be ignored, and you may assume that there is no friction in the pulleys. The properties of the nylon rope are: Young modulus of nylon = 2.70 GPa overall length of rope before adding the load = 6.00 m area of cross-section of nylon rope = 3.00×10^{-4} m^2 (a) The greater the length of a rope, the smaller the stiffness of the rope. Explain why.		
19(a)	$k = \frac{F}{\Delta x}$ **(1)** Extension is proportional to (original) length **Or** The greater the length of the rope, the greater the extension (for a given force) **(1)** **OR** $k = \frac{EA}{x}$ **(1)**		**2**

	The stiffness (constant) for the rope is inversely proportional to the length of the rope **(1)**		

	Show that the stiffness k of the nylon rope is about 1.4×10^5 N m^{-1}.			
19(b)(i)	Use of $E = \frac{\sigma}{\varepsilon}$ **and** $\sigma = \frac{F}{A}$ **and** $\varepsilon = \frac{\Delta x}{x}$ Use of $F = k\Delta x$ 1.35×10^5 (N m^{-1}) (to at least 3 significant figures)	**(1)** **(1)** **(1)**	Example of calculation $2.7 \times 10^9 \text{ Pa} = \frac{F \times 6.00 \text{ m}}{\Delta x \times 3.00 \times 10^{-4} \text{ m}^2}$ $k = \frac{F}{\Delta x} = \frac{2.7 \times 10^9 \text{ Pa} \times 3.00 \times 10^{-4} \text{ m}^2}{6.00 \text{ m}}$ $k = 1.35 \times 10^5 \text{ N m}^{-1}$	**3**
	The pulley system lifts the 5.00 kN weight at a steady rate. **Determine the extension of the rope while the lift is taking place.**			
19(b)(ii)	Correct use of factor of 2 to calculate F Use of $\Delta F = k\Delta x$ **Or** Use of of $E = \frac{\sigma}{\varepsilon}$ **and** $\sigma = \frac{F}{A}$ **and** $\varepsilon = \frac{\Delta x}{x}$ 1.85×10^{-2} (m) (ecf from b(i)) ('show that' value gives 1.79×10^{-2} (m))	**(1)** **(1)** **(1)**	Example of calculation $F = \frac{5000 \text{ N}}{2} = 2500 \text{ N}$ $\Delta x = \frac{2\,500 \text{ N}}{1.35 \times 10^5 \text{ N m}^{-1}} = 1.85 \times 10^{-2} \text{ m}$ Example of calculation $F = \frac{5000 \text{ N}}{2} = 2500 \text{ N}$ $2.7 \times 10^9 \text{ Pa} = \frac{2500 \text{ N} \times 6.0 \text{ m}}{\Delta x \times 3.00 \times 10^{-4} \text{ m}^2}$ $\Delta x = 0.0185 \text{ m}$	**3**
	Calculate the work done in stretching the rope.			
19(b)(iii)	Use of $\Delta E_{\text{el}} = \frac{1}{2} F \Delta x$ $W = 23$ J (ecf from 19(b)(ii) and 19(b)(i)) ('show that' value gives 22.3 J)	**(1)** **(1)**	Example of calculation $\Delta E_{\text{el}} = \frac{1}{2} \times 2500 \text{ N} \times 0.0185 \text{ m} = 23.1 \text{ J}$	**2**
	Total for question 19			**10**