3	**A 38 m** Incorrect Answers: B – $\frac{1}{2} \times 15\ m\ s^{-1} \times 6\ s = 45\ m$ i.e. area under graph if approximated to a triangle C – $(\frac{1}{2} \times 15\ m\ s^{-1} \times 6\ s) + (15\ m\ s^{-1} \times 1\ s) = 45\ m$ i.e. area under entire graph D – $15\ m\ s^{-1} \times 5\ s = 75\ m$ i.e. factor of ½ left out of area calculation	**1**

5	**C 0.850 m** Incorrect Answers: a metre rule measures to 3 sf so the final answer must be to 3 sf regardless of the units used A – answer to 2 sf in cm B – answer to 2 sf in m D – answer to 2 sf in m (using standard form)	**1**

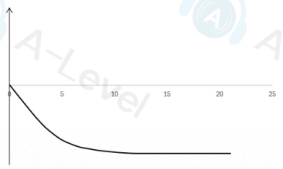
4	**B is the correct answer** A is not the correct answer as this would give a final velocity of 80 m s^{-1} N C is not the correct answer as this would give a final velocity of 120 m s^{-1} N D is not the correct answer as this would give a final velocity of 20 m s^{-1} S	**(1)**

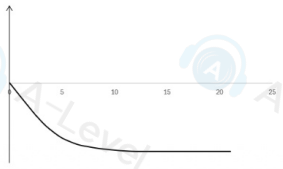
6	**A is the correct answer** B is not the correct answer as the change in velocity is not 2 m s^{-1}. C is not the correct answer as it gives a negative time, and the collision takes a positive amount of time. D is not the correct answer for the same reason that B is not.	**(1)**

*18(a)	**(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)** (A lower start height would) decrease the (initial) GPE At take-off KE is lower. Travels less distance **Or** (take off)velocity lower **Or** velocity (during flight) is lower Landing velocity/force/impact is lower (and the jump is safer.)	(1) (1) (1) (1)	**4**
18(b)(i)	Use of $v = u + at$ for vertical motion Vertical component of velocity after 4.0 s = 39.2 (m s^{-1}) Use of trigonometry with two velocities to obtain direction Direction = 54° to 55 ° <u>Example of calculation</u> $v = 0 + (9.81\ N\ kg^{-1})(4.0\ s)$ $v = 39.2\ m\ s^{-1}$ direction to horizontal = $\tan^{-1}\left(\frac{39.2\ m\ s^{-1}}{28\ m\ s^{-1}}\right)$ direction to horizontal = 54.46°	(1) (1) (1) (1)	**4**
18(b)(ii)	**Either** Use of $s_v = ½\ gt^2$ **Or** use $s_H = v_H t$ Use of trig or Pythagoras to obtain the distance along the slope of landing from start position Subtract 120 from distance along slope Points = 89 to 91 (points) **Or** use $s_H = v_H t$ calculates horizontal distance to k-point s_k (120 cos 35) use of (s_H - s_k) / cos 35 Points = 89 to 91 (points) <u>Example of calculation</u> $s = 0 + (½ \times 9.81\ N\ kg^{-1} \times (4.0\ s)^2) = 78.5\ m$ Distance travelled along slope = 78.5/sin 35 = 136.9 m Distance travelled beyond K-point = 136.9 m – 120 m = 16.9 m points scored = 60 + (1.8 × 16.9) = 90.4 points	(1) (1) (1) (1) (1) (1) (1) (1)	**4**

18(c)	**Either** Air resistance **Or** drag **Or** friction due to the air (allow 'friction' unless they have stated it is between skis and snow) (1) Vertical acceleration reduced **Or** causes a horizontal deceleration (1) velocity reduced (1) Shorter distance travelled (so lands higher up) (1) **Or** Lift (1) Air exerts upward force on skis (1) Vertical acceleration is lower (1) Greater distance travelled so landing position lower down (1)	**4**
	Total for question 18	**16**

Question Number	Acceptable Answer		Additional Guidance	Mark
20(a)	Use of $s = ut + \frac{1}{2}at^2$ with $u = 0$	**(1)**	allow use of any valid suvat method to determine a	
	$a = 9.78\ \text{m s}^{-2}$	**(1)**		
	Determines an appropriate proportion of g	**(1)**		
	Comparison of calculated value of a with $0.95g$ and consistent conclusion	**(1)**	MP4 dependent on MP3 Example calculation $11 = (0.0 \times 1.5) + \frac{1}{2}a \times 1.5^2$ $a = \frac{2 \times 11\ \text{m}}{(1.5\ \text{s})^2} = 9.78\ \text{m s}^{-2}$ $\frac{9.78\ \text{m s}^{-2}}{9.81\ \text{m s}^{-2}} = 0.997$ 0.997 is greater than 0.95 so air resistance was negligible	**4**

Question Number	Acceptable Answer		Additional Guidance	Mark
20(a)	Use of $s = ut + \frac{1}{2}at^2$ with $u = 0$	**(1)**	allow use of any valid suvat method to determine a	**4**
	$a = 9.78\ \text{m s}^{-2}$	**(1)**		
	Determines an appropriate proportion of g	**(1)**		
	Comparison of calculated value of a with 0.95 g and consistent conclusion	**(1)**	MP4 dependent on MP3 Example calculation $11 = (0.0 \times 1.5) + \frac{1}{2}\ a \times 1.5^2$ $a = \frac{2 \times 11\ \text{m}}{(1.5\ \text{s})^2} = 9.78\ \text{m s}^{-2}$ $\frac{9.78\ \text{m s}^{-2}}{9.81\ \text{m s}^{-2}} = 0.997$ 0.997 is greater than 0.95 so air resistance was negligible	
20(b)	Curved line starting at zero with negative gradient decreasing in magnitude	**(1)**	ignore any values added to the y-axis	**2**
	Horizontal line after 12 seconds	**(1)**	Line should not be along the x-axis Example graph: 	

Question Number	Acceptable Answer		Additional Guidance	Mark
20(a)	Use of $s = ut + \frac{1}{2}at^2$ with $u = 0$	**(1)**	allow use of any valid suvat method to determine a	**4**
	$a = 9.78\ \text{m s}^{-2}$	**(1)**		
	Determines an appropriate proportion of g	**(1)**		
	Comparison of calculated value of a with 0.95 g and consistent conclusion	**(1)**	MP4 dependent on MP3 Example calculation $11 = (0.0 \times 1.5) + \frac{1}{2}\ a \times 1.5^2$ $a = \frac{2 \times 11\ \text{m}}{(1.5\ \text{s})^2} = 9.78\ \text{m s}^{-2}$ $\frac{9.78\ \text{m s}^{-2}}{9.81\ \text{m s}^{-2}} = 0.997$ 0.997 is greater than 0.95 so air resistance was negligible	
20(b)	Curved line starting at zero with negative gradient decreasing in magnitude	**(1)**	ignore any values added to the y-axis	**2**
	Horizontal line after 12 seconds	**(1)**	Line should not be along the x-axis Example graph: 	

20(c)	E_{grav} decreases (throughout)	**(1)**		**4**
	While accelerating, E_k increases	**(1)**		
	and work is done against air resistance **or** and energy is dissipated due to (work done against) air resistance	**(1)**	Ignore references to heating Ignore references to thermal energy Allow energy is transferred to the surroundings due to (work done against) air resistance	
	At terminal velocity (E_k is constant and) all ΔE_{grav} is dissipated (due to work done against air resistance)	**(1)**		

Question Number	Acceptable Answer		Additional Guidance	Mark
20(a)	Use of $s = ut + \frac{1}{2}at^2$ with $u = 0$	**(1)**	allow use of any valid suvat method to determine a	
	$a = 9.78\ \text{m s}^{-2}$	**(1)**		
	Determines an appropriate proportion of g	**(1)**		
	Comparison of calculated value of a with $0.95\,g$ and consistent conclusion	**(1)**	MP4 dependent on MP3 <u>Example calculation</u> $11 = (0.0 \times 1.5) + \frac{1}{2}\,a \times 1.5^2$ $a = \frac{2 \times 11\ \text{m}}{(1.5\ \text{s})^2} = 9.78\ \text{m s}^{-2}$ $\frac{9.78\ \text{m s}^{-2}}{9.81\ \text{m s}^{-2}} = 0.997$ 0.997 is greater than 0.95 so air resistance was negligible	**4**
20(b)	Curved line starting at zero with negative gradient decreasing in magnitude	**(1)**	ignore any values added to the y-axis	**2**
	Horizontal line after 12 seconds	**(1)**	Line should not be along the x-axis <u>Example graph:</u> 	
20(c)	E_{grav} decreases (throughout)	**(1)**		
	While accelerating, E_k increases	**(1)**		
	and work is done against air resistance **or** and energy is dissipated due to (work done against) air resistance	**(1)**	Ignore references to heating Ignore references to thermal energy Allow energy is transferred to the surroundings due to (work done against) air resistance	
	At terminal velocity (E_k is constant and) all ΔE_{grav} is dissipated (due to work done against air resistance)	**(1)**		**4**
20(d)	(When the parachute opens,) air resistance is greater than weight	**(1)**	Allow drag for air resistance throughout	
	(So) resultant force is upwards and acceleration is upwards **or** (so) resultant force is upwards and the skydiver decelerates	**(1)**	Ignore speed decreases	
	(As speed decreases) air resistance decreases (so acceleration/deceleration decreases)	**(1)**		
	(Until upthrust +) air resistance = weight	**(1)**		
	(so) resultant force = 0 and acceleration = 0	**(1)**	Ignore speed is constant	**5**

(Total for Question 20 = 15 marks)
TOTAL FOR PAPER = 80 MARKS

Question Number	Answer		Mark
13(a)	Use of $s = ut + \frac{1}{2}at^2$ Allow any valid suvat method.	**(1)**	
	Uses difference in distances travelled by A and B of 9m	**(1)**	
	$t = 1.13$ (s)	**(1)**	**3**
	Example calculation $(93\ \text{ms}^{-1} \times t) + 9\ \text{m} = (93\ \text{ms}^{-1} \times t) + \left(\frac{1}{2} \times 14\ \text{ms}^{-2} \times t^2\right)$ $9\ \text{m} = \left(\frac{1}{2} \times 14\ \text{ms}^{-2} \times t^2\right)$ $t = \sqrt{\frac{9\ \text{m}}{\frac{1}{2} \times 14\ \text{ms}^{-1}}} = \sqrt{1.29\ \text{s}} = 1.13\ \text{s}$		
13(b)	Use of $s = ut + \frac{1}{2}at^2$ Allow any valid suvat method.	**(1)**	
	Time for A to finish = 1.075 s **Or** Time for B to finish = 1.084 s (allow correctly calculated value for another quantity given in the question)	**(1)**	
	Comparison of time for A to finish with time for B to finish and valid conclusion **Or** comparison of time for A to finish with 1.13 s and valid conclusion (ecf from **13(b)**) (allow valid conclusion based on comparison of calculated values for other quantities given in the question)	**(1)**	**3**
	Example calculation $t_A = \frac{100\ \text{m}}{93} = 1.075\ \text{s}$ $109 = 93t_B + \frac{1}{2} \times 14 \times {t_B}^2$ $t_B = \frac{-93 + \sqrt{93^2 - 4 \times \left(\frac{14}{2}\right) \times (-109)}}{2 \times \frac{14}{2}} = 1.084\ \text{s}$ 1.075 s < 1.084 s so car A will finish first.		
	Total for question 13		**6**