1)

(a)		(Force is 1 N) when a **1 kg** mass has an acceleration of **1 m s^{-2}**	**B1**	**Not**: '1 kg and 1 m **s^{-1}**' **Allow**: (1 N =) **1 kg** × **1 m s^{-2}**
(b)		The mass of particles increases (at its speed gets closer to the speed of light)	**B1**	**Not**: 'weight of particle increases' **Not**: 'mass changes / different'
(c)	**(i)**	net force = 120 (N) $a = \frac{120}{900}$ a = 0.13 (m s^{-2})	**C1** **A1**	 **Note**: Bald answer scores 2 marks; answer must be 2 sf or more
	(ii)	The drag force changes with speed / acceleration is not constant	**B1**	
(d)		$F = 72 \times 1.4$ (= 100.8 N) / weight = 72 × 9.81 (= 706.32 N) T = (72 × 9.81) + (72 × 1.4) T = 807 (N) or 810 (N)	**C1** **C1** **A1**	**Note**: Bald 101 (N) or 706 (N) scores 1 mark **Note**: Bald answer scores 3 marks Bald 605.52 to at least 2 sf scores 1 mark
		Total	**8**	

2)

a	…incorrect Mass (of the particle) increases (as it approaches speed of light)	M1 A1	**In question 5, use tick or cross on Scoris to show if the mark is awarded** **Not**: mass *changes*
b	….correct KE is changed into (G)PE or (G)PE is changed into KE or change in KE = change in (G)PE (AW)	M1 A1	 **Note**: This mark is for stating the transfer of energy between kinetic and (gravitational) potential
c	…incorrect Weight is equal to drag / air resistance / friction (and not acceleration of free fall)	M1 A1	Allow **alternative** response: ……. incorrect M1 Acceleration and weight are not the same quantities (AW) A1
d	…incorrect The technique is trilateration ✎ **The term *trilateration* to be included and spelled correctly to gain the A1 mark**	M1 A1	 **Note** 1 mark if 'trilateration' is misspelled but candidate has mentioned that the statement is incorrect
	Total	**8**	

3)

(a)		mass = $\frac{590}{9.8(1)}$ (= 60 kg)	B1	**Allow**: weight = 60 × 9.8(1) **Allow**: 60 × 9.8(1) = 588 (N) or 60 × 9.8(1) = 590 (N)
(b)		net force = 60 × 0.50 (= 30 N) R = 590 + 30 R = 620 (N)	 C1 A1	 **Allow**: 1 mark for '590 – 30 = 560 (N)'
(c)		resultant force = 0 / 'a = 0 and F = ma = 0'	B1	**Not**: Acceleration = 0 or 'forces are balanced'
(d)		weight > R (for deceleration) / R = 590 – 60a / R = mg -ma Hence R decreases	M1 A1	**Allow**: W or mg for 'weight'
		Total	**6**	

4)

(a)		$F_H = 20\cos 38 = 15.76 \approx 15.8$ (N) $F_V = 20\sin 38 = 12.31 \approx 12.3$ (N)	**B1** **B1**	**Allow**: 2 sf answers of 16 (N) and 12 (N) **Allow**: 1 mark if vertical and horizontal components have been interchanged
(b)	**(i)**	net force vertically = 0 / weight = upward forces weight = 12.3 + 12.3 weight = 24.6 (N) ≈ 25 (N) ---------- Or ---------- correct triangle of forces diagram correct determination of weight weight = 24.6 (N) ≈ 25 (N)	**C1** **C1** **A0** **C1** **C1** **A0**	 Possible ecf from F_V value from **(a)** At least one label needed (e.g: 20, correct angle, etc) – arrows not needed Weight in the range 22 – 27 (N)
	(ii)	mass = $\frac{25}{9.81} = 2.55$ (kg) density = $\frac{2.55}{2.9\times10^{-4}}$ density = 8.8 × 10^3 (kg m^{-3})	**C1** **C1** **A1**	**Note**: 2.51 kg if 24.6 N is used **Note**: 'weight/volume' scores zero **Note**: Answer is 8.7 × 10^3 if 2.51 kg is used **Allow**: 2 marks if g = 10 used and 25 N → 2.5 kg $\therefore \rho$ = 8620 (kg m^{-3}) **Note**: Bald 8.7× 10^3 or 8.8 × 10^3 scores 3 marks **Allow**: 1 mark if 20 N is used instead of 25 N – this gives 7030 (kg m^{-3})
		Total	**7**	

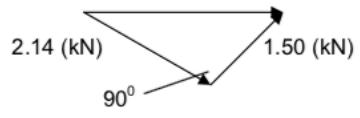
5)

(a)		$W = mg$ weight = $1.50\times9.81 = 14.72$ (N) or 14. 7 (N) or 15 (N)	B1	**Allow**: Use of 9.8 (m s^{-2}) **Allow**: Bald 15 (N); but **not** '1.50 × 10 = 15(N)'
(b)	**(i)**	Net / resultant force (on **B**) is less / (net) force (on **B**) is less than its weight / there is tension (in the string) / there is a vertical / upward / opposing force (on **B**)	B1	**Note**: Must have reference to force

6)

(a)		mass = $\underline{140 \times 3.0}$ (= 420 kg)	B1	**Allow**: $\frac{420}{3.0} = 140$ (reverse argument)
(b)	**(i)**	total mass = 500 + 560 + 420 (= 1480 kg)	C1	**Note**: Omitting one of the masses – can score maximum of 3
		total weight = 1480 × 9.8(1) / total weight = 14520 (N)	C1	Omitting two masses – can score maximum of 2
		net force = 1480 × 1.8 / net force = 2664 (N)	C1	**Examples:** 3 marks if mass of cable is omitted
		tension = 14520 + 2664	C1	tension = 1908 +10400 = 1.23×10^4 (N) 2 marks if mass of cable and people are omitted
		tension = $1.7(2) \times 10^4$ (N)	A0	tension = 900 + 4905 = 5.8×10^3 (N) **Note**: 4 marks for 'tension = $(m(g+a) =)$ 1480 × (9.81 + 1.8)'
	(ii)	stress = $\frac{1.72 \times 10^4}{3.8 \times 10^{-4}}$ / stress = $\frac{(b)(i)}{3.8 \times 10^{-4}}$ stress = $4.5(3) \times 10^7$ (Pa)	C1 A1	Possible ecf from **(i)** **Note**: A tension of 1.7×10^4 (N) gives an answer of $4.4(7) \times 10^7$ (Pa)
		Total	**7**	

7)

(i)	Correct vector triangle drawn  	B1	**Note**: Expect at least one 'label' on the sketch, eg: 2.14, 1.5, 90^0 The 'orientation' of the triangle is not important The directions of all three arrows are required
	(resultant force)^2 = $2.14^2 + 1.50^2$	C1	
	resultant force = 2.61 (kN)	A1	**Allow**: 2 sf answer of 2.6 (kN) **Allow** a scale drawing; 2 marks if answer is within ±0.1 kN and 1 mark if ± 0.2 kN **Alternative** for the C1 A1 marks: 1.50cos(55) or 2.14cos(35) C1 resultant force = 1.50cos(55) + 2.14cos(35) resultant force = 2.61 (kN) A1
(ii)	2.6(1) (kN)	B1	Possible ecf
	(Constant velocity implies) zero net force / zero acceleration	B1	**Not**: '*resultant force = drag*' since the first B1 assumes this

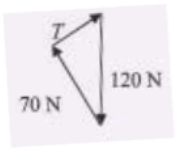
8)

(a)		acceleration = rate of change of velocity (or acceleration = change in velocity / time)	B1	**Allow** '$a = (v - u)/t$' or '$\Delta v/t$' if v, u and t or Δv and t are defined
(b)		Mass and (net) force	B1	
(c)	**(i)**	**1** acceleration **2** deceleration / negative acceleration Detail mark: Constant used in either 1 or 2 or reaches maximum height at 25 (s) or stops at 25 (s)	B1 B1 B1	**Allow**: velocity / speed increases **Allow**: velocity / speed decreases **Allow**: 'uniform / same' for 'constant'
	(ii)	height = area under graph from 0 to 25 (s) height = ½ × 25 × 200 height = 2500 (m)	C1 C1 A1	**Allow** 1 mark for either 500 (m) or 2000 (m)
	(iii)	A sensible suggestion, for example: • $v^2 = 2 \times g \times 2500$, $v = 220$ (m s^{-1}) – allow $g = 10$ (m s^{-2}) • For 200 (m s^{-1}) at ground, the (maximum) height would only be 2040 (m) (with $g = 9.81$ m s^{-2}) or 2000 (m) (with $g = 10$ m s^{-2}) • (Burning) rocket fuel does work on the rocket (AW)	B1	
		Total	**9**	

9)

a	The (net) force (is a newton) when a 1 kg mass has acceleration of 1 m s^{-2}	B1	**Not**: 1 N = 1 kg m s^{-2} because this is too brief for a definition
b(i)	weight = $1.9 \times 10^6 \times 9.81$ weight = 1.86×10^7 (N)	 B1	**Allow**: 9.8 (m s^{-2}) for g but not 10 (m s^{-2}) **Allow**: A bald answer of 1.9×10^7 N, but **not** if 10 (m s^{-2}) is seen
b(ii)	net force = 1.24×10^7 (N) or 1.2×10^7 (N) $a = \frac{F}{m} = \frac{1.24 \times 10^7}{1.9 \times 10^6}$ acceleration = 6.53 (m s^{-2}) or 6.5 (m s^{-2})	C1 A1	**Allow**: The C1 mark for "(net force) = $(3.1 - 1.86) \times 10^7$ (N)" **Allow**: 2 marks for a bald answer **Allow**: Answer of 6.3 (m s^{-2}) if 1.9×10^7 (N) is used for weight or net force of 1.2×10^7 (N) is used **Allow**: 1 mark for '$3.1 \times 10^7/1.9 \times 10^6 = 16.3$' **Not:** '$1.86 \times 10^7/1.9 \times 10^6 = 9.8$'
b(iii)	The mass / weight (of spaceship) decreases (as it loses fuel)	B1	**Allow**: 'g' / acceleration of free fall / gravitational field strength decreases (but **not** gravity decreases) **Not**: 'less drag / air resistance'
	Total	**5**	

10)

a		A quantity with magnitude / size and direction Suitable example: displacement / velocity / acceleration / force / weight etc	B1 B1	
b	**i**	$F_x = F\cos\theta$ $7.0 = F \times \cos 30$ $F = 8.1$ (N) or 8.08 (N)	 C1 A1	**Allow**: 1 mark for 'radian' error; answer is 45.3 (N) **Note**: No marks for '7.0 × cos30 = 6.06 N'
	ii	**1** $W = 7.0 \times 5.0$ or $W = 8.08 \times 5.0 \times \cos 30$ work done = 35 (J) **2** 'power' = 35/4.2 = 8.3 (W)	 C1 A1 B1	 Possible ecf **Note**: If answer for **(b)(i)** is 6.06 (N), then '6.06 × 5.0 × cos30 = 26.2 (J)' scores 2/2 because of ecf Possible ecf
c	**i**	Magnitude is 120 (N) / equal to weight Direction is (vertically) up / opposite to weight	B1 B1	
	ii	Correct diagram Correct detail on diagram  $120^2 = 70^2 + T^2$ $T = 97$ (N) or 97.5 (N)	M1 A1 C1 A1	**Note**: For the M1 mark, the basic diagram must have all sides labelled (70, 120 and T) and the angle between 70 (N) and T is judged by eye to be 90° **Note**: For the A1 mark, all the arrows are marked and cyclic **Note**: For the C1 A1 marks, $T = \sqrt{120^2 + 70^2} = 140$ scores zero **Allow:** 2 marks for T in the range of 94 (N) to 100 (N) if scale drawing is done
		Total	**13**	

11)

(a)		velocity = rate of change of displacement	B1	**Allow**: Equation if labels are defined **Not**: velocity = displacement/time **Not**: A mixture of quantity and unit, e.g: 'change in displacement per second'
(b)		work done = force × distance moved in direction of force	M1 A1	**Allow**: 'force × displacement' for the M1 mark
(c)	(i)	It is at right angles to motion	B1	**Allow:** It is at right angles to slope / sledge
	(ii)	The component of the weight / W / mg (down the slope)	B1	**Allow:** $W\sin\theta$ or $mg\sin\theta$ **Not**: 'component of gravity' **Allow**: Resultant of W and N

12)

(a)		(net vertical force =) 120 – 90 $F^2 = 30^2 + 18^2$ net force = 35 (N) $\tan\theta = 30/18$ angle = 59°	C1 C1 A1 B1	**Allow**: 2 marks for 1224 (N) - answer not square-rooted **Allow**: 1 mark for resultant of 18 and 90; equal to 91.8 (N) **Allow**: 1 mark for resultant of 18 and 120; equal to 121.3 (N) **Alternative for scale drawing:** (net vertical force =) 30 (N) C1 Correct 'triangle'; at least one of the sides labelled C1 *F* in the range 34 to 36 (N) A1 Possible ecf from net force
(b)		Any <u>two</u> from: • speed of balloon • (frontal) area • texture of balloon • temperature of air / density of air / viscosity (of air)	B1×2	**Not**: size / shape of balloon
		Total	**6**	

13)

(a)		time = $6.9 \times 3.16 \times 10^7$ ($= 2.18 \times 10^8$ s) average speed = $\frac{5.0\times10^{12}}{6.9\times3.16\times10^7}$ average speed = 2.29×10^4 or 2.3×10^4 (m s^{-1})	C1 A1	**Allow**: 1 mark for $5.0 \times 10^{12}/6.9 = 7.2(46) \times 10^{11}$ (m y^{-1}) **Allow**: 1 mark for $\frac{5.0\times10^{12}}{3.16\times10^7} = 1.58\times10^5$ (m s^{-1})
(b)		distance = 0.70×200 (= 140 mm) or KE = ½ × $4.0 \times 10^{-6} \times 6100^2$ (= 74.4 J) work done = change in KE $F \times (0.70\times10^{-3} \times 200) = \frac{1}{2} \times 4.0\times10^{-6} \times 6100^2$ *F* = 530 (N) ---------- or ---------- *F* = *ma* $a = \frac{6100^2}{2\times(0.70\times10^{-3}\times200)}$ (=1.33×10^8) *F* = $4.0 \times 10^{-6} \times 1.33 \times 10^8$ *F* = 530 (N)	C1 C1 A1 C1 C1 A1	**Note**: Bald answer scores 3/3 marks **Note**: 0.53 (N) scores 2/3 because of 10^n error in distance 1.06×10^5 (N) scores 2/3 because '200' not taken into account 106 (N) scores 1/3 because '200' missed out and 10^n error
		Total	**5**	

14)

(a)		It has **direction** (and magnitude/size)	B1	**Note:** ***direction*** must be spelled correctly for the mark
(b)	**(i)**	perpendicular component = 8.0×10^{-5} cos30 perpendicular component = 6.9×10^{-5} (N) parallel component = 8.0×10^{-5} sin30 parallel component = 4.0×10^{-5} (N) or 4×10^{-5} (N)	B1 B1	**Allow**: 1 mark if the correct numerical values of the components have been swapped **Note**: Penalise POT error once only; eg 6.9 and 4 respectively scores 1 mark **Note**: Calculator in radian mode gives 1.23×10^{-5} and (-) 7.90×10^{-5} (N); this scores 1 mark
	(ii)	(F =) 4.0×10^{-5} (N) The net force parallel to windscreen = 0 or F is equal to the parallel component (of the weight down the windscreen) or parallel forces must be equal and opposite or $F = 8.0 \times 10^{-5}$ sin30	B1 B1	Possible ecf from **(b)(i)** **Allow**: Total force down/up the windscreen/slope is zero **Not**: 'net force = 0' – this is an incomplete answer
		Total	**5**	

15)

(a)	Aristotle: Heavier/massive objects fall faster (AW) Galileo: All objects (irrespective of their mass) fall at the same rate / have same acceleration (of free fall)	B1 B1	 **Allow**: 'the same rate of acceleration' for this B1 mark
(b)(i)	Any **two** from: • speed • area • density of air / viscosity of air • streamlining / texture of clothing	B1	**Not**: 'wind' for 'speed' **Allow:** surface / frontal area
(b)(ii)	Acceleration is equal to 9.8(1) $\underline{\text{m s}^{-2}}$ / g There is no drag / net force = weight / 'only force acting is mg'	B1 B1	
(b)(iii)	Correct shape curve with finite value at $t = 0$ Value of $F = 0$ after 10 s	B1 B1	 **Allow** a tolerance of +/- 0.5 of a square
(b)(iv)	weight = 80×9.81 or 784.8 (N) or (net force) = 80×3 or 240 (N) (80×9.81) – drag = 240 drag = 540 (N)	 C1 C1 A1	**Note**: The first C1 mark is either for the weight or the net force **Note**: Answer to 3sf is 545 (N) and 544.8 (N) to 4sf
	Total	**10**	