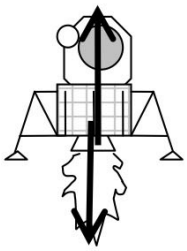
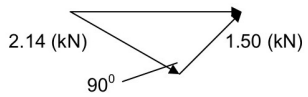
Question 5			
(a)	(i)	$\left(a = \frac{F}{m}\right) = \frac{(-)30(000)}{15100}$ ✓ = (–) 2.0 (= 1.99 m s^{-2}) ✓	**2**
(a)	(ii)	($v = u + at$) $t = \frac{v-u}{a}$ or substitution ✓ = $\left(\frac{150-2040}{-1.99}\right)$ = 950 (s) ✓ ecf from (i)	**2**
(b)	(i)	 opposing vertical arrows of roughly equal length **or** labelled weight/mg/gravity/W **and** thrust/reaction/R/F/TF/engine force/rocket force/motor force/motive force/driving force ✓ correctly labelled + arrows vertical + not more than 2 mm apart + roughly central + weight arrow originates within rectangular section and thrust originates within rectangular section or on jet outlet ✓	**2**
(b)	(ii)	new mass = 15100 × 0.47 = 7097 (kg) ✓ ($F = mg$ = 7097 × 16(1)) = 11000 (= 11426 N) ✓	**2**
(c)		($v^2 = u^2 + 2as$ $v = \sqrt{0.80^2 + 2 \times 1.61 \times 1.2}$) correct u, a and s clearly identified ✓ = 2.1 (= 2.122 m s^{-1}) ✓	**2**
		Total	**10**

Question			Expected Answers	Marks	Additional Guidance
3	(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**	

Question			Expected Answers	Marks	Additional Guidance
4	(a)		The mass (of the electron) increases as its speed approaches <u>c</u> / <u>speed of light</u> / 3×10^8 <u>m s^{-1}</u>	M1 A1	**Not**: mass 'changes' / 'electron becomes heavier'
	(b)	(i)	A line with correct arrow in the *y* direction has length of 14 to 16 'small squares' A line with correct arrow in the *x* direction has length of 24 to 26 'small squares'	B1 B1	 **Note**: If correct arrows are not shown, then maximum mark is 1
		(ii)	component = ($8.0\cos 31 =$)6.86 (m s^{-1}) or 6.9 (m s^{-1})	B1	**Allow**: 6.85 as BOD
	(c)	(i)	Correct vector triangle drawn  (resultant force)^2 = 2.14^2 + 1.50^2 resultant force = 2.61 (kN)	B1 C1 A1	**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 **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) (Constant velocity implies) zero <u>net</u> force / zero acceleration	B1 B1	Possible ecf **Not**: '*resultant force = drag*' since the first B1 assumes this
			Total	**10**	

Q 1	Expected Answers	Marks	Additional Guidance
a	10^6 nano (n) 10^{12}	B1 B1 B1	**Allow**: 1000 000 **Allow**: nano / n / nano (N) as BOD **Allow**: 1000 000 000 000
b	Circled quantities: density <u>and</u> volume	B1	
c	$1.5\times10^{11} = 3.0\times10^8 \times t$ time = $\frac{1.5\times10^{11}}{3.0\times10^8}$ / 500 (s) time = 8.33 (min) ≈ 8.3 (min)	C1 A1	**Allow**: Any subject **Note**: Bald 500 (s) scores 1 mark **Allow**: 2 marks for a bald answer of 8.3 **Allow**: Answer as a fraction – 25/3 (min) / 8 min 20 s **Allow**: 1 mark for '(500/3600 =) 0.139'
d(i)	Mention of weight or drag Net / total / resultant force (on drop) is zero 'upward force = downward force' / 'weight = drag' / 'weight balances drag'	B1 B1	**Allow:** (air) resistance / (air) friction for 'drag' **Not:** 'gravity' for 'weight' **but** 'force of gravity' is fine **Not**: 'acceleration = 0' since question requires answer in terms of <u>forces</u> **Not**: 'All forces are equal' **Note**: 'weight = drag' / 'weight balances drag' scores 2 marks
d(ii)1	A downward line / arrow (from the raindrop) leaning to the right	B1	**Note**: Answer **must** be on Fig. 1.2 Judge by eye – the angle is not important
d(ii)2	$v^2 = 1.5^2 + 4.0^2$ velocity = 4.27 (m s^{-1}) ≈ 4.3 (m s^{-1})	C1 A1	 **Allow**: 2 marks for a scale drawing with value in the range 4.1 to 4.5. If value in the range 4.0 to 4.1 or 4.5 to 4.6 then give 1 mark **Allow**: 2 marks for a bald answer of 4.3 (m s^{-1})
	Total	**11**	

Q 3	Expected Answers	Marks	Additional Guidance
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**	

Question			Expected Answers	Marks	Additional Guidance
4	a		Any two from: • area • speed / velocity • viscosity (of air) / temperature / density • (surface) texture / 'aerodynamic' (shape)	B1×2	**Not**: shape / size **Allow**: 'streamlining'
	b	i	Correct directions of arrows *W* and *D*	B1	Award the mark for two arrows in opposite directions as long as one of them is labelled
		ii	weight = 75 × 9.81 weight = 736 (N) or 740 (N)	 B1	**Reminder**: weight can be quoted to more than 2 sf (e.g: 735.75) **Not**: '75 × 10 = 750 N'
		iii	$D = 0.30 \times 20^2$ (= 120 N) $736 - 120 = 75a$ $a = 8.2$ (m s^{-2})	C1 C1 A1	 **Allow**: Answer to 2sf or more **Bald** answer of 8.2 or 8.21 scores 3 marks **Note**: Using 740 (N) gives an answer 8.3 (m s^{-2})
		iv	(*D* and *W* are) equal	B1	**Not**: *D* and *W* are 'balanced/equilibrium'
		v	drag = weight $736 = 0.30 \times v^2$ $v = 49.5$ (m s^{-1}) or 50 (m s^{-1})	 C1 A1	 **Bald** answer of 49.5 (m s^{-1}) or 50 (m s^{-1}) scores 2 marks
			Total	**10**	