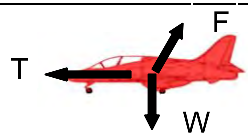
Question			Answer	Mark	Guidance
1	(a)	(i) (ii) (iii)	 Correct direction and labelling for W <u>and</u> T Straight line for F Correct direction **not** horizontal or vertical	B1 B1	**Both** forces must be correct to score this mark. **Allow:** Freehand sketch of *F* must lie between 15º and 75º to the horizontal to score this mark.
	(b)	(i)	$a = T / m$ $a = 28 \times 10^3 / 6200$ (= 4.516) $v^2 = u^2 + 2as$ $56^2 = 0 + 2 \times 4.516s$ (any subject) s = 350 (m)	C1 C1 A1	Must substitute to score this mark. Answer to 3 sf = 347 (m). **Allow:** max 2 marks if v is not squared but correct formula was quoted. [Expect s = 6.2 (m)] **Allow:** $Fs = ½ mv^2$ [C1] $28 \times 10^3 s = ½ \times 6200 \times 56^2$ [C1] (any subject) s = 350 (m) [A1] **Allow:** $Ft = mv$ t = 12.4 (s) [C1] $s = ½ vt = ½ \times 56 \times 12.4$ [C1] s = 350 (m) [A1]
		(ii)	Air resistance/drag/friction acts on aircraft <u>decreasing</u> **either** the net forward force **or** the acceleration Fs = ΔKE so reduced force must act over a longer distance to produce enough kinetic energy for take-off OR $v^2 = (u^2) + 2as$ so reduced acceleration means longer distance to reach take-off speed.	M1 A1	**Not:** 'slowing the aircraft down'. **Allow** word equation. **Note:** This mark cannot be given if the previous (M1) mark has not been scored.
	(c)	(i)	$L \cos 35^\circ = 6200 \times 9.81$ $L = \dfrac{6200 \times 9.81}{\cos 35^\circ}$ OR $L = 7.42 \times 10^4$ $L = 7.4 \times 10^4$ (N)	 M1 A0	**Allow:** Use of 9.8 **Note:** There is no mark for the answer as it is given in the question. Marks in 'Show' questions are for the working.

Question			Answer	Mark	Guidance
		(ii)	$L\sin 35^\circ = mv^2/r$ $r = \dfrac{6200 \times 86^2}{7.4 \times 10^4 \sin 35^\circ}$ r = 1100 (m)	C1 C1 A1	Possible ecf from (c)(i). Correct answer to 3 sf = 1.08×10^3 (m). **Allow:** 1 mark for using cos 35º instead of sin 35º. Expect gives an answer of 760 (m). **Allow:** 2 marks for correct working using v = 56 (m s^{-1}) Expect an answer of r = 460 (m). No marks for using tan 35º or for omitting a trig function.
	(d)	(i)1	Indication at 'top' of circle (by eye)	B1	
		(i)2	0 (N)	B1	
		(ii)	P is not the resultant force **OR** Resultant force must be towards centre of circle so *P* must have a component acting vertically upwards, equal in magnitude to *W* (AW)	B1	**Allow:** (Horizontal) component of *P* provides centripetal acceleration and vertical component of *P* is equal to weight. (AW)
			Total	14	

Question			Answer	Marks	Guidance
2	(a)	(i)	Arrow (labelled F) directed towards centre of circle	B1	**Allow:** arrow drawn parallel to the string
		(ii)	Resultant force (F) acts at 90^o to motion / velocity of bung so no work done is done by F (hence no change in speed)	B1 B1	**Allow:** No component of F acts in the direction of motion (B1) hence there is no acceleration in the direction of motion (AW) (B1)
	(b)	(i)	Student tries to rotate bung at constant radius / tries to keep reference mark at end of tube (AW) Force F is calculated using $F = Mg$. where M is mass of slotted masses Measure time t for n revolutions of the bung (hence calculate T for 1 revolution). Measure radius r when stationary Calculate v using $2\pi r\, n / t$ (or $2\pi r / T$).	B1 B1 B1 B1 B1	**Not:** bald 'constant radius' **Not** : F = weight **Not:** 'take time for 1 revolution'
		(ii)	**1** Straight line of positive gradient passing through the origin **2** $F = \frac{m}{r} v^2$ hence gradient $= \frac{m}{r}$ Mass = gradient (of graph) x radius (of orbit)	B1 B1 B1	 Cannot award this mark if graph is curved Can score this mark if graph is curved
			Total	**11**	

3	Expected Answers	Marks	Additional guidance
(a)(i)	A body will remain at rest or continue to move with constant velocity unless acted upon by a force (WTTE)	B1	Do not allow speed unless “speed in a straight line” is stated. Allow “uniform motion”
(a)(ii)	The force which gives a mass of 1 kg an acceleration of 1 m s^{-2}	B1	**Allow** 1N = 1 kg m s^{-2}
(b)(i)	Use of $v = u + at$ OR $a = (v – u) / t \Rightarrow a = (55 – 0) / 2.2$ $a = 25$ (m s^{-2})	C1 A1	
(b)(ii)	Use of $s = ut + ½ at^2$ e.g. $s = 0 + ½ \times 25 \times 2.2^2$ $s = 60.5$ (m)	C1 A1	**Allow** other valid solutions e.g. using $v^2 = u^2 + 2as$
(b)(iii)	$F = ma = 3.2 \times 10^4 \times 25 = 8.0 \times 10^5$ (N)	A1	**Allow** ecf from (b)(i)
(c)(i)	<u>towards the centre of the circle</u>.	B1	Do not allow a bare “perpendicular to the velocity” Do not allow “in the same direction as the acceleration.”
(c)(ii)	use $F = mv^2/r$ e.g. $F = (3.2 \times 10^4 \times 120^2)/870$ $F = 5.3 \times 10^5$ (529655) (N)	C1 A1	If 55 is used instead of 120 for the velocity F = 1.1×10^5 ms^{-1} and scores 1 mark
(d)(i)	At top of the circle when the weight provides/equals the required centripetal force	M1 A1	**Allow** “when the resultant force = weight”
(d)(ii)	realisation that acc = g (OR 9.81) AND (hence) $v^2/r = g$ $\{v = \sqrt{(gr)} = \sqrt{(9.81 \times 1500)}\} \Rightarrow v = 120$ (m s^{-1}) (121.3)	M1 A1	**Accept** 121.24 as this corresponds to 9.8, do **not** allow 122.5 since this assumes $g = 10$ ms^{-2}
	Total	**14**	

Question			Expected Answers	Marks	Additional guidance
4	**a**	**i**	($v = 2\pi r/t$) $t = 2\pi 60/0.26$ = **1450** s	B1	Correct answer is 1449.96 hence allow 1.4×10^3 Do not allow a bare 1.5×10^3
		ii	(ii) corr substitution into $F = mv^2/r$: eg $F = (9.7\times10^3 \times 0.26^2)/60$ F = **10.9** N	C1 A1	Allow 11 N
	b	**i**	THREE correct arrows at A, B and C **all** pointing towards the centre (judged by eye)	B1	Ignore starting point of arrow
		ii	1. Greatest reaction force is a **C** because it supports weight of sock AND provides the required upward resultant (centripetal) force (WTTE) 2. Least a **A** because sock's weight provides part of the required downward resultant (centripetal) force (WTTE)	**M1** A1 B1	This is a mandatory M mark. The second mark cannot be gained unless this is scored. Any indication that candidates think that the centripetal force is a **third** force loses this second and possibly the next mark. They must make correct reference to the resultant force that provides the required centripetal force/acceleration. Allow answers using the equation $F = mv^2/r$ such as $N_c - mg$ (at C) = centripetal force OR mv^2/r OR $mg + N_A$ (at A) = centripetal force OR mv^2/r
			Total	**7**	