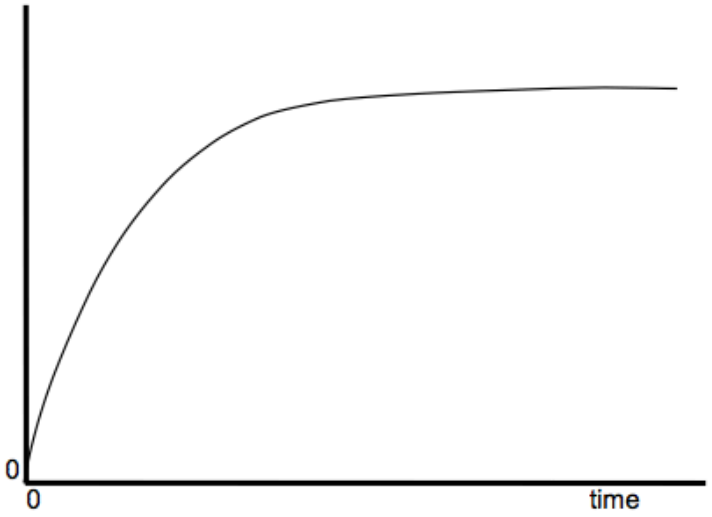
1)

(a)	(sum of) clockwise moments (about a point) =(sum of) anticlockwise moments ✓ (for a system) in equilibrium ✓ accept *balanced* not *stationary*	**2**
(b)	(780 × 0.35 =) 270 (Nm) ✓ (273) **Nm** ✓ or newton metre(s) accept Newton metre(s) (not J, nm or nM, Nms, etc)	**2**
(c)	1 (b) + (1100 x 0.60) ✓ (=) F_A × 1.3 ✓ (F_A = 660 + 273/1.3 gets both marks) (= 933/1.3) = 720 (N) ✓ (717.7 or 715 for use of 930) ecf 1 (b) **2 sf only** ✓ independent mark	**4**
(d)	(780 +1100 – (1(c)) = 1200 ✓ (1162 N) ecf 1 (c)	**1**
(e)	$\left(F = \frac{P}{v}\right) = \frac{7.5\,(\times 10^3)}{26}$ ✓ must be arranged in this form = 290 (N) ✓ (288.46)	**2**
	Total	**11**

2)

a	i	180000 × 2.8 ✓ = 500000 ✓ (504000 Nm) ecf from first line for incorrect power of 10	**2**
a	ii	7.4 × lift fan thrust ✓ = 180000 × 2.8 (504000 Nm) ✓ ecf from part ai F = 68000 or 68 k (N) ✓ (68108 N) ecf	**3**
a	iii	180k – 68.1k = (111.9 =) 112 k (N) ✓ ecf from part aii **or** by taking moments	**1**
b	i	(*m* = *W*/*g*) = 180 000/9.81 ✓ (= 18349 kg) *a* = *F*/*m* = 155 000/18349 = 8.4 ✓ (8.4475 ms^{-2}) ecf for use of 180 in 1st mark use of weight rather than mass gets zero	**2**
b	ii	**cross-sectional or surface** area/shape/streamlining/aerodynamics/nature of surface/drag coefficient ✓ **correctly linked** to its effect on air resistance/drag ✓ **or maximum** thrust/force power of engine ✓ counterforce increases with speed **or** when drag equals thrust (forces are balanced) ✓	**2**

b	ii	velocity  line starting at zero and **curving with decreasing gradient** ✓ reaching a constant velocity ✓	**2**
c		steepest/maximum gradient ✓	**1**
		Total	**13**

3)

a		(sum of) clockwise moment(s) = (sum of) anticlockwise moment(s) ✓ **sum of** clockwise moment **s** = **sum of** anticlockwise moment **s** (about any given point) ✓ (for a system in) equilibrium ✓ allow 'balanced'	3	third mark depends upon the first Don't allow references to 'forces' being balanced. Don't allow 'stationary'. Allow 'total', etc instead of sum Ignore definitions of moment
b	i	35 × 110 ($\times 10^{-3}$) ✓ (= 3.85) = 3.9 (or 3.8) ✓ (3.9) **Nm** / allow (3850, 3900) **Nmm** ✓ don't allow nm, NM	3	allow 4 or 3.90 but not 4.0 unit must match answer
b	ii	3.85 = T × 25 ($\times 10^{-3}$) ✓ ecf from (bi) T = 3.85 / 25 ($\times 10^{-3}$) = 0.150 ($\times 10^{3}$) ✓ ecf = 150 (154 N) ✓	3	Correct answer with no working gets 2 out of three. Allow 156 (160) N from rounding error
c		($P = Fv$, $F = P/v$) = 2.8($\times 10^{3}$) / 15 ✓ = 190 (186.7 N) ✓	2	
		total	11	

4)

a	i	(one) **force** × distance between the **forces** ✓ (one) **force** × **perpendicular** distance between the **lines of action** **or** (one) **force** × **perpendicular** distance between the (two) **forces** ✓	**2**
a	ii	(810 × 7.3 =) 5900 ✓ (5913) (or alternative correct method) **Nm** ✓	**2**
b		*P* = *Fv* = (2 ×) 810 × 0.91 ✓ (1620 × 0.91) = 1500 ✓ (1474 W) **any number to 2 sf** ✓	**3**
c		to enable comparison between steam and horses **or** mill owners/engineers etc needed to know which steam engine would be suitable **or** would easily be able to compare the cost/time saved **or** good marketing ploy for steam engines **or** easily understood (by industrialists or the public) **or** other suitable valid reason ✓	**1**
		Total	**8**

5)

a	i	(moment = 520 x 0.26) = 140 (135.2) ✓ **Nm** ✓	2
a	ii	**180 x 0.41** and **0.63 X** seen ✓ 135.2 = 180 x 0.41 + 0.63 X ✓ ecf from 3(a)(i) (X = (135.2 – 73.8) / 0.63) = 97 ✓ (N) (97.46) allow 105 from use of 140Nm ecf from 3(a)(i)	3
a	iii	(520 – (180 + 97.46)) = 240 ✓ (242.5 N) ecf (or from correct moments calculation)	1

6)

a	i	$m = W/g$) (3.4 x 10^4 / 9.81 =) 3500 (3466 kg) ✓	1		Allow use of g=10
a	ii	(moment = 34 000 x 5.0) = 1.7 x 10^5 ✓ (Nm) **Nm** ✓ do not allow NM \ nM etc	2		allow in words
a	iii	170 000 = T x 12 OR T = 170 000 / 12 ✓ ecf aii = 1.4(167) x 10^4 ✓ (N)	2		
a	iv	(Component of T perpendicular to lever) = T cos 24 **OR** 14 167 x 0.9135 **OR** 12942 (N) ✓ ecf aiii allow 2.5cos24 x T (12942) x 2.5 = **F** x 8.0 **OR** F = ((12942) x 2.5) / 8.0 ✓ ecf for incorrect component of T or T on its own F = 4000 (N) ✓ (4044) ecf ecf for incorrect component of T or T on its own allow 4100 for use of 14 200 (4054)	3		Some working required for full marks. Correct answer only gets 2. Failure to find component of T is max 2 (4400 N)
		total	8		

7)

2a	(moment =) Force x perpendicular distance ✓ Between line of action (of force) and pivot/point ✓	both marks need to be clear – avoid bod If the force is named specifically (eg weight) mark the work but give a maximum of 1 mark. Ignore extra material such as law of moments.	2	
2bi	moment = 250 x 0.048 = 12 ✓ (allow 12000 for this mark) **N m** ✓ (stand alone mark if no number is present but only for N mm, N cm and N m)	only allow answers in other units if consistent eg 1200 N cm no working shown can gain full marks if answer and unit are consistent newton should be upper case if a symbol and metre should be in lower case (but only penalise if it is very obviously wrong)	2	
2bii	Y x 0.027 = 12 OR Y = 12/0.027 ✓ (allow use of 12 and 27 for this mark) = 440 (N) ✓ (444.4 N) CE from 2bi	Y = 2b(i)/0.027 treat power of 10 error as an AE note 450 N is wrong 1 sig fig is not acceptable	2	
biii	($k = F/\Delta L$) = 444.4 / 0.015 ✓ CE from 2b(ii) = 3.0 × 10^4 (Nm^{-1}) ✓ (29630 Nm^{-1})	k = 2b(ii)/0.015 treat power of 10 error as an AE using 440 gives 2.9 × 10^4 (Nm^{-1}) 1 sig fig is not acceptable	2	
biv	W (= ½ $F\,\Delta L$) = ½ x 444.4 x 0.015 Or W (= ½ $k\,\Delta L^2$) = ½ × 29630 × 0.015^2 ✓ (give this mark for seeing the digits only ie ignore powers of 10 and allow CE from b(ii) or b(iii) as appropriate = 3.3 (J) ✓ (3.333 J)	W = ½ × b(ii) × 0.015 W = ½ × b(iii) × 0.015^2 treat power of 10 error as an AE If either equation misses out the ½ no marks. Common CE is to use F = 250 N which can be used giving W = 1.9 J	2	