1	**(i)**	DF = 22500 ÷ 18	B1		
			M1		For using Newton's second law with 3 terms
		22500/18 – R = 600 × 1.4	A1		
		R = 410 N	A1	4	
	(ii)	Rate of working is 6150 W	B1√	1	ft on incorrect R, i.e. R × 15
2	**(i)**		M1		For using $s = ut + \frac{1}{2}at^2$ to obtain an equation in T from $s_{AP} + s_{BP} = 10$
		$\frac{1}{2}\ 0.5T^2 + 0.75T = 10$	A1		
		$[T^2 + 3T - 40 = 0 = (T + 8)\ (T - 5)]$	M1		For solving the resulting 3 term quadratic equation either by factorising or formula and finding a value for T
		T = 5 only	A1	4	Reject/ignore T = – 8
		Alternative mark scheme for 2(i)			
	(i)	$x = \frac{1}{2}\ \frac{1}{2}\ T^2$ $\quad 10 - x = \frac{3}{4}\ T$ Eliminate T $x = \frac{1}{4}\ [4/3(10 - x)]^2$	M1		Set up an equation for x, the distance travelled by particle A
		$x = 6.25$	A1		Solve for x reject/ignore $x = 16$
		$10 - 6.25 = \frac{3}{4}\ T$ or $6.25 = \frac{1}{4}\ T^2$	M1		Substitute for x into either of the above equations
		T = 5	A1		Reject/ignore T = –5
	(ii)	Speed is 2.5 ms^{-1}	B1√	1	ft for speed = 0.5T
3			M1		For resolving forces acting on P horizontally (3 terms)
		$0.8T_1 + 0.96T_2 = 10$ or $T_1 \cos 36.9 + T_2 \cos 16.3 = 10$	A1		
			M1		For resolving forces acting on P vertically (3 terms)
		$0.6T_1 - 0.28T_2 = 0.7g$ or $T_1 \sin 36.9 - T_2 \sin 16.3 = 0.7g$	A1		
			M1		For solving simultaneous equations and finding both T_1 and T_2
		$T_1 = 11.9$ **and** $T_2 = 0.5$	A1	6	

4	**(i)**		M1		For differentiation to find *a(t)* for $t \geqslant 8$
		$a(t) = t^{-1/3}/3$	A1		
		[0.25 – (1/2) / 3 = 1/4 – 1/6]	M1		Decrease = $a(8^-) - a(8^+)$
		Decrease is $1/12\ \text{ms}^{-2}$	A1	4	AG
	(ii)		B1		$s_1 = ½ ¼ 8^2 = 8$
		$s_2 = \int_8^{27} \frac{1}{2} t^{2/3} dt = [0.3t^{5/3}]_8^{27}$	M1		Using definite integration to find s_2
		Distance is 71.3 m	A1	3	$s_1 + s_2 = 71.3$
	Alternative method for the final two marks				
		$s = \int \frac{1}{2} t^{2/3} dt = 0.3t^{5/3} + c$ $s(8) = 8$ gives $c = -1.6$	M1		Using indefinite integration to find *s* and finding the constant of integration by using the value of s_1
		$s(27) = 0.3(27)^{5/3} - 1.6 = 71.3$	A1		Finding *s*(27)
5	**(i)**	KE gain is $10.5v^2$ J	B1	1	
	(ii) **(a)**	[PE Loss = 16 (10) *x* – 5 (10) *x* sin 30]	M1		For use of PE = mgh and Loss by system = loss by B – gain by A
		PE loss by system is 135*x* J	A1	2	
	(b)	R = 5 (10) × (√3 ÷ 2)	B1		
		F = 25	B1		
		Work done is 25*x* J	B1√	3	ft incorrect F
	(iii)	[$10.5v^2 = 135x - 25x$]	M1		For using 'Gain in KE = Loss in PE – WD against friction'
		$21v^2 = 220x$	A1	2	AG
6	**(i)**	$v^2 = 2 \times g \times 7.2$ ➔ speed at surface is $12\ \text{ms}^{-1}$	B1		
		[$6^2 = 12^2 + 2a \times 0.8$]	M1		For using $6^2 = v^2 + 2as$ and finding *a*
		Deceleration is $67.5\ \text{ms}^{-2}$	A1		
		[$0.2g - R = -0.2 \times 67.5$]	M1		For using Newton's 2nd law with three terms for P in the liquid
		R = 15.5	A1	5	

(ii)	$[3.6 = ½\ a \times 4^2]$	M1		For using $s = 0 + ½\ at^2$ and finding a
	$a = 0.45\ \text{ms}^{-2}$	A1		
	$[T – R – 0.2g = 0.2 \times 0.45]$	M1		For using Newton's 2nd law with P in the liquid
	Tension is 17.6 N (17.59 exact)	A1ft	4	ft incorrect R
Alternative Energy Method				
(i)		M1		For using PE lost = WD by R in liquid + KE gain
	$0.2g \times 8 = R(0.8) + ½\ (0.2)\ 6^2$	A1		
	$R = 15.5$	A1		Finding R
	$0.2g – 15.5 = 0.2a$	M1		For using Newton's 2nd law in the liquid
	$a = –67.5$	A1	5	
(ii)		M1		For using $s = (0 + v)/2 \times t$ to find v at surface of liquid
	$3.6 = v/2 \times 4 \qquad v = 1.8$	A1		
	$T(3.6) = R(3.6) + 0.2g(3.6) + ½(0.2)1.8^2$	M1		For using WD by T = WD by R + PE gain + KE gain
	$T = 17.6\,\text{N}$	A1	4	
7 (i)	$[\ T_A – 2.5 = 0.25 \times a\ ] \qquad [\ 7.5 – T_B = 0.75 \times a\ ]$	M1		For applying Newton's 2nd law to either particle A or particle B
	$T_A = 2.5 + 0.25a$	A1		
	$T_B = 7.5 – 0.75a$	A1	3	
(ii)	$F = 0.4 \times 5$	B1		
	$[T_B – T_A – F = 0.5a]$	M1		For using Newton's 2nd law for P with friction and both tensions represented (4 terms)
	$7.5 – 0.75a\ – (2.5 + 0.25a) – 2 = 0.5a \rightarrow a = 2$	A1	3	AG

	Alternative method for (ii)			
(ii)	$F = 0.4 \times 5$	B1		
	$a = 2$ used to find $T_A = 3$, $T_B = 6$ and used in $T_B - T_A - F = 0.5 \times a$	M1		Assume given value of a, find T_A and T_B and use the values in 4 term Newton's 2nd law
	$a = 2$	A1		Justify the value $a = 2$
(iii)	$[v^2 = 2 \times 2 \times 0.36]$	M1		For using $v^2 = 2as$ with $s = 1 - ½ (5.28 - 4)$
	Speed is 1.2 ms^{-1}	A1	2	
(iv)	$-T_A - 2 = 0.5a$ and $T_A - 2.5 = 0.25a$	M1		For applying Newton's 2nd law to particle P **and** substituting for T_A
	Deceleration is 6 ms^{-2}	A1	2	$a = -6$ or $d = 6$