1		M1		For resolving forces vertically (3 terms required)
	$R + 2000\cos 15^\circ = 400g$	A1		
	$F = 2000\sin 15^\circ$	B1		
	$[2000\sin 15^\circ = \mu(400g - 2000\cos 15^\circ)]$	M1		For using $F = \mu R$
	Coefficient is 0.25	A1	**[5]**	
	SR(max. 4/5) for candidates who either: have sin and cos interchanged or have angle 15° above the horizontal			
		M1		For resolving forces vertically
	$R + 2000\sin 15^\circ = 400g$ <u>and</u> $F = 2000\cos 15^\circ$	A1		
	$[2000\cos 15^\circ = \mu(400g - 2000\sin 15^\circ)]$	M1		For using $F = \mu R$
	Coefficient is 0.55	A1		
2	Driving force = 400/4	B1		
		M1		For using Newton's second law (either case) – 3 terms needed
	$DF - 80g\sin 2^\circ = 80a$ **(i)** or $DF + 80g\sin 2^\circ = 80a$ **(ii)**	A1		
	Acceleration is $0.9\ ms^{-2}$ **(i)** or Acceleration is $1.6\ ms^{-2}$ **(ii)**	A1		Accept 0.90 or 0.901 and 1.60
	Acceleration is $1.6\ ms^{-2}$ **(ii)** and Acceleration is $0.9\ ms^{-2}$ **(i)**	B1ft	**[5]**	ft Ans **(i)** + **(ii)** = 2.5
	SR(max. 3/5) for candidates who have sin and cos interchanged			
	Driving force = 400/4	B1		
		M1		For using Newton's second law (either case) – 3 terms needed
	$a = -8.74$ **(i)** <u>and</u> $a = 11.2$ **(ii)**	A1		
3		M1		For resolving forces in **i** and **j** directions (3 terms in at least one of the equations)
	$6\cos\alpha^\circ + 5\cos(90^\circ - \alpha^\circ) = F$ and $6\sin\alpha^\circ - 5\sin(90^\circ - \alpha^\circ) = F$	A1		
	$[6\cos\alpha^\circ + 5\sin\alpha^\circ = 6\sin\alpha^\circ - 5\cos\alpha^\circ$ $\rightarrow 11\cos\alpha^\circ = \sin\alpha^\circ]$	DM1		For attempting to solve for α°. Dependent on 1st M1
	$\alpha = 84.8$	A1		
	$[F = 6\cos 84.8^\circ + 5\sin 84.8^\circ;\ F = 6\sin 84.8^\circ - 5\cos 84.8^\circ]$	DM1		For substituting to find F; dependent on the 1st M1
	$F = 5.52$	A1	**[6]**	

First alternative scheme			
$[2F^2 = 25 + 36]$	M1		For using '(resultant of forces of magnitude F)^2 = (resultant of forces of magnitudes 5 and 6)^2'
F = 5.52	A1		
	M1		For using 'resultant of forces of magnitudes 5 and 6 makes angle 45° with x-axis'
	M1		For using relevant trigonometry
$\tan(\alpha^\circ - 45^\circ) = 5/6$ or $\tan(135^\circ - \alpha^\circ) = 6/5$ or $\cos(\alpha^\circ - 45^\circ)$ or $\sin(135^\circ - \alpha^\circ) = 6/\sqrt{61}$ or $\sin(\alpha^\circ - 45^\circ)$ or $\cos(135^\circ - \alpha^\circ) = 5/\sqrt{61}$	A1		
$\alpha = 84.8$	A1		
Second alternative scheme			
$[6\cos\alpha^\circ + 5\cos(90^\circ - \alpha^\circ) = 6\sin\alpha^\circ - 5\sin(90^\circ - \alpha^\circ)]$	M1		For using Rx = Ry
$[11\cos\alpha^\circ - \sin\alpha^\circ = 0]$	M1		For attempting to solve for α°
$\alpha = 84.8$	A1		
For $F = 6\cos\alpha^\circ + 5\cos(90^\circ - \alpha^\circ)$ or $F = 6\sin\alpha^\circ - 5\sin(90^\circ - \alpha^\circ)$	B1		
	M1		For substituting for α
F = 5.52	A1		
4 **(i)** $[\frac{1}{2}\,20(2.5^2 - 1.5^2),\ 20\text{x}10\text{x}10\sin 4.5^\circ]$	M1		For using KE loss = ½ $m(u^2 - v^2)$ or PE gain = $mg(L\sin\alpha)$
KE loss = 40 J or PE gain = 157 J	A1		
PE gain = 157 J or KE loss = 40 J	B1	**[3]**	
(ii) [WD = 157 – 40 + 50]	M1		For using WD by pulling force = PE gain – KE loss + WD against resistance
Work done is 167 J	A1ft	**[2]**	ft incorrect PE gain + 10, even if –ve
(iii) $[167 = F\text{x}10\cos15^\circ]$	M1		For using WD = FLcos 15°
Magnitude is 17.3 N	A1ft	**[2]**	
SR (max. 1/2) for candidates who (implicitly) make the unjustifiable assumption that acceleration is constant and apply Newton's second law			
For magnitude is 17.3 N from $F\cos 15^\circ - 20g\sin4.5^\circ - 50/10 = 20 \times (-0.2)$	B1		

5	(i)	[$15 = 20t - 5t^2$ → $5(t^2 - 4t + 3) = 0$]	M1		For use of $h = ut - ½ gt^2$
		$t = 1, 3$	A1		
		Duration is 2 s (accept $1 < t < 3$)	B1ft	[3]	ft $t_2 - t_1$
	(ii)		M1		For using $h_P = h_Q$ at time t after P's (or Q's) projection
		$20t - 5t^2 = 25(t - 0.4) - 5(t - 0.4)^2$ (or $20(t + 0.4) - 5(t + 4)^2 = 25t - 5t^2$ or $(20 \times 0.4 - 5 \times 0.4^2) + 16t - 5t^2 = 25t - 5t^2$)	A1		
		$t = 1.2$ (or $t = 0.8$)	A1		
		[$v_P = 20 - 10\text{x}1.2$; $v_Q = 25 - 10\text{x}(1.2 - 0.4)$ (or $v_P = 20 - 10\text{x}(0.8 + 0.4)$; $v_Q = 25 - 10\text{x}0.8$)]	M1		For using $v = u - gt$ for both v_P and v_Q
		Velocities are $8\,ms^{-1}$ and $17\,ms^{-1}$	A1	[5]	
6	(i)	[½ 2.5($speed_{max}$) = 4]	M1		For using area property for distance
		Greatest speed is $3.2\,ms^{-1}$	A1	[2]	
		SR (max. 1/2) for candidates who (implicitly) make the unjustifiable assumption that $speed_{max}$ occurs when $t = 1.25$			
		Greatest speed is $3.2\,ms^{-1}$ from 2 x ½ 1.25($speed_{max}$)v = 4	B1		
	(ii)	[V = 3x2]	M1		For using $a = (V - 0)/(4.5 - 2.5)$ or $V = 0 + at$
		V = 6	A1	[2]	
	(iii)		M1		For using area property for distance from t = 2.5 to t = 14.5
		½ 6(12 + T) = 48 or ½ 6x2 + 6T + ½ 6(10 – T) = 48 or ½ 6x2 + 6(10 – τ) + ½ 6τ = 48	A1ft		
		t = 8.5	A1	[3]	from 4.5 + T or 14.5 – τ
	(iv)		M1		For using $a = (0 - V)/(14.5 - 8.5)$ or $0 = V + a(14.5 - 8.5)$
		Deceleration is $1\,ms^{-2}$	A1ft	[2]	

7	**(i)**	$a(t) = 0.006t^2 - 0.24t + 1.8$	B1		
		$[0.006(t^2 - 40t + 300) = 0]$	M1		For solving a(t) = 0
		$T_1 = 10$, $T_2 = 30$	A1		
			M1		For integrating v(t)
		$s(t) = 0.0005t^4 - 0.04t^3 + 0.9t^2 + 5t + (C)$	A1		
		[405 – 1080 + 810 + 150]	M1		For using limits 0 to T_2 or equivalent
		Distance is 285 m	A1	**[7]**	
	(ii)	Velocity is 5 ms^{-1}	B1		
		For curve with v increasing from a +ve value at t = 0 to a maximum	B1		
		Then decreases to a +ve minimum and thereafter increases	B1	**[3]**	