1 (i)	[$-11 = 11 - 10t$]	M1		For using $v = u - gt$ (or equivalent method) to find the duration of motion
	Time after projection is 2.2 seconds	A1	2	
(ii)	$h = 0 + ½\,g \times 2.2^2 = 24.2$	B1√		
	$V = 0 + g \times 2.2 = 22$	B1√	2	
2 (i)	[$X = 25 \times 0.96 - 30 \times 0.8 = 0$]	M1		For resolving forces in the x direction
	Component in x-direction is zero	A1	2	AG
(ii)	[$Y = 25 \times 0.28 - 20 + 30 \times 0.6 = 5$]	M1		For resolving forces in the y direction
	Resultant has magnitude 5 N and acts in the positive y direction	A1	2	
(iii)	Replacement has magnitude 30 N and acts in the –ve y direction	B1	1	
3 (i)	[$v_B = 1.2 \times 28 \div 0.96$]	M1		For using $P = Fv$ and the factors 1.2 and 0.96 and an equation in v_B only
	Speed of the train at B is 35 ms^{-1}	A1	2	AG
(ii)	KE increase = $100\,000(35^2 - 28^2)$	B1		
	WD by engine $= 44.1 \times 10^6 + 2.3 \times 10^6$ J	M1		For using WD by engine = KE increase + WD against resistance
	Work done is 46 400 kJ or 46.4×10^6 J	A1	3	or 46 400 000 J
4 (i)	[$X\cos30° = 40\cos60°$]	M1		For resolving forces horizontally
	$X = 23.1$ $(= 40 / \sqrt{3})$	A1	2	
(ii)	[$X\cos30° - 10 = 40\cos60°$]	M1		For resolving forces horizontally
	$X = 60 \div \sqrt{3}$ or 34.6	A1		
	[$R + X\sin30° + 40\sin60° = 15g$]	M1		For resolving forces vertically ($R = 98.038$)
	[$\mu = 10 \div (150 - 30/\sqrt{3} - 20\sqrt{3})$]	M1		For using $F = \mu R$
	Coefficient is 0.102	A1	5	

5 (i) (a)	[$F = 0.7 \times 3$, WD $= 2.1 \times 0.9$]	M1		For using $F = \mu R$ and WD $= Fs$
	Work done is 1.89 J	A1	2	
(b)	Loss of PE $= 3 \times 0.9 = 2.7$ J	B1	1	
(c)	[KE gain $= 2.7 - 1.89$]	M1		For 'gain in KE = loss in PE – WD by friction'
	Gain in KE = 0.81 J	A1	2	
(ii)	$\frac{1}{2}(0.3 + 0.3)v_{\text{at break}}^2 = 0.81$]	M1		For using $\frac{1}{2}(m_A + m_B)v^2$ = gain in KE
	$v_{\text{floor}}^2 = v_{\text{at break}}^2 + 2g \times 0.54$	M1		For using $v^2 = u^2 + 2gs$
	Speed at the floor is 3.67 ms^{-1}	A1	3	
	Alternative method for (i) (c) and (ii)			
(c)	[$T - 2.1 = 0.3a$ and $3 - T = 0.3a$ $\rightarrow$ $a = 1.5$] [$v^2 = 2 \times 1.5 \times 0.9 = 2.7$]	M1		For applying Newton's 2nd law to both particles and finding a **and** using $v^2 = 0 + 2as$ **and** attempting KE
	KE $= 0.5 \times (0.3 + 0.3) \times 2.7 = 0.81$ J	A1	2	
(ii)	[$v_{\text{at break}}^2 = 2.7$]	M1		For using their v^2 in (i)(c) as $v_{\text{at break}}^2$
	$v_{\text{floor}}^2 = v_{\text{at break}}^2 + 2g \times 0.54$	M1		For using $v^2 = u^2 + 2gs$
	Speed at floor = 3.67 ms^{-1} (= $1.5\sqrt{6}$)	A1	3	
	Alternative method for (ii)			
(ii)	[$0.3 \times g \times 0.54$] **or** [$\frac{1}{2} \times 0.3 \times (v^2 - 2.7)$]	M1		For attempting PE loss or KE gain for the falling particle only
	[$1.62 = \frac{1}{2} \times 0.3 \times (v^2 - 2.7)$]	M1		For using PE loss = KE gain of this particle
	Speed at floor = 3.67 ms^{-1} (= $1.5\sqrt{6}$)	A1	3	
6 (i) (a)	(a) Acceleration is 2.8 ms^{-2}	B1		Using acceleration = $g \sin \alpha$
(b)	[$mg \times 0.28 - 0.5mg \times 0.96 = ma$]	M1		For using Newton's 2nd law
	Acceleration is – 2 ms^{-2}	A1	3	

(ii)	$v_B{}^2 = 2 \times 2.8(AB)$ and $2^2 = 5.6(AB) - 2 \times 2(5 - AB)$	M1 A1ft		For using $v^2 = u^2 + 2as$ for AB and for BC and using $AB + BC = 5$ ft incorrect answers in (i)
	Distance is 2.5 m	A1	3	
	Alternative method for (ii)			
	$[mg \times 5 \times 0.28 = ½\, m\, 2^2 + \mu \times mg \times 0.96 \times BC]$	M1		For using Loss in PE = Gain in KE + WD against Friction for the motion from A to C
	$14 = 2 + 4.8 \times BC$	A1		Correct equation
	$BC = 12/4.8 = 2.5$ m	A1	3	
(iii)		M1		For using $t = 2s \div (u + v)$ for AB and BC
	$T = 2 \times 2.5 \div (0 + \sqrt{14}) + 2 \times 2.5 \div (\sqrt{14} + 2)$	A1		
	Time taken is 2.21 s	A1	3	
7 (i)	$v = -4.8$	B1		
	$[\pm 4.8 = 3a]$	M1		For using $v = 0 + at$
	Magnitude of acceleration is $1.6\,\text{ms}^{-2}$	A1	3	
(ii)	$[-0.4t + 4\ (= 0 \text{ when } t = 10)]$	M1		For finding the value of t when $dv/dt = 0$
		M1		For evaluating $v(10)$ as v_{max} (the graph excludes the possibility of $v(10)$ as v_{min})
	$v_{max} = -0.2 \times 100 + 4 \times 10 - 15 \rightarrow$ Maximum velocity is $5\,\text{ms}^{-1}$	A1	3	
(iii) (a)	Distance 0 to 3 s = ½ × 3 × 4.8 (= 7.2)	B1		
	Distance 3 to 5s $= -\int_3^5 \left(-0.2t^2 + 4t - 15\right) dt$	M1		Attempt to integrate and use limits
	Distance = ± 4.5333…m	A1		
	Average speed = (7.2 + 4.533) ÷ 5 = $2.35\,\text{ms}^{-1}$	B1		

(b)	Distance *BC* $= \left[-\frac{0.2t^3}{3} + 2t^2 - 15t \right]_5^{15}$ and Av speed = (*AB* + *BC*) ÷ 15	M1		ft for errors in coefficients in cubic expression
	Av speed = (45.066 ÷ 15) = 3.00 ms^{-1}	A1	6	