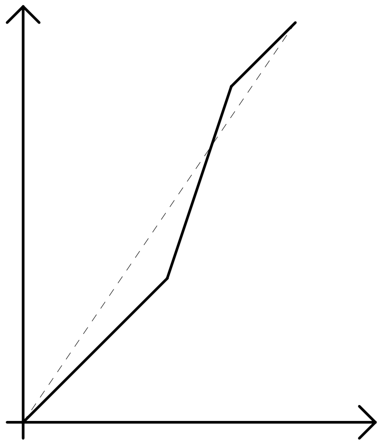
Mark Scheme 4728
June 2006

1		Momentum before = $3M - 1200\times3$ Momentum after = 1200×5	B1 B1		Ignore g if included; accept inconsistent directions (or loss of momentum of loaded wagon = $3M$ B1 gain of momentum of unloaded wagon = 1200(5 + 3) B1)
		$3M - 3600 = 6000$ $3(1200 + m) - 3600 = 6000$ $m = 2000$	M1 A1 A1	 5	Equation with all terms; accept with g For any correct equation in m, M
2	(i)	 $2.5 = 6.5\sin\theta$ $\theta = 22.6^{\circ}$	M1 A1 A1	 3	For resolving forces in the **i** direction or for relevant use of trigonometry AG Accept verification
	(ii)	 $R = 6.5\cos22.6^{\circ}$ $R = 6$	M1 A1 A1	 3	For resolving forces in the **j** direction or for using Pythagoras or relevant trigonometry.

3	**(i)**		B1	Line segment *AB* (say) of +ve slope from origin
			B1	Line segment *BC* (say) of steeper +ve slope and shorter time interval than those for *AB*. ***SR***: If the straight line segments are joined by curves, this B1 mark is not awarded
			B1	Line segment *CD* (say) of less steep slope compared with *BC*. (An (x, t) graph is accepted and the references to more/less steep are reversed.)
		Time intervals 80, 40, 40	B1	May be implied; any 2 correct
		t = 80, 120, 160	B1	
	(ii)	Line joining (0, 0) and (160, 360)	B1 ft 6	
	(iii)	v = 360/160	M1	Woman's velocity (= 2.25)
			M1	For equation of man's displacement in relevant interval
		$s = 120 + 4.5(t - 80)$	A1	Accept omission of -80
		$2.25t$	M1	Woman's displacement, awarded even if t is interpreted differently in man's expression
		$t = 106\frac{2}{3}$ (107)	A1 5	Accept also 106.6, 106.7 but not 106
		SR Construction method		
		Plotting points on graph paper	M1	Candidates reading the displacement intersection from graph, then dividing this distance by the woman's speed to find t, also get v = 360/160 M1 as above for the woman's velocity.
		t between 104 and 109 inclusive	A1	
4	**(i)**	Displacement is 20 m	B1 1	20+c (from integration) B0
	(ii)		M1	For using $s(t) = \int v(t)dt$
		$s(t) = 0.01t^3 - 0.15t^2 + 2t$ (+A)	A1	Can be awarded prior to cancelling
		$10 - 15 + 20 + A = 20$	M1	For using $s(10)$ = cv (20)
		Displacement is $0.01t^3 - 0.15t^2 + 2t + 5$	A1 4	AG
	(iii)		M1	For using $a(t) = dv/dt$
		$a = 0.06t - 0.3$	A1	
		$0.06t - 0.3 = 0.6$	DM1	For starting solving $a(t) = 0.6$ depends on previous M1
		$t = 15$	A1	
		Displacement is 35 m	B1 5	

5	(i)	 $R = mg$ $m = 2.55$	M1 M1 A1 3	For using $F = 5$ and $F = \mu R$ Accept 2.5 or 2.6
	(ii)a	$P\cos\alpha = 6$ $R = P\sin\alpha + 25$ $0.2R = 6$ $0.2(P\sin\alpha + 25) = 6$ $\alpha = 39.8^o$	B1 M1 A1ft B1 M1 A1	 For resolving vertically with 3 distinct forces Or $P \sin\alpha$ + (cv m)g For using $F = 6$ and $F = \mu R$. Can be implied by $0.2(P\sin\alpha + 25) = 6$ For an equation in $P\sin\alpha$ (=5)after elimination of R Accept a r t 40^o
	(ii)b	$P^2 = 6^2 + 5^2$ or $P\cos 39.8^o = 6$ or $P\sin 39.8^o = 5$ $P = 7.81$	M1 A1 8	For eliminating or substituting for α with cv(6). Evidence is needed that 5 is the value of $P\sin\alpha$ (rather than the original frictional force) Accept a r t 7.8
6	(i)	10500 + 3000 + 1500 Driving force below 15000 gives retardation	M1 A1 2	For summing 3 resistances Accept generalised case or specific instance
	(ii)	35000 – 15000 = 80000a Acceleration is 0.25 ms^{-2}	M1 A1 2	Newton's second law for whole train AG Accept verification
	(iii)	 35000 – 10500 – 8500 = $0.25m$ Mass is 64000 kg	M1 A1 A1 3	For applying Newton's second law to E only, at least 2 forces out of the relevant 3.
	(iv)	 -15000 – 15000 = 80000a OR -3000-10500-15000=(80000 - m)a -1500 = ma Mass is 4000 kg	M1 A1 M1 A1 A1 5	For applying Newton's second law with all appropriate forces a = -0.375 For applying Newton's second law to B only, only 1 force Or cv(a)
	(v)	-15000 – 10500 $\pm$ T = 64000(-0.375) $T = \pm 1500$ ➔ forward force on E of 1500 N OR (working with A and B) -1500 – 3000 $\pm$ T = (80000 - 64000)(-0.375) $T = \pm 1500$ ➔ forward force on E of 1500	B1ft B1 2 B1ft B1	Follow through cv (m_E, a), or accept use of m_E, a Follow through cv (m_E, a), or accept use of m_E, a

7	(i)	$0 = 6 + (\pm)1.5a$	M1	For using $v = u + at$ with $v = 0$

		$a = (\mp)4\text{ms}^{-2}$	A1		
		$-mg\sin 15^o - F = ma$	M1		For applying Newton's second law with 2 forces
		$-0.1\times 9.8\sin 15^o - F = 0.1\times(-4)$	A1		
		$R = 0.1g\cos 15^o$	B1		
		$0.146357 \ldots = \mu 0.946607 \ldots$	M1		For using $F = \mu R$
		Coefficient is 0.155	A1	7	Anything between 0.15 and 0.16 inclusive
	(ii)	$mg\sin 15^o > \mu mg\cos 15^o$ (or $\tan 15^o > \mu$)	M1		For comparing weight component with frictional force (or tan 'angle of friction' with μ)
		➔ particle moves down	A1	2	Awarded if conclusion is correct even though values are wrong
	(iii)	$(6 + 0)\div 2 = s\div 1.5$	M1		For using $(u + v)\div 2 = s\div t$
		$s = 4.5$	A1		
		$mg\sin 15^o - F = ma$	M1		For using Newton's second law with 2 forces
		$0.25364 \ldots - 0.146357 \ldots = 0.1a$	A1		Values must be correct even if not explicitly stated. Note that the correct value of friction may legitimately arise from a wrong value of μ and a wrong value of R
		$v^2 = 2(1.07285 \ldots)4.5$	M1		For using $v^2 = 2as$ with any value of a
		Speed is 3.11 ms^{-1}	A1	6	Accept anything rounding to 3.1 from correct working