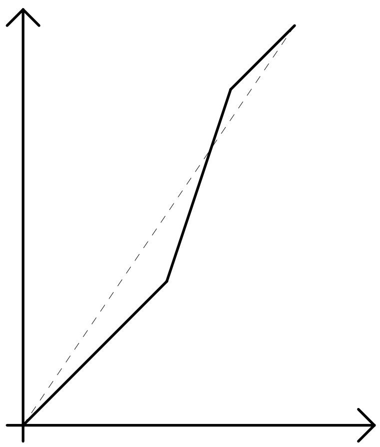
Mark Scheme 4728
June 2006

1		Momentum before = $3M - 1200\times 3$ 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)**	 $2.5 = 6.5\sin\theta$ $\theta = 22.6^o$	M1 A1 A1	3	For resolving forces in the **i** direction or for relevant use of trigonometry AG Accept verification
	(ii)	 $R = 6.5\cos 22.6^o$ $R = 6$	M1 A1 A1	3	For resolving forces in the **j** direction or for using Pythagoras or relevant trigonometry.

3	**(i)**	 Time intervals 80, 40, 40 t = 80, 120, 160	B1 B1 B1 B1 B1	Line segment *AB* (say) of +ve slope from origin 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 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.) May be implied; any 2 correct
	(ii)	Line joining (0, 0) and (160, 360)	B1 ft 6	
	(iii)	v = 360/160 s = 120 + 4.5(t – 80) 2.25t $t = 106\frac{2}{3}$ (107) ***SR*** Construction method Plotting points on graph paper t between 104 and 109 inclusive	M1 M1 A1 M1 A1 5 M1 A1	Woman's velocity (= 2.25) For equation of man's displacement in relevant interval Accept omission of -80 Woman's displacement, awarded even if t is interpreted differently in man's expression Accept also 106.6, 106.7 but not 106 Candidates reading the <u>displacement</u> 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.
4	**(i)**	Displacement is 20 m	B1 1	20+c (from integration) B0
	(ii)	 $s(t) = 0.01t^3 – 0.15t^2 + 2t$ (+A) 10 – 15 + 20 + A = 20 Displacement is $0.01t^3 – 0.15t^2 + 2t + 5$	M1 A1 M1 A1 4	For using $s(t) = \int v(t)dt$ Can be awarded prior to cancelling For using s(10) = cv (20) AG
	(iii)	 $a = 0.06t – 0.3$ $0.06t – 0.3 = 0.6$ t = 15 Displacement is 35 m	M1 A1 DM1 A1 B1 5	For using $a(t)$ = dv/dt For starting solving $a(t)$ = 0.6 depends on previous M1

5	**(i)**		M1	For using $F = 5$ and $F = \mu R$
		$R = mg$	M1	
		$m = 2.55$	A1 3	Accept 2.5 or 2.6
	(ii)a	$P\cos\alpha = 6$	B1	
			M1	For resolving vertically with 3 distinct forces
		$R = P\sin\alpha + 25$	A1ft	Or $P\sin\alpha$ + (cv m)g
		$0.2R = 6$	B1	For using $F = 6$ and $F = \mu R$. Can be implied by $0.2(P\sin\alpha + 25) = 6$
		$0.2(P\sin\alpha + 25) = 6$	M1	For an equation in $P\sin\alpha$ (=5)after elimination of R
		$\alpha = 39.8^o$	A1	Accept a r t 40^o
	(ii)b	$P^2 = 6^2 + 5^2$ or $P\cos39.8^o = 6$ or $P\sin39.8^o = 5$	M1	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)
		$P = 7.81$	A1 8	Accept a r t 7.8
6	**(i)**	10500 + 3000 + 1500	M1	For summing 3 resistances
		Driving force below 15000 gives retardation	A1 2	Accept generalised case or specific instance
	(ii)	35000 – 15000 = 80000a	M1	Newton's second law for whole train
		Acceleration is 0.25 ms^{-2}	A1 2	AG Accept verification
	(iii)		M1	For applying Newton's second law to E only, at least 2 forces out of the relevant 3.
		35000 – 10500 – 8500 = 0.25m	A1	
		Mass is 64000 kg	A1 3	
	(iv)		M1	For applying Newton's second law with all appropriate forces
		-15000 – 15000 = 80000a OR -3000-10500-15000=(80000 - m)a	A1	a = -0.375
			M1	For applying Newton's second law to B only, only 1 force
		-1500 = ma	A1	Or cv(a)
		Mass is 4000 kg	A1 5	
	(v)	-15000 – 10500 $\pm$ T = 64000(-0.375)	B1ft	Follow through cv (m_E, a), or accept use of m_E, a
		$T = \pm1500$ ➔ forward force on E of 1500 N	B1 2	
		OR (working with A and B) -1500 – 3000 $\pm$ T = (80000 - 64000)(-0.375)	B1ft	Follow through cv (m_E, a), or accept use of m_E, a
		$T = \pm1500$ ➔ forward force on E of 1500	B1	

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

		$a = (\mp)4\text{ms}^{-2}$	A1		
		$-mg\sin15^o - F = ma$	M1		For applying Newton's second law with 2 forces
		$-0.1\times9.8\sin15^o - F = 0.1\times(-4)$	A1		
		$R = 0.1g\cos15^o$	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)	$mg\sin15^o > \mu mg\cos15^o$ (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)	$(6 + 0)\div2 = s\div1.5$	M1		For using $(u + v)\div2 = s\div t$
		$s = 4.5$	A1		
		$mg\sin15^o - F = ma$	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