

**Mark Scheme 4728**  
**June 2006**

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

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

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

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