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| 1 i | $t = 5/1.2$ $t = 4.17 \text{ s}$ | M1 A1 [2] | $5=1.2t$ or $0=5-1.2t$ 4 1/6 s, 4.166 or better, 4.16 recurring. |
| ii | $s = (-5)^2/2 \times 1.2$ $s = 10.4 \text{ m}$ <i>OR (using(i))</i> $s = 5 \times 4.17 - 1.2 \times 4.17^2/2$ $s = 10.4 \text{ m}$ <i>OR (using(i))</i> $s = (5 (+ 0))/2 \times 4.17$ $s = 10.4 \text{ m}$ | M1 A1 [2] M1 A1 M1 A1 | $s = 5^2/2 \times 1.2$ or $5^2 = 2 \times 1.2s$ or $0 = 5^2 - 2 \times 1.2s$ Accept 10 5/12, but not 10 Time must be > 0 . Accept $ t $ from (i) Award if $ -4.17 $ used. |
| iii | $F_r = 3 \times 1.2$ $R = 3 \times 9.8$ $\mu = (3 \times) 1.2 / (3 \times) 9.8$ $\mu = 0.122$ <i>OR</i> $R = 3 \times 9.8$ Mass \times acceleration = $\pm 3 \times 1.2$ $\pm \mu \times 29.4 = \pm 3 \times 1.2$ $\mu = 0.122$ | B1 B1 M1 A1 [4] B1 B1 M1 A1 | Accept 3.6, \pm / Accept 3g, \pm / Ratio of 2 positive numerical force terms Not 0.12 Accept 3g, \pm / Either both positive or both negative. |
| 2 i | $\pm / -(0.4 \times 3 - 0.6 \times 1.5)$ $\pm / -(0.4 \times 0.1 + 0.6v)$ $(0.4 \times 3 - 0.6 \times 1.5) = \pm / -(0.4 \times 0.1 + 0.6v)$ speed $ v = 0.433 \text{ ms}^{-1}$ <i>OR</i> $\pm / (0.4 \times 3 - 0.4 \times 0.1) = \pm / - 1.16$ $(0.6v + 0.6 \times 1.5) = 0.6v + 0.9$ $1.16 = \pm / -(0.6v + 0.9)$ speed $ v = 0.433 \text{ ms}^{-1}$ | B1 B1 M1 A1 [4] B1 B1 M1 A1 | $\pm / - 0.3$ Nb the terms have same signs Equating their total mom before & after Accept 13/30 or 0.43 recurring, but not 0.43 Momentum change of P Momentum change of Q Equating momentum changes $0.26/0.6 = v$ |
| ii | $\pm / -(0.4 \times 0.1 - 0.6v)$ $(0.4 \times 3 - 0.6 \times 1.5) = \pm / -(0.6v - 0.4 \times 0.1)$ $v = 0.567$ $PQ = 0.1 \times 3 + 0.567 \times 3$ $PQ = 2 \text{ m}$ <i>OR</i> $\pm / - 0.4 \times 3 + 0.4 \times 0.1$ and $\pm / - 0.6v + 0.6 \times 1.5$ $1.24 = \pm / - 0.6v + 0.9$ $v = 0.567$ etc | B1 M1 A1 M1 A1 [5] B1 M1 A1 | Nb the terms have different signs Must use $\pm / -$ same before momentum as in (i) May be implied, or in any format $(0.1 + 0.567) \times 3$ Accept 2.00(1), 2.0, 2.00 Both must be correct Equating change in momentum May be implied, or in any format |
| 3 i | $H = \pm / -(9 - 5 \cos 60)$ $H = 6.5 \text{ N}$ | AG M1 A1 [2] | $\pm / -(9 + 5 \cos 120)$ |
| ii | $V = \pm / -(12 - 5 \sin 60)$ $V = 7.67 \text{ N}$ | M1 A1 [2] | $\pm / -(12 + 5 \cos 150)$ Accept 7.666 or better, or 7.6 recurring |
| iii | $R^2 = 6.5^2 + 7.67^2$ $R = 10.1 \text{ N}$ $\tan A = 6.5/7.67$ or $7.67/6.5$ $A = 40(.3)$ or 49.7 Bearing = 320° | M1 A1 M1 A1 A1 [5] | Uses Pythagoras on forces V(ii) and 6.5 10.053.. Uses trigonometry in relevant triangle May be implied by final answer As this is not a final answer, exact accuracy is not an issue Or better |

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| 4 i | $3.2 - 0.2t^2 = 0$ $t = 4 \text{ s}$ | M1 A1 [2] | Puts 0 for v and attempts to solve QE Accept dual solution +/-4 |
| ii | $a = -2 \times 0.2t$ $a = -0.4 \times 4$ $a = -1.6 \text{ ms}^{-2}$ | M1* D*M1 A1 [3] | Differentiates v Substitutes +ve t(i) in derivative of v Negative only |
| iii | $s = 3.2t - 0.2t^3/3 (+c)$ $t = 0, s = 0$ so $c = 0$ $s(4) = 3.2 \times 4 - 0.2 \times 4^3/3$ $s = 8.53 \text{ m}$ | M1* A1 B1 D*M1 A1 [5] | Integrates v, not multiplication by t Or correct use of limits 0 and 4 Accept without/loss of c 8/8/15 Accept with/without c |

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| 5 i | $+/-3 \times 20/2$ 30 m | M1 A1 [2] | Use area of <u>scalene</u> triangle(s). Not suvat. Accept -30 |
| ii | $(t+4) \times 3/2 = 30$ or $3t/2 = 30 - 4 \times 3$ $t = 16$ or $t = 12$ $T = 76$ | M1 A1 A1 A1 [4] | Equates <u>scalene</u> trapezium area to distance (i) [(T-60)+4]x3/2 =30, award A2 |
| iii | $T(\text{accn}) = 3/0.4 (=7.5 \text{ s})$ $\text{decn} = 3/([76-60] - 4 - 7.5)$ $\text{decn} = (+/-) 2/3 \text{ ms}^{-2}$ <i>OR</i> $S(\text{accn}) = 3^2/(2 \times 0.4) (= 11.25 \text{ m})$ $\text{decn} = 3^2 / [2 \times (30 - 3 \times 4 - 11.25)]$ $\text{decn} = (+/-) 2/3 \text{ ms}^{-2}$ | B1 M1 A1 [3] B1 M1 A1 | Or $3 = \text{decn} \times ([76-60] - 4 - 7.5)$ $(+/-) 0.667$ or better - accept 0.6 recurring $(+/-) 0.667$ or better - accept 0.6 recurring |

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| 6 i a | $T - 0.85g \sin 30 = 0.85a$ $0.55g - T = 0.55a$ $a = 1.225/1.4$ $a = 0.875$ $T = 4.91$ | B1 B1 M1 A1 A1 [5] | Either equation correct Both eqns correct and consistent 'a' direction Solves 2 sim eqn 4.908 or better – has to be positive |
| b | $F = 2T \cos 30$ $F = 8.5(02..)$ | M1 A1ft [2] | Or Pythagoras or cosine rule $cv(4.91) \times \sqrt{3}$ |
| ii | $v^2 = 1.3^2 + 2 \times 0.875 \times 1.5 (=4.315)$ $a = +/-g \sin 30$ $0 = 4.315 - 2 \times 4.9s$ $(s = 0.44...)$ $S = 1.94$ | M1 A1ft B1 M1 A1 A1 [6] | Uses $v^2 = u^2 + 2a(1.5)$, u non-zero, a from (i) $v = 2.077... (v^2 = 1.69 + 3 \times cv(0.875))$ $a = +/-4.9$ Uses $0^2 = u^2 +/- 2as$, with a not g or (i), u not 1.3 May be implied – need not be 3sf |

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| <p>7 i</p> | <p>$Fr = 4 + 5\sin 60$ $Fr = 8.33$ $R = 12 - 5\cos 60$ $R = 9.5$ $\mu = (4 + 5\sin 60)/(12 - 5\cos 60)$ $\mu = 0.877$</p> | <p>M1 A1 M1 A1 M1 A1 [6]</p> | <p>All 4 + component 5 ($4 + 4.333(01)$) May be implied +/- (All 12 – component 5 ($12 - 2.5$)) May be implied, +ve from correct work Friction/Reaction, $Fr > 4$, $R < 12$, both positive</p> |
| <p>ii</p> | <p>Upper block $\mu = 5\sin 60/(9 - 5\cos 60)$ (=4.3/6.5) $\mu = 0.666$</p> | <p>M1 A1 [2]</p> | <p>(Component 5)/(9-component 5)</p> |
| <p>iii</p> | <p>Upper mass = 9/g $(9/g)a = 5\sin 60 - 0.1(9 - 5\cos 60)$ $a = 4.01$ Lower mass Tractive force = $4 + 0.1(9 - 5\cos 60)$ (= 4.65) Max Friction = $0.877(3 + (9 - 5\cos 60))$ (= 8.33) Tractive force < Max Friction $a = 0$ <i>OR for Lower Mass</i> $ma = 4 + 0.1(9 - 5\cos 60) - 0.877(3 + 9 - 5\cos 60)$ -ve a caused by friction impossible, hence $a = 0$</p> | <p>B1 M1 A1 M1 A1 A1 [6] M1 A1 A1</p> | <p>0.918(36..) N2L $0.918(36..)a = 4.33(01..) - 0.1 \times 6.5$ where friction = $0.1 \times (9 - \text{component } 5)$ Compares TF (tractive force) and max friction N2L with 3 force terms:</p> |