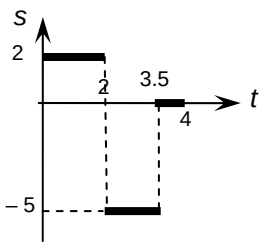
# 4761 Mechanics 1

| | | | | |
|---|---|---|---|---|
| **1 (i)** | $0 < t < 2$, $v = 2$<br>$2 < t < 3.5$ $v = -5$ | B1<br>B1 | Condone '5 downwards' and ' – 5 downwards' | 2 |
| **(ii)** |  | <br><br><br><br>B1<br><br><br>B1 | Condone intent – e.g. straight lines free-hand and scales not labelled; accept non-vertical sections at $t = 2$ & 3.5.<br><br><br>Only horizontal lines used and 1st two parts present.<br>BOD $t$-axis section. One of 1st 2 sections correct. FT (i) and allow if answer correct with (i) wrong<br>All correct. Accept correct answer with (i) wrong. FT (i) only if 2nd section –ve in (i) | 2 |
| **(iii)** | (A) upwards; (B) and (C) downwards | E1 | All correct. Accept +/- ve but not towards/away from O<br>Accept forwards/backwards. Condone additional wrong statements about position. | 1 |
| | | | | 5 |
| **2 (i)** | $\begin{pmatrix}12\\9\end{pmatrix} = \begin{pmatrix}2\\-3\end{pmatrix} + 4\mathbf{a}$<br>so $\mathbf{a} = \begin{pmatrix}2.5\\3\end{pmatrix}$ | M1<br><br>A1 | Use of $\mathbf{v} = \mathbf{u} + \mathbf{a}t$<br><br>If vector **a** seen, isw. | 2 |
| **(ii)** | **either**<br>$\mathbf{r} = \begin{pmatrix}-1\\2\end{pmatrix} + \begin{pmatrix}2\\-3\end{pmatrix} \times 4 + \frac{1}{2}\mathbf{a} \times 4^2$<br>$\mathbf{r} = \begin{pmatrix}27\\14\end{pmatrix}$ so $\begin{pmatrix}27\\14\end{pmatrix}$ m<br>**or** | M1<br><br>A1<br>A1<br><br><br><br>M1<br><br>A1<br><br>A1<br><br>SC2 for $\begin{pmatrix}28\\12\end{pmatrix}$ | For use of $\mathbf{s} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$ with **their a.** Initial position may be omitted.<br>FT **their a.** Initial position may be omitted.<br>cao. Do not condone magnitude as final answer.<br><br><br><br>Use of $\mathbf{s} = 0.5t(\mathbf{u} + \mathbf{v})$ Initial position may be omitted.<br>Correct substitution. Initial position may be omitted.<br>cao Do not condone mag as final answer. | 3 |

| | | | | |
|---|---|---|---|---|
| **(iii)** | Using N2L<br>$\mathbf{F} = 5\mathbf{a} = \begin{pmatrix}12.5\\15\end{pmatrix}$ so $\begin{pmatrix}12.5\\15\end{pmatrix}$ N | M1<br>F1 | Use of $\mathbf{F} = m\mathbf{a}$ or $\mathbf{F} = mg\mathbf{a}$.<br>FT **their a** only. Do not accept magnitude as final ans. | 2 |
| | | | | 7 |
| **3 (i)** | $\lvert\mathbf{F}\rvert = \sqrt{(-1)^2 + 5^2}$<br>$= \sqrt{26} = 5.0990...$ = 5.10 (3 s. f.)<br><br>Angle with **j** is arctan(0.2)<br>so 11.309… so 11.3° (3 s. f.) | M1<br>A1<br><br>M1<br>A1 | Accept $\sqrt{-1^2 + 5^2}$ even if taken to be $\sqrt{24}$<br><br><br>accept arctan($p$) where $p = \pm 0.2$ or $\pm 5$ o.e.<br>cao | 4 |
| **(ii)** | $\begin{pmatrix}-2\\3b\end{pmatrix} = 4\begin{pmatrix}-1\\5\end{pmatrix} + \begin{pmatrix}2a\\a\end{pmatrix}$<br><br>$a = 1$, $b = 7$<br>so $\mathbf{G} = \begin{pmatrix}2\\1\end{pmatrix}$ and $\mathbf{H} = \begin{pmatrix}-2\\21\end{pmatrix}$<br>or $\mathbf{G} = 2\mathbf{i} + \mathbf{j}$ and $\mathbf{H} = -2\mathbf{i} + 21\mathbf{j}$ | M1<br><br>M1<br><br>A1<br><br>A1 | $\mathbf{H} = 4\mathbf{F} + \mathbf{G}$ soi<br><br>Formulating at least 1 scalar equation from **their** vector equation soi<br>$a$ correct **or G** follows from their wrong $a$<br><br>**H** cao | 4 |
| | | | | 8 |
| **4(i)** | 20cos 15 = 19.3185….<br>so 19.3 N (3 s. f.) in direction BC | B1 | Accept no direction. Must be evaluated | 1 |
| **(ii)** | Let the tension be $T$<br>$T$ sin 50 = 19.3185….<br>so $T$ = 25.2185… so 25.2 N (3 s. f.) | M1<br>F1 | Accept $\sin \leftrightarrow \cos$ but not (i) × sin 50<br>FT **their** 19.3… only. cwo | 2 |
| **(iii)** | $R$ + 20 sin 15 – 2.5$g$ – 25.2185…× cos 50 = 0<br><br><br><br>$R$ = 35.5337… so 35.5 N (3 s. f.) | M1<br><br><br><br>B1<br>A1<br>A1 | Allow 1 force missing or 1 tension not resolved.<br>FT $T$.<br>No extra forces. Accept mass used.<br>Accept $\sin \leftrightarrow \cos$.<br>Weight correct<br>All correct except sign errors. FT **their** $T$<br>cao. Accept 35 or 36 for 2. s.f. | 4 |
| **(iv)** | The horizontal resolved part of the 20 N force is not changed. | E1 | Accept no reference to vertical component but do not accept 'no change' to both components.<br>No need to be explicit that value of tension in AB depends only on horizontal component of force at C | |
| | | | | 1 |
| | | | | 8 |

| | | | | |
|---|---|---|---|---|
| **5(i)** | $a = 6t - 12$ | M1<br>A1 | Differentiating<br>cao | 2 |
| **(ii)** | We need $\int_1^3 (3t^2 - 12t + 14)\mathrm{d}t$<br>$= \left[t^3 - 6t^2 + 14t\right]_1^3$<br>**either**<br>$= (27 - 54 + 42) - (1 - 6 + 14)$<br>$= 15 - 9 = 6$ so 6 m<br>**or**<br>$s = t^3 - 6t^2 + 14t + C$<br>$s = 0$ when $t = 1$ gives<br>$0 = 1 - 6 + 14 + C$ so $C = -9$<br>Put $t = 3$ to give<br>$s = 27 - 54 + 42 - 9 = 6$ so 6 m. | M1<br>A1<br><br>M1<br>A1<br><br>M1<br><br><br>A1 | Integrating. Neglect limits.<br>At least two terms correct. Neglect limits.<br><br>Dep on 1st M1. Use of limits with attempt at subtraction seen.<br>cao<br><br><br>Dep on 1st M1. An attempt to find $C$ using $s(1) = 0$ and then evaluating $s(3)$.<br><br>cao | 4 |
| **(iii)** | $v > 0$ so the particle always travels in the same (+ve) direction<br>As the particle never changes direction, the final distance from the starting point is the displacement. | E1<br>E1 | Only award if explicit<br>Complete argument | |
| | | | | 2 |
| | | | | 8 |
| **6 (i)** | Component of weight down the plane is<br>$1.5 \times 9.8 \times \frac{2}{7} = 4.2$ N | M1<br><br>E1 | Use of $mgk$ where $k$ involves an attempt at resolution<br>Accept $1.5 \times 9.8 \times \frac{2}{7} = 4.2$ or $14.7 \times \frac{2}{7} = 4.2$ seen | 2 |
| **(ii)** | Down the plane. Take $F$ down the plane.<br>$4.2 - 6.4 + F = 0$<br><br>so $F = 2.2$. Friction is 2.2 N down the plane | M1<br><br>A1 | Allow sign errors. All forces present. No extra forces.<br>Must have direction. [Award 1 for 2.2 N seen and 2 for 2.2 N down plane seen] | 2 |
| **(iii)** | $F$ up the plane<br>N2L down the plane<br>$4.2 - F = 1.5 \times 1.2$<br><br>so $F = 4.2 - 1.8 = 2.4$<br>Friction is 2.4 N up the plane | M1<br><br>A1<br>A1<br>A1 | N2L. $F = ma$. No extra forces. Allow weight term missing or wrong<br>Allow only sign errors<br>$\pm 2.4$<br>cao. Accept no reference to direction if $F = 2.4$. | 4 |
| **(iv)** | $2^2 = 0.8^2 + 2 \times 1.2 \times s$<br><br>$s = 1.4$ so 1.4 m | M1<br>A1<br>A1 | Use of $v^2 = u^2 + 2as$ or sequence<br>All correct in 1 or 2-step method | 3 |

| | | | | |
|---|---|---|---|---|
| **(v)** | Diagrams | B1 | Frictions and coupling force correctly labelled with arrows. | |
| | | B1 | All forces present and properly labelled with arrows. | |
| | **either** | | | |
| | Up the plane | M1 | N2L. $F = ma$. No extra forces. Condone sign errors. | |
| | $10 - 3.5\times 9.8\times \frac{2}{7} - (2.3+0.7) = 3.5a$ | | Allow total/part weight **or** total/part friction omitted (but not both). Allow mass instead of weight and mass/weight not or wrongly resolved. | |
| | | B1 | Correct overall mass and friction | |
| | $a = -0.8$ so 0.8 m s$^{-2}$. | | | |
| | down the plane | A1 | Clear description or diagram | |
| | For barge B up the plane | | | |
| | $T - 2\times 9.8\times \frac{2}{7} - 0.7 = 2\times(-0.8)$ | M1 | N2L on one barge with **their** $\pm a$ ($\neq 1.2$ or 0). All forces present and weight component attempted. No extra forces. Condone sign errors. | |
| | $T = 4.7$ so 4.7 N. Tension | A1 | cao | |
| | **or** (separate equations of motion) | | In eom for A **or** B allow weight or friction missing and also allow mass used instead of weight and wt not or wrongly resolved. In other equn weight component attempted and friction term present. | |
| | Barge A | M1 | N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. | |
| | Barge B | M1 | N2L. Do not allow $F = mga$. No extra forces. Condone sign errors. | |
| | | M1 | Solving a pair of equns in $a$ and $T$ | |
| | $a = -0.8$ so 0.8 m s$^{-2}$. | | | |
| | down the plane | A1 | Clear description or diagram | |
| | $T = 4.7$ so 4.7 N. Tension | A1 | cao cwo | |
| | | | | 7 |
| | | | | 18 |
| **7 (i)** | $y(0) = 1$ | B1 | | 1 |
| | **Either** | | | |
| **(ii)** | $\frac{1}{2}(20+5) - 5 = 7.5$ | M1 | Use of symmetry e.g. use of $\frac{1}{2}(20+5)$ | |
| | | A1 | 12.5 o.e. seen | |
| | | A1 | 7.5 cao | |
| | **or** | M1 | Attempt at $y'$ and to solve $y' = 0$ | |
| | | A1 | $k(15 - 2x)$ where $k = 1$ or $\frac{1}{100}$ | |
| | | A1 | 7.5 cao, seen as final answer | |
| | $y(7.5) = \frac{1}{100}(100 + 15\times 7.5 - 7.5^2)$ | M1 | FT **their** 7.5 | |
| | $= \frac{25}{16}$ (1.5625) so 1.5625 m | E1 | AG<br>[SC2 only showing 1.5625 leads to $x = 7.5$] | 5 |

| | | | | |
|---|---|---|---|---|
| **(iii)** | $4.9t^2 = \frac{25}{16}$ (1.5625) | M1 | Use of $s = ut + 0.5at^2$ with $u = 0$. Condone use of $\pm 10,\ \pm 9.8,\ \pm 9.81$. If sequence of *suvat* used, complete method required. | |
| | $t^2 = 0.31887\ldots$ so $t = \pm 0.56469\ldots$ | A1 | In any method only error accepted is sign error | |
| | Hence 0.565 s ( 3 s. f.) | E1 | AG. Condone no reference to –ve value. www. 0.565 must be justified as answer to 3 s. f. | 3 |
| **(iv)** | $\dot{x} = \frac{12.5}{0.56469...} = 22.1359...$ | M1 | or 25 / (2×0.56469..) | |
| | | B1 | Use of 12.5 or equivalent | |
| | so 22.1 m s $^{-1}$ (3 s. f.)) | E1 | 22.1 must be justified as answer to 3 s. f. Don't penalise if penalty already given in (iii). | |
| | **Either** | | | |
| | Time is $\frac{20}{12.5} \times 0.56469...$ s | M1 | | |
| | so 0.904 s (3 s. f.) | A1 | cao Accept 0.91 (2 s. f.) | |
| | **or** | | | |
| | Time is $\frac{20}{22.1359...}$ s | M1 | | |
| | = 0.903507… so 0.904 s (3 s. f.) | A1 | cao Accept 0.91 (2 s. f.) | |
| | **or** | | | |
| | (iii) $+ \frac{7.5}{\textbf{their } \dot{x}}$ | M1 | | |
| | so 0.904 s (3 s. f.) | A1 | cao Accept 0.91 (2 s. f.) | 5 |
| **(v)** | $v = \sqrt{\dot{x}^2 + \dot{y}^2}$ | M1 | Must have attempts at both components | |
| | $\dot{y}^2 = 0^2 + 2 \times 9.8 \times \frac{25}{16}$ or | M1 | Or equiv. $u = 0$. Condone use of $\pm 10,\ \pm 9.8,\ \pm 9.81$. | |
| | $\dot{y} = 0 + 9.8 \times 0.5646...$ | | Accept wrong *s* (or *t* in alternative method) | |
| | = $\frac{245}{8}$ (30.625) or $\dot{y} = \pm 5.539...$ | A1 | Or equivalent. May be implied. Could come from (iii) if $v^2 = u^2 + 2as$ used there. Award marks again. | |
| | so $v = \sqrt{490 + 30.625}$ = 22.8172… m s $^{-1}$ | | | |
| | so 22.8 m s $^{-1}$ (3 s. f.) | A1 | cao. www | 4 |
| | | | | 18 |