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**Pearson**
**Edexcel GCE**

Centre Number | | | | | |

Candidate Number | | | | |

# Mechanics M1

## Advanced/Advanced Subsidiary

Wednesday 8 June 2016 – Morning
**Time: 1 hour 30 minutes**

Paper Reference
**6677/01**

**You must have:**
Mathematical Formulae and Statistical Tables (Pink)

Total Marks

**Candidates may use any calculator allowed by the regulations of the Joint Council for Qualifications. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.**

## Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B). Coloured pencils and highlighter pens must not be used.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided – *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Whenever a numerical value of $g$ is required, take $g = 9.8$ m s$^{-2}$, and give your answer to either two significant figures or three significant figures.
- When a calculator is used, the answer should be given to an appropriate degree of accuracy.

## Information

- The total mark for this paper is 75.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*

## Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

*Turn over* ▶


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**1.** [*In this question* **i** *and* **j** *are horizontal unit vectors due east and due north respectively and position vectors are given relative to a fixed origin O.*]

Two cars $P$ and $Q$ are moving on straight horizontal roads with constant velocities. The velocity of $P$ is $(15\mathbf{i} + 20\mathbf{j})$ m s$^{-1}$ and the velocity of $Q$ is $(20\mathbf{i} - 5\mathbf{j})$ m s$^{-1}$

(a) Find the direction of motion of $Q$, giving your answer as a bearing to the nearest degree.

**(3)**

At time $t = 0$, the position vector of $P$ is $400\mathbf{i}$ metres and the position vector of $Q$ is $800\mathbf{j}$ metres. At time $t$ seconds, the position vectors of $P$ and $Q$ are $\mathbf{p}$ metres and $\mathbf{q}$ metres respectively.

(b) Find an expression for

(i) $\mathbf{p}$ in terms of $t$,

(ii) $\mathbf{q}$ in terms of $t$.

**(3)**

(c) Find the position vector of $Q$ when $Q$ is due west of $P$.

**(4)**

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| Question Number | Scheme | Marks |
|---|---|---|
| **1(a)** | $\tan q = \frac{5}{20}$<br>$q = 14.036..^0$<br>$q = 104^0$ nearest degree | M1<br>A1<br>A1 (3) |
| **(b)** | $\mathbf{p} = 400\mathbf{i} + t(15\mathbf{i} + 20\mathbf{j})$<br>$\mathbf{q} = 800\mathbf{j} + t(20\mathbf{i} - 5\mathbf{j})$ | M1 A1<br>A1 (3) |
| **(c)** | Equate their **j** components: $20t(\mathbf{j}) = (800 - 5t)(\mathbf{j})$<br>$t = 32$<br>$\mathbf{s} = 800\mathbf{j} + 32(20\mathbf{i} - 5\mathbf{j})$<br>$= 640\mathbf{i} + 640\mathbf{j}$ | M1<br>A1<br>M1<br>A1 (4)<br>**10** |
| **1(a)** | **Notes**<br>**Allow column vectors throughout**<br>M1 for $\tan q = \pm\frac{5}{20}$ or $\pm\frac{20}{5}$ (or any other complete method)<br>First A1 for $\pm 14.04^o$ or $\pm 75.96^o$<br>Second A1 for $104^o$ | |
| **1(b)**<br>**(i)**<br>**(ii)** | M1 for clear attempt at either **p** or **q** (allow slip but *t* must be attached to the velocity vector and position vector and velocity vector must be paired up correctly)<br>First A1 $400\mathbf{i} + t(15\mathbf{i} + 20\mathbf{j})$ "**p** =" not needed but must be clear it's *P*<br>Second A1 $800\mathbf{j} + t(20\mathbf{i} - 5\mathbf{j})$ "**q** =" not needed but must be clear it's *Q* | |
| **1(c)** | First M1 for equating their **j** components; allow **j**'s on both sides<br>First A1 for $t = 32$<br>Second M1 independent for substituting their *t* value into their **q** from (b)<br>Second A1 for $640\mathbf{i} + 640\mathbf{j}$ | |

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**2.**

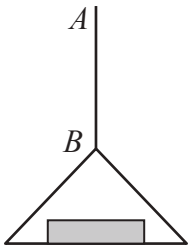


**Figure 1**

A vertical rope $AB$ has its end $B$ attached to the top of a scale pan. The scale pan has mass 0.5 kg and carries a brick of mass 1.5 kg, as shown in Figure 1. The scale pan is raised vertically upwards with constant acceleration 0.5 m $s^{-2}$ using the rope $AB$. The rope is modelled as a light inextensible string.

(a) Find the tension in the rope $AB$.

**(3)**

(b) Find the magnitude of the force exerted on the scale pan by the brick.

**(3)**

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| Question Number | Scheme | Marks |
|---|---|---|
| **2(a)** | $T - 0.5g - 1.5g = 2 \times 0.5$<br>$T = 20.6$ (N) or 21 (N) | M1 A1<br>A1 (3) |
| **(b)** | $R - 1.5g = 1.5 \times 0.5$<br>Force = 15.5 (N) or 15 (N)<br><br>OR: $T - R - 0.5g = 0.5 \times 0.5$<br>Force = 15.5 (N) or 15 (N) | M1 A1<br>A1 (3)<br>**OR**<br>M1 A1<br>A1 (3)<br>**6** |
| | **Notes** | |
| **2(a)** | **N.B.** In both parts of this question use the mass which is being used to guide you as to which part of the system is being considered<br><br>M1 is for an equation for whole system in $T$ only, with usual rules<br>First A1 for a correct equation<br>Second A1 for 20.6 or 21 | |
| **2(b)** | First M1 is for an equation for the brick only ($1^{st}$ alternative) or for the scale pan only ($2^{nd}$ alternative) with usual rules.<br>First A1 for a correct equation (in the second alternative $T$ does not need to be substituted)<br>Second A1 for 15.5 or 15 | |
| | **N.B.** If $R$ is replaced by $-R$ in either equation, can score M1A1. This would lead to $R$ = -15.5 or -15. The second A1 can then only be scored if the candidate explains why the –ve sign is being ignored. | |
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**3.** A particle $P$ of mass 0.4 kg is moving on rough horizontal ground when it hits a fixed vertical plane wall. Immediately before hitting the wall, $P$ is moving with speed 4 m s$^{-1}$ in a direction perpendicular to the wall. The particle rebounds from the wall and comes to rest at a distance of 5 m from the wall. The coefficient of friction between $P$ and the ground is $\frac{1}{8}$.

Find the magnitude of the impulse exerted on $P$ by the wall.

**(7)**

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| Question Number | Scheme | Marks |
|---|---|---|
| **3.** | $F = \frac{1}{8} \times 0.4g$ | M1 |
| | $-\frac{1}{8} \times 0.4g = 0.4a$ | M1 A1 |
| | $0 = u^2 + 2\left(-\frac{1}{8}g\right) \times 5$ | M1 A1 |
| | $I = 0.4 \times (3.5 - -4) = 3\text{Ns}$ | M1 A1 |
| | | **7** |
| | **Notes** | |
| **3.** | First M1 for 1/8 x 0.4$g$ (Allow if $g$ omitted)<br>Second M1 for resolving horizontally with their $F$ (could just be $F$)<br>First A1 for a correct equation in $a$ only<br>Third M1 for use of $v^2 = u^2 + 2as$ with $v = 0$, $s = 5$ and *a calculated value of a*. (M0 if $u = 4$ or if $u = 0$)<br>Second A1 for a correct equation in $u$ only ($u$ may be in terms of $I$)<br>Fourth M1 (M0 if $g$ included or if $u = 0$ or $u = 4$) for $\pm 0.4(u - \pm 4)$ where $u$ is their calculated value.<br>Third A1 for 3, 3.0 or 3.00 (Ns)<br><br><u>Alternative work –energy method:</u><br>$F$ = ($^1/_8$ x 0.4$g$) M1<br>: ½ 0.4$u^2$ = ($^1/_8$ x 0.4$g$) x 5 M2 A2 (M2 if $F$ not substituted)<br>$I$ = 0.4 x (3.5 - -4) M1<br>= 3 (Ns) A1 | |
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**4.** Two trains $M$ and $N$ are moving in the same direction along parallel straight horizontal tracks. At time $t = 0$, $M$ overtakes $N$ whilst they are travelling with speeds $40\ \text{m s}^{-1}$ and $30\ \text{m s}^{-1}$ respectively. Train $M$ overtakes train $N$ as they pass a point $X$ at the side of the tracks.

After overtaking $N$, train $M$ maintains its speed of $40\ \text{m s}^{-1}$ for $T$ seconds and then decelerates uniformly, coming to rest next to a point $Y$ at the side of the tracks.

After being overtaken, train $N$ maintains its speed of $30\ \text{m s}^{-1}$ for 25 s and then decelerates uniformly, also coming to rest next to the point $Y$.

The times taken by the trains to travel between $X$ and $Y$ are the same.

(a) Sketch, on the same diagram, the speed-time graphs for the motions of the two trains between $X$ and $Y$.

**(4)**

Given that $XY = 975$ m,

(b) find the value of $T$.

**(8)**

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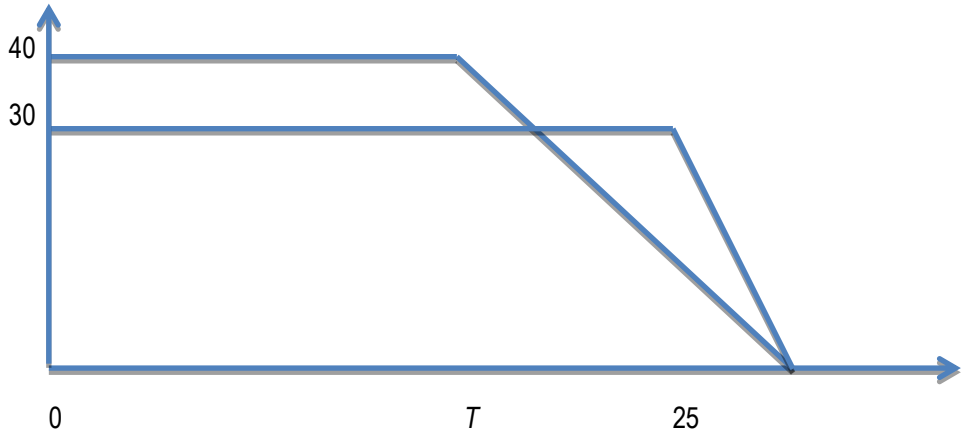
| Question Number | Scheme | Marks |
|---|---|---|
| **4(a)** |  | B1 shape (*M*)<br>B1 figs (40,*T*)<br>B1 shape (*N*)<br>B1 figs (30,25)<br>(4) |
| **(b)** | **For N**: $\frac{1}{2}(25+25+t).30=975$ OR $\frac{1}{2}(25+t_1).30=975$<br>$t=15$ $t_1=40$<br>**For M**: $\frac{1}{2}(25+t+T).40=975$ OR $\frac{1}{2}(t_1+T).40=975$<br>$T=8.75$ ($8\frac{3}{4}$ or $\frac{35}{4}$ oe)<br><br>ALTERNATIVE: They may find $t$ or $t_1$ , in terms of $T$, from their (*M*) equation , and substitute for $t$ or $t_1$ in their (*N*) equation, and then solve for $T$:<br><br>**For M**: $\frac{1}{2}(25+t+T).40=975$ OR $\frac{1}{2}(t_1+T).40=975$<br>$t=(\frac{1950}{40}-25-T)$ $t_1=(\frac{1950}{40}-T)$<br><br>**For N** : $\frac{1}{2}(25+25+t).30=975$ OR $\frac{1}{2}(25+t_1).30=975$<br>sub for $t$ or sub for $t_1$<br>$T=8.75$ ($8\frac{3}{4}$ or $\frac{35}{4}$ oe) | M1 A1<br>**DM**1 A1<br>M1 A1<br>**DM**1 A1 (8)<br>**12**<br><br>M1 A1<br>**DM**1 A1<br><br>M1 A1<br><br>**DM**1 A1 (8)<br>**12** |
| | **Notes** | |
| **4(a)** | First B1 (*M*) for correct shape – *must start and finish on the axes*.<br>Second B1 for 40 and *T* marked clearly (if delineators omitted B0) and correctly<br>Third B1 (*N*) for correct shape – *must start and finish on the axes*.<br>Fourth B1 for 30 and 25 (if delineators omitted B0) marked clearly and correctly<br>**N.B.** If graphs do not cross and/or do not finish at the same point, max score is B1B1B0B1. | |

| | | |
|---|---|---|
| | **N.B.** If graphs done on separate diagrams, mark each and award the higher mark i.e. can score max 2/4 for part (a). | |
| **4(b)** | **N.B.** When attempting to find the area of a triangle, must see ½ x …. to be able to award an M mark i.e. M0 if ½ is missing<br>**N.B.** When attempting to find the area of a trapezium, must see something of the form : ½ x $(a + b)h$ to be able to award an M mark i.e. M0 if ½ is missing and bracket is not a **sum**<br><br>First M1 for attempt at using 975m distance travelled by $N$ to obtain an equation in one unknown *time* (usually extra time $t$ after 25 s, but could, for example, be whole time $t_1$) .They may use the area under their graph or use *suvat* (**N.B.** Any single *suvat* equn using $s = 975$ is M0).<br>First A1 for a correct equation in their unknown *time*<br>e.g. $(30 \times 25) + \frac{1}{2}\ 30t = 975$ **OR** $(30 \times 25) + \frac{1}{2}\ 30\ (t_1 - 25) = 975$<br>Second M1, dependent on first M, for solving their equation<br>Second A1 for a correct value for their unknown.<br><br>Third M1 for attempt at using 975m distance travelled by $M$ to obtain an equation in $T$ and possibly one other unknown *time* (usually extra time $t$ after 25 s, but could, for example, be whole time $t_1$). They may use the area under their graph or use *suvat* (**N.B.** Any *suvat* equn using $s = 975$ is M0)<br><br>Third A1 for a correct equation in $T$ and possibly their unknown.<br>This A1 can be earned if they just have a letter for their unknown :-<br>e.g. $40T + \frac{1}{2}\ 40.(25 + t - T) = 975$ **OR** $40T + \frac{1}{2}\ 40.(t_1 - T) = 975$<br>or <u>for an incorrect numerical value in place of $t$ or $t_1$</u>.<br><br>Fourth M1, dependent on first, second and third M's, for solving for $T$.<br>Fourth A1 for 8.75 or 35/4 or any other equivalent<br><br>SEE MARKS FOR ALTERNATIVE ABOVE. | |

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**5.**

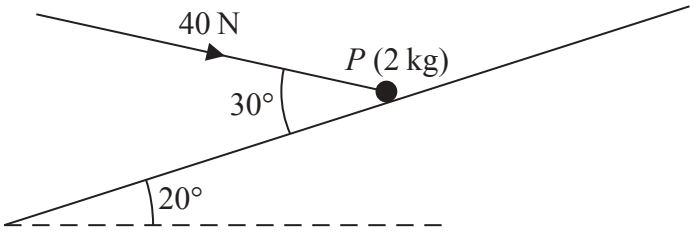


**Figure 2**

A particle $P$ of mass 2 kg is held at rest in equilibrium on a rough plane by a constant force of magnitude 40 N. The direction of the force is inclined to the plane at an angle of 30°. The plane is inclined to the horizontal at an angle of 20°, as shown in Figure 2. The line of action of the force lies in the vertical plane containing $P$ and a line of greatest slope of the plane. The coefficient of friction between $P$ and the plane is $\mu$.

Given that $P$ is on the point of sliding up the plane, find the value of $\mu$.

**(10)**

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| Question Number | Scheme | Marks |
|---|---|---|
| **5.** | $mR$<br>$R = 2g\cos 20^\circ + 40\cos 60^\circ$<br>$F = 40\cos 30^\circ - 2g\cos 70^\circ$<br>$m = \dfrac{40\cos 30^\circ - 2g\cos 70^\circ}{2g\cos 20^\circ + 40\cos 60^\circ}$<br>$= 0.73$ or $0.727$ | B1<br>M1 A2<br>M1 A2<br>M1 M1<br>A1<br>**10** |
| | **Notes** | |
| **5.** | B1 for $\mu R$ seen or implied. | |
| | First M1 for resolving perpendicular to the plane with usual rules (must be using $2(g)$ with $20^0$ or $70^0$ and 40 with $30^0$ or $60^0$) | |
| | First and second A1's for a correct equation. A1A0 if one error | |
| | Second M1 for resolving parallel to the plane with usual rules (must be using $2(g)$ with $20^0$ or $70^0$ and 40 with $30^0$ or $60^0$) | |
| | Third and fourth A1's for a correct equation. A1A0 if one error | |
| | Third M1 <u>independent</u> for eliminating $R$ to produce an equation in $\mu$ only. Does not need to be $\mu =$ …. | |
| | Fourth M1 <u>independent</u> for solving for $\mu$ | |
| | Fifth A1 for 0.727 or 0.73 | |
| | **N.B.** They may choose to resolve in 2 other directions e.g. horizontally and vertically. | |
| | **N.B.** If $F$ is replaced by $-F$ in the second equ$^n$, treat this as an error unless they subsequently explain that they have their $F$ acting in the wrong direction, in which case they could score full marks for the question. | |
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**6.** A non-uniform plank $AB$ has length 6 m and mass 30 kg. The plank rests in equilibrium in a horizontal position on supports at the points $S$ and $T$ of the plank where $AS = 0.5$ m and $TB = 2$ m.

When a block of mass $M$ kg is placed on the plank at $A$, the plank remains horizontal and in equilibrium and the plank is on the point of tilting about $S$.

When the block is moved to $B$, the plank remains horizontal and in equilibrium and the plank is on the point of tilting about $T$.

The distance of the centre of mass of the plank from $A$ is $d$ metres. The block is modelled as a particle and the plank is modelled as a non-uniform rod. Find

(i) the value of $d$,

(ii) the value of $M$.

**(7)**

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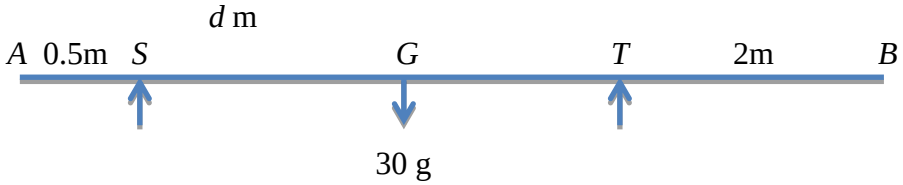
| Question Number | Scheme | Marks |
|---|---|---|
| **6.** |  <br>$M(S)$: $Mg \times 0.5 = 30g(d - 0.5)$<br>$M(T)$: $Mg \times 2 = 30g(4 - d)$<br>dividing: $4 = \frac{(4-d)}{(d-0.5)}$ => (i) $d = 1.2$<br>=> (ii) $M = 42$ | M1 A1<br>M1 A1<br>**DM1** A1<br>A1 |
| **6.** | **Notes**<br>**N.B.** They may use a different variable, other than *d*, in their moments equations<br>e.g. say they use $x = SG$ consistently, they can score all the marks for their two equations and if they eliminate *x* correctly, DM1 A1 (for *M*), and, if they found *x* correctly, then added 0.5 to obtain *d*, the other A1 also. | |
| | First M1 for moments about *S* (need correct no. of terms, so if they don't realise that the reaction at *T* is zero it's M0) *to give an equation in d and M only*. | |
| | First A1 for a correct first equation *in d and M only*. (A1 for both g's or no g's but A0 if one g is missing ) | |
| | **N.B.** They may use 2 equations and eliminate to obtain their equation *in d and M only*<br>e.g. $M(A)$ $0.5R_S = 30gd$ and (^) $R_S = 30g + Mg$ and then eliminate $R_S$.<br>The M mark is only earned once they have produced an equation *in d and M only*, with all the usual rules about correct no. of terms etc applying to all the equations they use to obtain it. | |
| | Second M1 for moments about *T* (need correct no. of terms, so if they don't realise that the reaction at *S* is zero it's M0) *to give an equation in d and M only* | |
| | Second A1 for a correct second equation *in d and M only*. (A1 for both g's or no g's but A0 if one g is missing ) | |
| | **N.B.** They may use 2 equations and eliminate to obtain their equation *in d and M only*<br>e.g. $M(B)$ $2R_T = 30g(6 - d)$ and (^) $R_T = 30g + Mg$ and then eliminate $R_T$.<br>The M mark is only earned once they have produced an equation *in d and M only*, with all the usual rules about correct no. of terms etc applying to all the equations they use to obtain it. | |

| | | |
|---|---|---|
| | Third M1, dependent on 1st and 2nd M marks, for eliminating either *M* or *d* to produce an equation in either *d* only or *M* only. | |
| | Third A1 for (*d* =) 1.2 oe (**N.B.** Neither this A mark nor the next one can be awarded if there are any errors in the equations.)<br>**Beware:** If one g is missing consistently from each of their equations, they can obtain *d* = 1.2 but award A0 | |
| | Fourth A1 for (*M* =) 42 | |
| | | |
| | | |
| | Scenario 1: Below are the possible equations, (if they don't use *M(S)*), any two of which can be used, by eliminating $R_S$ , to obtain an equation *in d and M only* , for the first M1.<br>N.B. If $R_T$ appears in any of these and doesn't subsequently become zero then it's M0. | |
| | *M(A)* $0.5R_S = 30gd$ | |
| | *M(B)* $5.5R_S = 30g(6 - d) + 6Mg$ | |
| | *M(T)* $3.5R_S = 30g(4 - d) + 4Mg$ | |
| | (^) $R_S = 30g + Mg$ | |
| | | |
| | Scenario 2: Below are the possible equations, (if they don't use *M(T)*), any two of which can be used, by eliminating $R_T$ , to obtain an equation *in d and M only* , for the second M1.<br>N.B. If $R_S$ appears in any of these and doesn't subsequently become zero then it's M0. | |
| | *M(A)* $4R_T = 30gd + 6Mg$ | |
| | *M(B)* $2R_T = 30g(6 - d)$ | |
| | *M(S)* $3.5R_T = 30g(d - 0.5) + 5.5Mg$ | |
| | (^) $R_T = 30g + Mg$ | |
| | | |
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**7.** Two forces $\mathbf{F}_1$ and $\mathbf{F}_2$ act on a particle $P$.

The force $\mathbf{F}_1$ is given by $\mathbf{F}_1 = (-\mathbf{i} + 2\mathbf{j})$ N and $\mathbf{F}_2$ acts in the direction of the vector $(\mathbf{i} + \mathbf{j})$.

Given that the resultant of $\mathbf{F}_1$ and $\mathbf{F}_2$ acts in the direction of the vector $(\mathbf{i} + 3\mathbf{j})$,

(a) find $\mathbf{F}_2$

**(7)**

The acceleration of $P$ is $(3\mathbf{i} + 9\mathbf{j})$ m s$^{-2}$. At time $t = 0$, the velocity of $P$ is $(3\mathbf{i} - 22\mathbf{j})$ m s$^{-1}$

(b) Find the speed of $P$ when $t = 3$ seconds.

**(4)**

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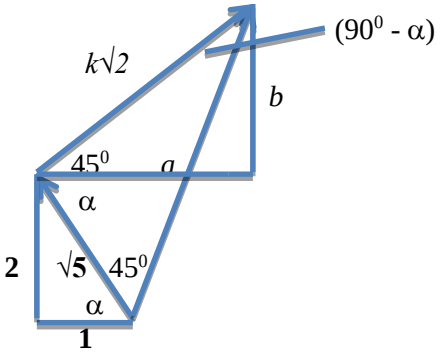
| Question Number | Scheme | Marks |
|---|---|---|
| **7(a)** | $\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$<br>$(-1+a)\mathbf{i} + (2+b)\mathbf{j}$<br>$\frac{-1+a}{2+b} = \frac{1}{3}$<br>$a = b = k = 2.5;\ \mathbf{F}_2 = 2.5\mathbf{i} + 2.5\mathbf{j}$<br>**ALTERNATIVE:**<br>$\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$<br>$(-1+a)\mathbf{i} + (2+b)\mathbf{j} = p(\mathbf{i} + 3\mathbf{j})$<br>$-1+a = p$<br>$2+b = 3p$<br>$a = b = k = 2.5;\ \mathbf{F}_2 = 2.5\mathbf{i} + 2.5\mathbf{j}$ | B1<br>M1<br>**DM**1 A1<br>**DM**1 A1; A1 (7)<br>B1<br>M1 for LHS<br>**DM**1 A1<br>**DM**1 A1; A1 (7) |
| **(b)** | $\mathbf{v} = 3\mathbf{i} - 22\mathbf{j} + 3(3\mathbf{i} + 9\mathbf{j})$<br>$= 12\mathbf{i} + 5\mathbf{j}$<br>$\lvert\mathbf{v}\rvert = \sqrt{12^2 + 5^2} = 13\ \text{ms}^{-1}$ | M1<br>A1<br>M1 A1 **cso** (4)<br><br>**11** |
| | **Notes** | |
| **7(a)** | B1 for $\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$ $(k \neq 1)$ seen or implied in working, including for an incorrect final answer, with the wrong $k$ value.<br>First M1 for adding the 2 forces (for this M mark we only need $\mathbf{F}_2 = a\mathbf{i} + b\mathbf{j}$), with **i**'s and **j**'s collected (which can be implied by later working) but allow a slip.<br>(M0 if $a$ and $b$ both assumed to be 1)<br>Second M1, dependent on first M1, for ratio of their cpts = 1/3 or 3/1 (Must be correct way up for the M mark)<br>First A1 for a correct equation which may involve two unknowns<br>Third M1, dependent on first and second M1, for solving for $k$ oe<br>Second A1 for a correct k value<br>Third A1 for $2.5\mathbf{i} + 2.5\mathbf{j}$ | |

**ALTERNATIVE: Using two simultaneous equations**

B1 for $\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$ ($k \neq 1$) seen or implied in working.
First M1 for adding the 2 forces (for this M mark we only need $\mathbf{F}_2 = a\mathbf{i} + b\mathbf{j}$), with **i**'s and **j**'s collected (LHS of equation) (M0 if *a* and *b* both assumed to be 1) but allow a slip
Second M1, dependent on first M1, for equating coeffs to produce *two* equations in 2 or 3 unknowns. Must have *p* and 3*p* ( M0 if *p* is assumed to be 1 or *k*)
First A1 for two correct equations
Third M1, dependent on first and second M1, for solving for *k* oe
Second A1 for a correct k value
Third A1 for $2.5\mathbf{i} + 2.5\mathbf{j}$

**ALTERNATIVE: Using magnitudes and directions**




$\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$, seen or implied — B1
Correct vector triangle — M1

$\frac{k\sqrt{2}}{\sin 45^0} = \frac{\sqrt{5}}{\sin(90^0 - a)}$, $a = \arctan 2$ — **DM**1 A1

$2k = 5$

$k = 2.5$; $\mathbf{F}_2 = 2.5\mathbf{i} + 2.5\mathbf{j}$ — **DM**1 A1; A1 (7)

**ALTERNATIVE: Using magnitudes and directions**
B1 for $\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$ seen or implied in working.
First M1 for a correct vector triangle (for this M mark we only need $\mathbf{F}_2 = a\mathbf{i} + b\mathbf{j}$). (M0 if *a* and *b* both assumed to be 1 and/or longest side is assumed to be $\sqrt{10}$)
Second M1, dependent on first M1, for using sine rule on vector triangle
First A1 for a correct equation. $45^0$ may not appear exactly.
Third M1, dependent on first and second M1, for solving for *k* oe
Second A1 for a correct *k* value
Third A1 for $2.5\mathbf{i} + 2.5\mathbf{j}$

| | | |
|---|---|---|
| | | |
| **(b)** | First M1 for use of $\mathbf{v} = \mathbf{u} + \mathbf{a}t$ with $t = 3$<br>First A1 for $12\mathbf{i} + 5\mathbf{j}$ seen or implied. However, if a wrong $\mathbf{v}$ is seen A0<br>Second M1 for finding magnitude of their $\mathbf{v}$<br>Second A1 for 13 | |
| | | |
| | | |

Leave blank

**8.**

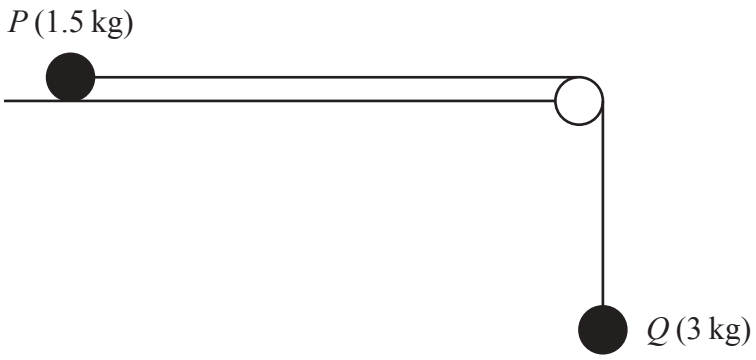



**Figure 3**

Two particles $P$ and $Q$ have masses 1.5 kg and 3 kg respectively. The particles are attached to the ends of a light inextensible string. Particle $P$ is held at rest on a fixed rough horizontal table. The coefficient of friction between $P$ and the table is $\frac{1}{5}$. The string is parallel to the table and passes over a small smooth light pulley which is fixed at the edge of the table. Particle $Q$ hangs freely at rest vertically below the pulley, as shown in Figure 3. Particle $P$ is released from rest with the string taut and slides along the table.

Assuming that $P$ has not reached the pulley, find

(a) the tension in the string during the motion,

**(8)**

(b) the magnitude and direction of the resultant force exerted on the pulley by the string.

**(4)**

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

| Question Number | Scheme | Marks |
|---|---|---|
| **8(a)** | $F = \frac{1}{5}R$<br>$R = 1.5g$<br>$T - F = 1.5a$<br>$3g - T = 3a$<br>$T = 1.2g$ or 11.8 N or 12 N | M1<br>B1<br><br>M1 A1<br>M1 A1<br><br>**DM1** A1<br>(8) |
| **(b)** | $R = \sqrt{T^2 + T^2}$ or $2T\cos 45^0$ or $\frac{T}{\cos 45^0}$<br>$= 16.6$ (N) or 17(N) or $\frac{6g\sqrt{2}}{5}$<br>Direction is 45° below the horizontal oe | M1 A1<br><br>A1<br><br>B1 (4)<br><br>**12** |
| | **Notes** | |
| **8(a)** | First M1 for *use of* $F = \frac{1}{5}R$ in an equation.<br>B1 for $R = 1.5g$<br>Second M1 for resolving horizontally with usual rules<br>First A1 for a correct equation<br>Third M1 for resolving vertically with usual rules<br>Second A1 for a correct equation<br>**N.B.** Either of the above could be replaced by a *whole system* equation: $3g - F = 4.5a$<br>**N.B.** All of the marks for the two equations can be scored if they consistently use $-a$ instead of $a$.<br>Fourth M1 dependent on first, second and third M marks for solving their equations for $T$<br>Third A1 for 1.2g, 11.8 (N) or 12 (N) | |
| **(b)** | First M1 for a complete method for finding the magnitude of the resultant (**N.B.** M0 if different tensions used),<br>First A1 for $\sqrt{T^2 + T^2}$ or $2T\cos 45^o$<br>Second A1 for 16.6(N) or 17 (N)<br>B1 for 45° below the horizontal or a diagram with an arrow and a correct angle. Ignore subsequent wrong answers e.g. a bearing of $225^0$, which scores B0, as does SW etc. | |