Paper Reference(s)

# 6677/01

# Edexcel GCE

## Mechanics M1

## Bronze Level B2

## Time: 1 hour 30 minutes

| **Materials required for examination** | **Items included with question papers** |
|---|---|
| Mathematical Formulae (Green) | Nil |

**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 formulas stored in them.**

### Instructions to Candidates

In the boxes on the answer book, write the name of the examining body (Edexcel), your centre number, candidate number, the unit title (Mechanics M1), the paper reference (6677), your surname, other name and signature.
Whenever a numerical value of $g$ is required, take $g = 9.8 \text{ m s}^{-2}$.
When a calculator is used, the answer should be given to an appropriate degree of accuracy.

### Information for Candidates

A booklet 'Mathematical Formulae and Statistical Tables' is provided.
Full marks may be obtained for answers to ALL questions.
There are 8 questions in this question paper. The total mark for this paper is 75.

### Advice to Candidates

You must ensure that your answers to parts of questions are clearly labelled.
You must show sufficient working to make your methods clear to the Examiner. Answers without working may gain no credit.

**Suggested grade boundaries for this paper:**

| A* | A | B | C | D | E |
|---|---|---|---|---|---|
| 74 | 68 | 62 | 52 | 42 | 34 |

**1.** A railway truck $P$, of mass $m$ kg, is moving along a straight horizontal track with speed 15 m s$^{-1}$. Truck $P$ collides with a truck $Q$ of mass 3000 kg, which is at rest on the same track. Immediately after the collision the speed of $P$ is 3 m s$^{-1}$ and the speed of $Q$ is 9 m s$^{-1}$. The direction of motion of $P$ is reversed by the collision.

Modelling the trucks as particles, find

(*a*) the magnitude of the impulse exerted by $P$ on $Q$,

**(2)**

(*b*) the value of $m$.

**(3)**

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**2.** A car of mass 1000 kg is towing a caravan of mass 750 kg along a straight horizontal road. The caravan is connected to the car by a tow-bar which is parallel to the direction of motion of the car and the caravan. The tow-bar is modelled as a light rod. The engine of the car provides a constant driving force of 3200 N. The resistances to the motion of the car and the caravan are modelled as constant forces of magnitude 800 newtons and $R$ newtons respectively.

Given that the acceleration of the car and the caravan is 0.88 m s$^{-2}$,

(*a*) show that $R$ = 860,

**(3)**

(*b*) find the tension in the tow-bar.

**(3)**

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**3.**

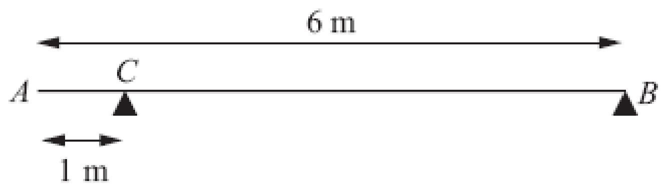


**Figure 1**

A uniform beam $AB$ has mass 20 kg and length 6 m. The beam rests in equilibrium in a horizontal position on two smooth supports. One support is at $C$, where $AC$ = 1 m, and the other is at the end $B$, as shown in Figure 1. The beam is modelled as a rod.

(*a*) Find the magnitudes of the reactions on the beam at $B$ and at $C$.

**(5)**

A boy of mass 30 kg stands on the beam at the point $D$. The beam remains in equilibrium. The magnitudes of the reactions on the beam at $B$ and at $C$ are now equal. The boy is modelled as a particle.

(*b*) Find the distance $AD$.

**(5)**

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**4.**

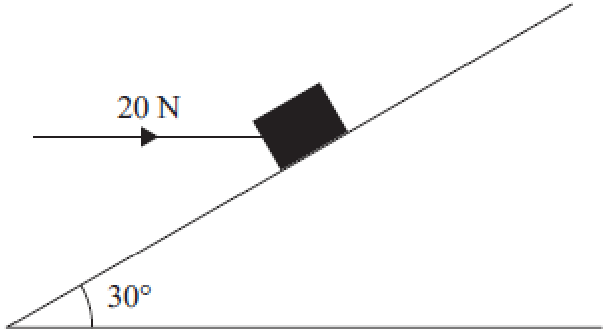


**Figure 2**

A box of mass 5 kg lies on a rough plane inclined at 30° to the horizontal. The box is held in equilibrium by a horizontal force of magnitude 20 N, as shown in Figure 2. The force acts in a vertical plane containing a line of greatest slope of the inclined plane.

The box is in equilibrium and on the point of moving down the plane. The box is modelled as a particle.

Find

(*a*) the magnitude of the normal reaction of the plane on the box,

**(4)**

(*b*) the coefficient of friction between the box and the plane.

**(5)**

**5.**

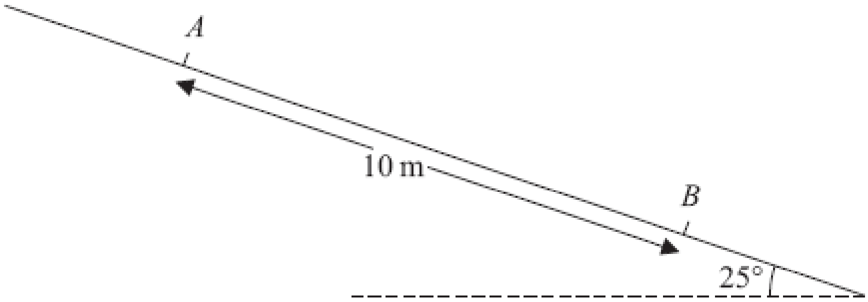


**Figure 3**

A particle $P$ of mass 0.6 kg slides with constant acceleration down a line of greatest slope of a rough plane, which is inclined at 25° to the horizontal. The particle passes through two points $A$ and $B$, where $AB$ = 10 m, as shown in Figure 3. The speed of $P$ at $A$ is 2 m s$^{-1}$. The particle $P$ takes 3.5 s to move from $A$ to $B$.

Find

(*a*) the speed of $P$ at $B$,

**(3)**

(*b*) the acceleration of $P$,

**(2)**

(*c*) the coefficient of friction between $P$ and the plane.

**(5)**

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**6.** A car moves along a straight horizontal road from a point $A$ to a point $B$, where $AB$ = 885 m. The car accelerates from rest at $A$ to a speed of 15 m s$^{-1}$ at a constant rate $a$ m s$^{-2}$.

The time for which the car accelerates is $\frac{1}{3}T$ seconds. The car maintains the speed of 15 m s$^{-1}$ for $T$ seconds. The car then decelerates at a constant rate of 2.5 m s$^{-2}$, stopping at $B$.

(*a*) Find the time for which the car decelerates.

**(2)**

(*b*) Sketch a speed-time graph for the motion of the car.

**(2)**

(*c*) Find the value of $T$.

**(4)**

(*d*) Find the value of $a$.

**(2)**

(*e*) Sketch an acceleration-time graph for the motion of the car.

**(3)**

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**7.** [*In this question, the unit vectors* **i** *and* **j** *are due east and due north respectively. Position vectors are relative to a fixed origin O.*]

A boat $P$ is moving with constant velocity $(-4\mathbf{i} + 8\mathbf{j})$ km h$^{-1}$.

(*a*) Calculate the speed of $P$.

**(2)**

When $t = 0$, the boat $P$ has position vector $(2\mathbf{i} - 8\mathbf{j})$ km. At time $t$ hours, the position vector of $P$ is $\mathbf{p}$ km.

(*b*) Write down $\mathbf{p}$ in terms of $t$.

**(1)**

A second boat $Q$ is also moving with constant velocity. At time $t$ hours, the position vector of $Q$ is $\mathbf{q}$ km, where

$$\mathbf{q} = 18\mathbf{i} + 12\mathbf{j} - t\,(6\mathbf{i} + 8\mathbf{j}).$$

(*c*) Find the value of $t$ when $P$ is due west of $Q$.

**(3)**

(*d*) Find the distance between $P$ and $Q$ when $P$ is due west of $Q$.

**(3)**

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**8.**

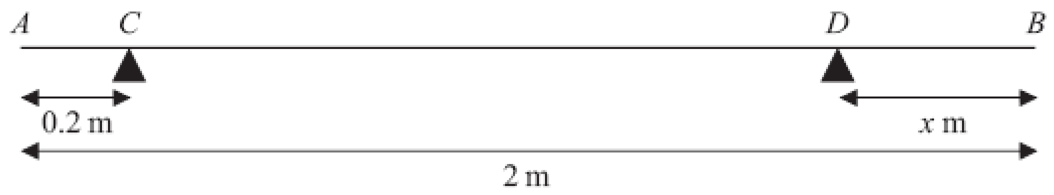


**Figure 5**

A uniform rod $AB$ has length 2 m and mass 50 kg. The rod is in equilibrium in a horizontal position, resting on two smooth supports at $C$ and $D$, where $AC = 0.2$ metres and $DB = x$ metres, as shown in Figure 5. Given that the magnitude of the reaction on the rod at $D$ is twice the magnitude of the reaction on the rod at $C$,

(*a*) find the value of $x$.

**(6)**

The support at $D$ is now moved to the point $E$ on the rod, where $EB = 0.4$ metres. A particle of mass $m$ kg is placed on the rod at $B$, and the rod remains in equilibrium in a horizontal position. Given that the magnitude of the reaction on the rod at $E$ is four times the magnitude of the reaction on the rod at $C$,

(*b*) find the value of $m$.

**(7)**

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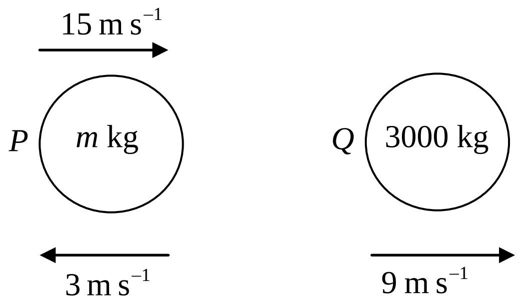
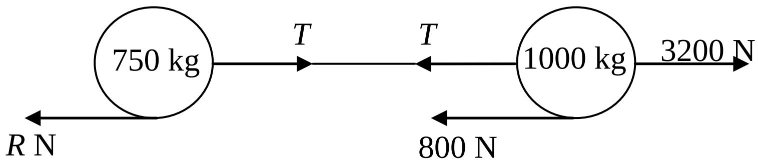
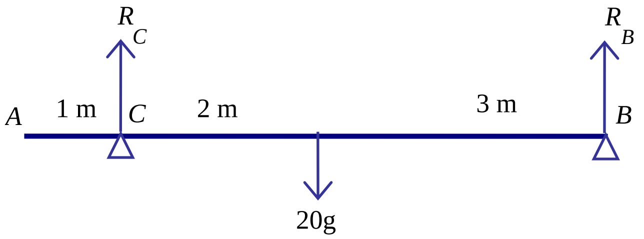
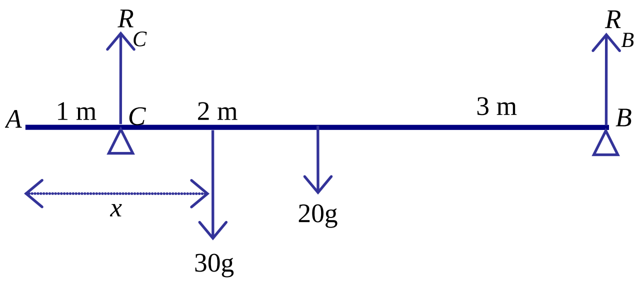
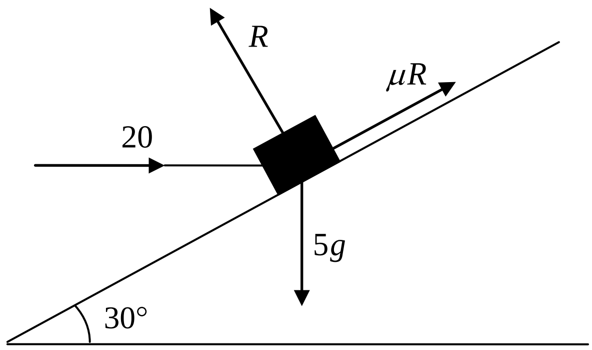
**TOTAL FOR PAPER: 75 MARKS**

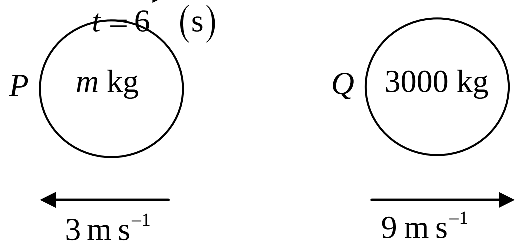
**END**

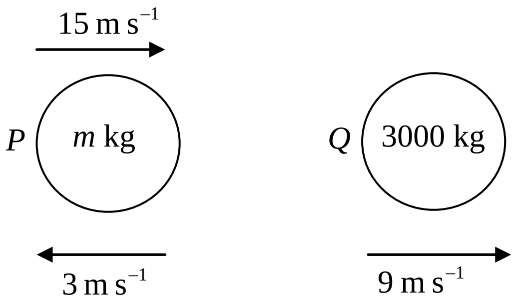
| Question Number | Scheme | Marks |
|---|---|---|
| **1. (a)** |  | |
| | For $Q$ $\quad I = 3000 \times 9 = 27\,000 \quad (\text{N s})$ | M1 A1 |
| | | (2) |
| **(b)** | Conservation of linear momentum | |
| | $15m = -3m + 3000 \times 9$ | M1 A1 |
| | Leading to $\quad m = 1500$ | A1 |
| | | (3) |
| | | **(5 marks)** |
| **2. (a)** |  | |
| | For the whole system | |
| | $\text{R}(\rightarrow) \quad 3200 - 800 - R = 1750 \times 0.88$ | M1 A1 |
| | Leading to $\quad R = 860$ ∗ | A1 |
| | | (3) |
| **(b)** | For the caravan | |
| | $\text{R}(\rightarrow) \quad T - 860 = 750 \times 0.88$ | M1 A1 |
| | Leading to $\quad T = 1520 \quad (\text{N})$ | A1 |
| | | (3) |
| | | **(6 marks)** |

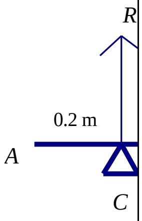
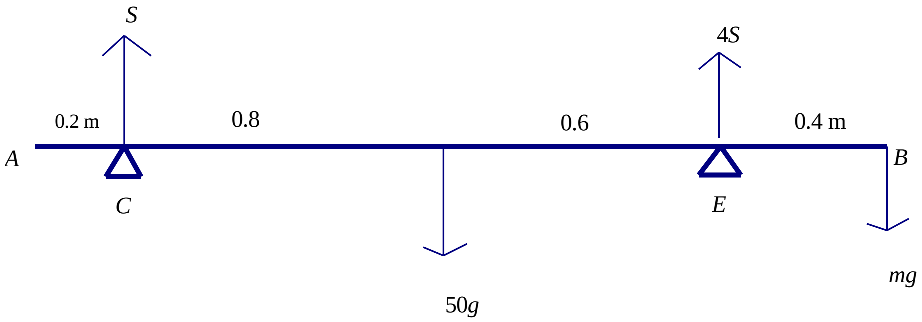
| Qn | Scheme | Marks |
|---|---|---|
| **3.** **(a)** | <br> | |
| | Taking moments about B: 5 x $R_C$ = 20g x 3 | M1A1 |
| | $R_C$ = 12g or 60g/5 or 118 or 120 | A1 |
| | Resolving vertically: $R_C + R_B = 20g$ | M1 |
| | $R_B = 8g$ or 78.4 or 78 | A1 |
| | | (5) |
| | | |
| **(b)** | <br> | |
| | Resolving vertically: 50g = R + R | B1 |
| | Taking moments about B: | |
| | $5 \times 25g \;=\; 3 \times 20g + (6 - x) \times 30g$ | M1 A1 A1 |
| | $30x = 115$ | |
| | $x$ = 3.8 or better or 23/6 oe | A1 |
| | | |
| | (5) | **[10]** |
| | | |
| | | |

| Question Number | Scheme | Marks |
|---|---|---|
| **4.** |  | |
| | (a) $\perp$ plane $R = 20\cos 60° + 5g\cos 30°$ | M1 A2(1,0) |
| | $= 52.4$ (N) or 52 | A1 **(4)** |
| | (b) $F_r = \mu R$ | B1 |
| | $\parallel$ plane $F + 20\cos 30° = 5g\cos 60°$ | M1 A2(1, 0) |
| | Leading to $\mu = 0.137$ or 0.14 | A1 **(5)** |
| | | **[9]** |

| **Question Number** | **Scheme** | **Marks** |
|---|---|---|
| **5.** **(a)** | $s = \frac{u+v}{2}t \quad 10 = \frac{2+v}{2} \times 3.5$ | M1A1 |
| | $v = \frac{20}{3.5} - 2 = \frac{26}{7} = 3.71$ (m s$^{-1}$) | A1 |
| | | **(3)** |
| **(b)** | $a = \frac{v-u}{t} = \frac{\frac{26}{7} - 2}{3.5} = \frac{24}{49} = 0.490$ (m s$^{-2}$) | M1A1 |
| | | **(2)** |
| **(c)** | Normal reaction : $R = 0.6g\cos 25°$ | B1 |
| | Resolve parallel to the slope : $0.6g\sin 25° - \mu \times R = 0.6 \times a$ | M1A2 |
| | $\mu = 0.41$ or 0.411 | A1 |
| | | **(5)** |
| | | **[10]** |

| Question Number | Scheme | Marks |
|---|---|---|
| **6. (a)** | $v = u + at \Rightarrow 0 = 15 - 2.5t$ | M1 |
| | $t = 6 \quad (\text{s})$ | A1 |
| | | (2) |
| **(b)** |  | |
| | Shape | B1 |
| | 15, $T$ | B1 |
| | | (2) |
| **(c)** | $\frac{1}{2}15\left(\frac{4}{3}T + 6 + T\right) = 885$ ft their 6 | M1 A1ft |
| | $\frac{7}{3}T = 118 - 6$ | |
| | $T = 112 \times \frac{3}{7} = 48$ | M1 A1 |
| | | (4) |
| **(d)** | $a = \frac{15}{\frac{1}{3}T} = \frac{15}{16}$ ,0.9375, 0.938, 0.94 | M1 A1 |
| | | (2) |
| **(e)** | | |
| | 3 horizontal lines | B1 |
| | Correctly placed;no cts vert line | B1 |
| | $-2.5$, ft their $\frac{15}{16}$ | B1 |
| | | (3) |
| | | **(13 marks)** |

| Question Number | Scheme | Marks |
|---|---|---|
| **7. (a)** | $\sqrt{\left((-4)^2+8^2\right)}=\sqrt{80}\quad(\text{km h}^{-1})$ accept exact equivalents or 8.9 or better | M1 A1 |
| | | (2) |
| **(b)** | $\mathbf{p}=(2\mathbf{i}-8\mathbf{j})+t(-4\mathbf{i}+8\mathbf{j})$ | B1 |
| | <br> | (1) |
| **(c)** | Equating **j** components<br>$-8+8t=12-8t$ | M1 A1 |
| | $t=\dfrac{5}{4}$ oe | A1 |
| | | (3) |
| **(d)** | Using their $t$ from (c) to find the **i**-cpts of **p** and **q and subtract them** | M1 |
| | $10\dfrac{1}{2}-(-3)=13\dfrac{1}{2}\quad(\text{km})$ | A1 ft A1 |
| | | (3)<br>**9** |

| Question Number | Scheme | Marks |
|---|---|---|
| **8.**<br>**(a)** |  | |
| | Vertical equilibrium: $R+2R=50g$ , | M1A1 |
| | Moments about $C$: $50g\times 0.8=(1.8-x)\times 2\times R$ | M1A1 |
| | $3\times 0.8=3.6-2x$ , $x=0.6$ | **DM1**A1<br>**(6)** |
| **(b)** |  | |
| | $S$, $4S$ | B1 |
| | Vertical equilibrium: $S+4S=(50+m)g=5S$ | M1A1 |
| | Moments about $B$: $50g\times 1=4S\times 0.4+S\times 1.8=3.4S$ | M1A1 |
| | $50\times\dfrac{5}{3.4}=(50+m)$ | **DM1** |
| | $m$ = 400/17, 24, 23.5 or better | A1<br>**(7)**<br>**[13]** |

# Examiner reports

## Question 1

This question seemed to pose few problems for the majority of candidates. In part (a) most found the magnitude of the impulse of *P* on *Q* with very few giving a negative answer. A few found the magnitude of the impulse on *P*, giving their answer in terms of *m*. A fairly common error was to include g in the impulse formula and this received no credit. In the second part, most used conservation of momentum and there were the usual sign errors. A few candidates struggled with re-arranging the equation.

## Question 2

In the first part, the majority of candidates wrote down a correct equation of motion for the 'whole system' which they successfully solved to derive the given value for the resistance force on the caravan. Some chose to consider the car and caravan separately, calculating the tension from the car equation and then using this value in the caravan equation, again generally successfully. There were more errors evident in finding the tension in part (b); the mass used in the '*ma*' term was not always consistent with the rest of the equation and occasionally the mass of the whole system was used in an equation relating only to one body. Sometimes the two resistances were confused, two tensions were added together in one equation or the '*ma*' term was omitted completely, showing a lack of understanding of the motion of connected particles. Less significant errors tended to involve wrong signs. Overall, however, this question was very well done with full marks often awarded.

## Question 3

The first part was done well, with the most common error being to give *Rc* as 117.6 N which was penalised for being over-accurate. The question required two equations and those who used a vertical resolution were almost always successful whereas those who used two moments equations often made errors. The same was true in part (b), but candidates often made errors when expressing the distances used in terms of *AD*. The omission of g was penalised in the first part but not in part (b), provided it was consistent, where it was not needed to obtain a fully correct solution. A few used the same values for the reactions in part (b) as those found in the first part and received little credit.

## Question 4

This was a well-answered question. The majority of candidates obtained the correct number of terms in the resolutions and were able to resolve properly, with most candidates making sensible choices of the methods to use. Common errors were due to wrong signs, specifically with the 20 component, or missing *g*. There were also a few instances of division by sin or cos or the use of tan. A few candidates also neglected the weight in their resolving. The vast majority of candidates opted to resolve perpendicular and parallel to the plane. Of the few who chose to resolve horizontally and vertically most were successful but a few left out a component. There were surprisingly many candidates who lost the final mark through over-accuracy.

Virtually all candidates gained the mark for the use of $F = \mu R$. A significant number did not realise that friction acted up the plane and the ensuing negative value for $\mu$ was then conveniently lost. It seemed that fewer candidates than in previous years made the mistake of using $g = 9.81$.

There was evidence of a few candidates having their calculators set in radians rather than in degrees.

**Question 5**

The first two parts of this question were generally answered very well with the appropriate *suvat* equations usually being used correctly. It was not uncommon to see the answer for the acceleration in part (b) appearing first and then it being used to find the velocity in the first part. There were more problems with the final part where the main error was forgetting to include the component of the weight when resolving parallel to the plane.

**Question 6**

In the first part, the majority of candidates found the required time in a valid way, although occasionally substitution into '$v = u + at$' without regard to sign (or interchanging $u$ and $v$) led to '$t = -6$' and a subsequent change to '$t = 6$' without explanation.

In part (b), the vast majority produced a speed-time graph of the correct shape (a trapezium starting and finishing on the $t$-axis), but some failed to mark the '$T$' correctly (often leading to the interval for the constant speed part of the graph being $\frac{2}{3}T$ rather than $T$). In the third part, most attempted to equate the area under the graph to the given distance, either using the trapezium formula or splitting into triangles and a rectangle; sometimes, however, there were errors in identifying the relevant lengths in terms of $T$. Attempts to apply constant acceleration formulae inappropriately to the whole distance were only very rarely seen. Most candidates evaluated the gradient in part (d) to find the acceleration as required, but those who were using an incorrect value for $T$ could only achieve one of the two available marks. The acceleration-time graph in the final part was generally drawn correctly with three separate horizontal sections. Marks lost tended to be from not labelling the known values of the acceleration (or writing '2.5' rather than '−2.5' on the negative acceleration axis) or from using continuous vertical lines to join the sections. Nevertheless, a significant number of full marks were seen with most candidates scoring well.

**Question 7**

Part (a) was generally correct, although the minus sign was often missing from many solutions. In the second part, most were able to write down a correct expression for $p$. A large number of candidates, in part (c), incorrectly equated the **i**-components instead of the **j**-components and obtained $t = 8$. For the final part, most of the candidates with an incorrect value of $t$ seemed to be able to substitute their value of $t$ into their $p$ and $q$ expressions yet fewer knew how to subtract one from the other correctly, taking into account any negative signs. Many of those who did try to subtract were unable to maintain accuracy when subtracting a negative term from within a bracket.

Despite the fact that the question said that one boat was due west of the other one, this didn't prompt candidates who obtained a non-zero **j**-component for $PQ$ to go back and check their value of $t$.

**Question 8**

Part (a) was a relatively straightforward question where the majority of candidates scored full marks. Resolving vertically and taking moments once, usually about *C*, was by far the most popular approach but a few opted to take moments twice and this inevitably made it more difficult. In the second part again many candidates scored full marks, with most resolving vertically and taking moments about *B*. Apart from the usual errors with distances in some of the moments equations, the other mistakes tended to be omitting the *mg* from the vertical resolution or using the reaction found in part (a).

**Statistics for M1 Practice Paper Bronze Level B2**

| Original paper | Qu | Mean score | Max score | Mean % | Mean score for students achieving grade: ALL | A | B | C | D | E | U |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1201 | **1** | 4.40 | 5 | 88 | 4.40 | 4.72 | 4.56 | 4.25 | 3.93 | 3.54 | 2.56 |
| 1201 | **2** | 4.84 | 6 | 81 | 4.84 | 5.68 | 5.02 | 4.32 | 3.48 | 2.89 | 1.56 |
| 1101 | **3** | 7.64 | 10 | 76 | 7.64 | 9.03 | 7.80 | 6.10 | 4.94 | 3.48 | 1.31 |
| 1206 | **4** | 7.06 | 9 | 78 | 7.06 | 8.52 | 7.90 | 7.17 | 6.23 | 4.95 | 2.53 |
| 1306R | **5** | 7.93 | 10 | 79 | 7.93 | 8.99 | 8.05 | 7.11 | 5.77 | 6.05 | 3.75 |
| 1201 | **6** | 9.99 | 13 | 77 | 9.99 | 11.72 | 10.31 | 9.08 | 7.76 | 6.88 | 4.58 |
| 1201 | **7** | 5.69 | 9 | 63 | 5.69 | 7.48 | 5.42 | 4.28 | 3.24 | 2.76 | 1.64 |
| 1306R | **8** | 10.53 | 13 | 81 | 10.53 | 12.32 | 11.39 | 9.59 | 7.46 | 6.52 | 3.82 |
| | | **58.08** | **75** | **78** | **58.08** | **68.46** | **60.45** | **51.90** | **42.81** | **37.07** | **21.75** |