## Monday 19 May 2014 - Morning

## A2 GCE MATHEMATICS (MEI)

## 4762/01 Mechanics 2

## QUESTION PAPER

Candidates answer on the Printed Answer Book.
OCR supplied materials:
Duration: 1 hour 30 minutes

- Printed Answer Book 4762/01
- MEI Examination Formulae and Tables (MF2)

Other materials required:

- Scientific or graphical calculator


## INSTRUCTIONS TO CANDIDATES

These instructions are the same on the Printed Answer Book and the Question Paper.

- The Question Paper will be found inside the Printed Answer Book.
- Write your name, centre number and candidate number in the spaces provided on the Printed Answer Book. Please write clearly and in capital letters.
- Write your answer to each question in the space provided in the Printed Answer Book. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Answer all the questions.
- Do not write in the bar codes.
- You are permitted to use a scientific or graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.
- The acceleration due to gravity is denoted by $\mathrm{gm} \mathrm{s}^{-2}$. Unless otherwise instructed, when a numerical value is needed, use $g=9.8$.


## INFORMATION FOR CANDIDATES

This information is the same on the Printed Answer Book and the Question Paper.

- The number of marks is given in brackets [ ] at the end of each question or part question on the Question Paper.
- You are advised that an answer may receive no marks unless you show sufficient detail of the working to indicate that a correct method is being used.
- The total number of marks for this paper is 72.
- The Printed Answer Book consists of 16 pages. The Question Paper consists of $\mathbf{8}$ pages. Any blank pages are indicated.


## INSTRUCTION TO EXAMS OFFICER/INVIGILATOR

- Do not send this Question Paper for marking; it should be retained in the centre or recycled. Please contact OCR Copyright should you wish to re-use this document.

1 (a) A particle, P , of mass 5 kg moving with speed $u \mathrm{~ms}^{-1}$ collides with another particle, Q , of mass 30 kg travelling with a speed of $\frac{u}{3} \mathrm{~m} \mathrm{~s}^{-1}$ towards P . The particles P and Q are moving in the same horizontal straight line with negligible resistance to their motion. As a result of the collision, the speed of P is halved and its direction of travel reversed; the speed of Q is now $V \mathrm{~ms}^{-1}$.
(i) Draw a diagram showing this information.

Find the velocity of Q immediately after the collision in terms of $u$. Find also the coefficient of restitution between P and Q .
(ii) Find, in terms of $u$, the impulse of P on Q in the collision.
(b) Fig. 1 shows a small object R of mass 5 kg travelling on a smooth horizontal plane at $6 \mathrm{~m} \mathrm{~s}^{-1}$. It explodes into two parts of masses 2 kg and 3 kg . The velocities of these parts are in the plane in which R was travelling with the speeds and directions indicated. The angles $\alpha$ and $\beta$ are given by $\cos \alpha=\frac{4}{5}$ and $\cos \beta=\frac{3}{5}$.

before


Fig. 1
(i) Calculate $u$ and $v$.
(ii) Calculate the increase in kinetic energy resulting from the explosion.

2 Fig. 2.1 shows the positions of the points $P, Q, R, S, T, U, V$ and $W$ which are at the vertices of a cube of side $a$; Fig. 2.1 also shows coordinate axes, where O is the mid-point of PQ .


Fig. 2.1
An open box, A, is made from thin uniform material in the form of the faces of the cube with just the face TUVW missing.
(i) Find the $z$-coordinate of the centre of mass of A.

Strips made of a thin heavy material are now fixed to the edges TW, WV and VU of box A, as shown in Fig. 2.2. Each of these three strips has the same mass as one face of the box. This new object is B.


Fig. 2.2
(ii) Find the $x$ - and $z$-coordinates of the centre of mass of B and show that the $y$-coordinate is $\frac{9 a}{16}$.

Object B is now placed on a plane which is inclined at $\theta$ to the horizontal. B is positioned so that face PQRS is on the plane with SR at right angles to a line of greatest slope of the plane and with PQ higher than SR, as shown in Fig. 2.3.


Fig. 2.3
(iii) Assuming that B does not slip, find $\theta$ if B is on the point of tipping.

B is now placed on a different plane which is inclined at $30^{\circ}$ to the horizontal. When B is released it accelerates down the plane at $2 \mathrm{~m} \mathrm{~s}^{-2}$.
(iv) Calculate the coefficient of friction between B and the inclined plane.

3 (a) Fig. 3.1 shows a framework in equilibrium in a vertical plane. The framework is made from 3 light rigid rods $\mathrm{AB}, \mathrm{BC}$ and CA which are freely pin-jointed to each other at $\mathrm{A}, \mathrm{B}$ and C . The pin-joint at A is attached to a fixed horizontal beam; the pin-joint at C rests on a smooth horizontal floor. BC is 2 m and angle BAC is $30^{\circ} ; \mathrm{BC}$ is at right angles to AC . AB is horizontal.

Fig. 3.1 also shows the external forces acting on the framework; there is a vertical load of 60 N at B , horizontal and vertical forces $X \mathrm{~N}$ and $Y \mathrm{~N}$ act at A; the reaction of the floor at C is $R \mathrm{~N}$.


Fig. 3.1
(i) Show that $R=80$ and find the values of $X$ and $Y$.
(ii) Using the diagram in your printed answer book, show all the forces acting on the pin-joints, including those internal to the rods.
(iii) Calculate the forces internal to the rods $\mathrm{AB}, \mathrm{BC}$ and CA , stating whether each rod is in tension or thrust (compression). [You may leave your answers in surd form. Your working in this part should correspond to your diagram in part (ii).]
(b) Fig 3.2 shows a non-uniform rod of length 6 m and weight 68 N with its centre of mass at G . This rod is free to rotate in a vertical plane about a horizontal axis through B, which is 2 m from A . G is 2 m from B . The rod is held in equilibrium at an angle $\theta$ to the horizontal by a horizontal force of 102 N acting at C and another force acting at A (not shown in Fig. 3.2). Both of these forces and the force exerted on the rod by the hinge (also not shown in Fig 3.2) act in a vertical plane containing the rod. You are given that $\sin \theta=\frac{15}{17}$.


Fig. 3.2
(i) First suppose that the force at A is at right angles to ABC and has magnitude $P \mathrm{~N}$.

Calculate $P$.
(ii) Now instead suppose that the force at A is horizontal and has magnitude $Q \mathrm{~N}$.

Calculate $Q$.
Calculate also the magnitude of the force exerted on the rod by the hinge.

4 (a) A small heavy object of mass 10 kg travels the path ABCD which is shown in Fig. 4. ABCD is in a vertical plane; $C D$ and $A E F$ are horizontal. The sections of the path $A B$ and $C D$ are smooth but section BC is rough.


Fig. 4
You should assume that

- the object does not leave the path when travelling along ABCD and does not lose energy when changing direction
- there is no air resistance.

Initially, the object is projected from A at a speed of $16.6 \mathrm{~m} \mathrm{~s}^{-1}$ up the slope.
(i) Show that the object gets beyond B.

The section of the path BC produces a constant resistance of 14 N to the motion of the object.
(ii) Using an energy method, find the velocity of the object at D .

At D , the object leaves the path and bounces on the smooth horizontal ground between E and F , shown in Fig. 4. The coefficient of restitution in the collision of the object with the ground is $\frac{1}{2}$.
(iii) Calculate the greatest height above the ground reached by the object after its first bounce.
(b) A car of mass 1500 kg travelling along a straight, horizontal road has a steady speed of $50 \mathrm{~ms} \mathrm{~s}^{-1}$ when its driving force has power $P \mathrm{~W}$.

When at this speed, the power is suddenly reduced by $20 \%$. The resistance to the car's motion, $F \mathrm{~N}$, does not change and the car begins to decelerate at $0.08 \mathrm{~m} \mathrm{~s}^{-2}$.

Calculate the values of $P$ and $F$.

## END OF QUESTION PAPER



| Question |  |  | Answer | Marks | Guidance |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | (a) | (i) | $\text { PCLM } \rightarrow+\mathrm{ve}$ $5 u-30 \frac{u}{3}=-5 \frac{u}{2}-30 \mathrm{~V}$ <br> so $V=\frac{u}{12}$ $\begin{aligned} & e=\frac{\frac{u}{2}-\frac{u}{12}}{u+\frac{u}{3}} \\ & =\frac{\frac{5}{12}}{\frac{4}{3}}=\frac{5}{16}(=0.3125) \end{aligned}$ | B1 <br> M1 <br> A1 <br> A1 <br> M1 <br> A1 <br> [6] | Accept $V$ in either direction. Given velocities and masses must be correct. <br> PCLM. Allow sign errors only <br> Award even if direction of $V$ used in PCLM does not match their diagram, so $\frac{u}{12}$ or $-\frac{u}{12}$ will get this A1 <br> WWW. Direction of $V$ correct (may be implied from diagram). <br> FT their $V$ : allow sign errors, but must be right way up |  |
| 1 | (a) | (ii) | $\begin{aligned} & \rightarrow+\mathrm{ve} \\ & 30\left(-\frac{u}{12}-\left(-\frac{u}{3}\right)\right) \end{aligned}$ <br> $7.5 u$ <br> Or: find impulse on P and reverse the sign | M1 <br> A1 <br> M1 <br> A1 <br> [2] | Allow sign errors. <br> $5\left(-\frac{u}{2}-u\right)=-\frac{15}{2} u$ and $7.5 u$ cao M0A0 unless sign is reversed <br> Direction must be given (may be implicit from diagram). |  |


| Question |  |  | Answer | Marks | Guidance |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | (b) | (i) | Either <br> As the parts move at $90^{\circ}$, PCLM in final directions <br> For 2 kg : $5 \times 6 \sin \alpha=2 u$ <br> so $5 \times 6 \times \frac{3}{5}=2 u$ <br> and $u=9$ <br> For 3 kg : $5 \times 6 \sin \beta=3 v$ <br> so $5 \times 6 \times \frac{4}{5}=3 v$ <br> and $v=8$ | $\begin{aligned} & \text { M1 } \\ & \text { M1 } \\ & \text { A1 } \\ & \text { A1 } \\ & \text { M1 } \\ & \text { A1 } \\ & \text { A1 } \end{aligned}$ | PCLM <br> Any form <br> PCLM <br> Any form |  |
|  |  |  | Or PCLM $\rightarrow 5 \times 6=2 u \sin \alpha+3 v \sin \beta$ $\text { so } 30=2 u \times \frac{3}{5}+3 v \times \frac{4}{5}$ <br> PCLM $\uparrow$ $2 u \cos \alpha-3 v \cos \beta=0$ <br> so $2 u \times \frac{4}{5}=3 v \times \frac{3}{5}$ <br> Solving $\begin{aligned} & u=9 \\ & v=8 \end{aligned}$ | M1 <br> A1 <br> M1 <br> A1 <br> M1 <br> A1 <br> F1 <br> [7] | PCLM Allow cos instead of sin if error in both terms; allow sign errors; masses need to be there. Award if embedded in vector method Any form <br> PCLM Allow sin instead of cos if error in both terms and cos used in previous PCLM eqn; allow sign errors; masses need to be there. <br> Award if embedded in vector method <br> Any form <br> A complete method involving 2 equations each in $u$ and $v$ cao for one of $u$ or $v$ <br> for the other: FT substitution into their eqn <br> Note: Award SC5 for $\mathrm{v}=6, \mathrm{u}=12$ (from $\cos / \sin$ reversal) <br> Uses velocity instead of mmtum: M0M0M1A0F1 max $2 / 7$ <br> Uses mass in one eqn only: M1A1M0M1A0F1 max 4/7 |  |
| 1 | (b) | (ii) | $\Delta \mathrm{KE}$ is $\begin{aligned} & \frac{1}{2} \times 2 \times 9^{2}+\frac{1}{2} \times 3 \times 8^{2}-\frac{1}{2} \times 5 \times 6^{2} \\ & =87 \mathrm{~J} \end{aligned}$ | M1 <br> A1 <br> [2] | M1 for attempt at difference of KE (3 terms of correct form) cao |  |


| Question |  | Answer | Marks | Guidance |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 2 | (i) | Let the mass of each face be $m$ $5 m \bar{z}=4 m \times \frac{a}{2}+0 \times m$ $\text { so } \bar{z}=\frac{2 a}{5}$ | $\begin{aligned} & \text { M1 } \\ & \text { A1 } \\ & \text { A1 } \\ & \text { [3] } \end{aligned}$ | Any complete method. Accept no mention of $m$ oe. <br> CLOSED/bottomless box is NOT a MR. Mark as per scheme giving method mark if appropriate: $\max 1 / 3$ |  |
| 2 | (ii) | By symmetry, $\bar{x}=0$ or by calculation $\begin{aligned} & 8 m \bar{y}=5 m \frac{a}{2}+2 m \frac{a}{2}+m a \\ & =\frac{9 a}{2} \text { so } \bar{y}=\frac{9 a}{16} \\ & 8 m \bar{z}=5 m \frac{2 a}{5}+3 m a \\ & =5 a \text { so } \bar{z}=\frac{5 a}{8} \end{aligned}$ | M1 <br> A1 <br> M1 <br> E1 <br> M1 <br> A1 <br> [6] | Can be awarded if closed/bottomless box used Any complete method. Accept no mention of $m$ oe. <br> Shown (answer given) <br> Any complete method. Accept no mention of $m$ oe. <br> cao CLOSED/bottomless box: max M1A1M1A0M1A0 |  |
|  |  | Alternative form of solution: $\begin{aligned} & 8 m\left(\begin{array}{l} \bar{x} \\ \bar{y} \\ \bar{z} \end{array}\right)=m\left(\begin{array}{l} 0 \\ 0 \\ a / 2 \end{array}\right)+m\left(\begin{array}{l} 0 \\ a / 2 \\ 0 \end{array}\right)+m\left(\begin{array}{l} a / 2 \\ a / 2 \\ a / 2 \end{array}\right)+m\left(\begin{array}{l} 0 \\ a \\ a / 2 \end{array}\right) \\ & +m\left(\begin{array}{l} -a / 2 \\ a / 2 \\ a / 2 \end{array}\right)+m\left(\begin{array}{l} -a / 2 \\ a / 2 \\ a \end{array}\right)+m\left(\begin{array}{l} 0 \\ a \\ a \end{array}\right)+m\left(\begin{array}{l} a / 2 \\ a / 2 \\ a \end{array}\right) \\ & =m\left(\begin{array}{l} 0 \\ 9 a / 2 \\ 5 a \end{array}\right) \\ & \text { so } \bar{x}=0, \bar{y}=9 a / 16, \bar{z}=5 a / 8 \end{aligned}$ | M1 <br> A1 | Each coordinate <br> cao |  |


| Question |  | Answer | Marks | Guidance |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 2 | (iii) | $\begin{aligned} & \tan \theta=\frac{\frac{7 a}{16}}{\frac{5 a}{8}}=0.7 \\ & \text { so } \theta=34.992 \ldots \text { so } 35^{\circ}(3 \text { s. f. }) \end{aligned}$ | B1 <br> B1 <br> M1 <br> M1 <br> A1 <br> [5] | $G$ vertically above bottom edge <br> Use of their $\bar{z}$ and $a-\bar{y}$ oe. <br> Use of $\tan$ (or equivalent) with either $\bar{z}$ or $a-\bar{z}$ and $\bar{y}$ or $a-\bar{y}$ <br> (or equivalent) <br> cao. <br> 55 as answer can get B1B1M1M0A0: 3/5 |  |
| 2 | (iv) | Friction $F \mathrm{~N}$, normal reaction $R \mathrm{~N}$ $R=M g \cos 30$ <br> N2L down plane $M g \sin 30-F=2 M$ $F=\mu R$ <br> so $\mu=\frac{g \sin 30-2}{g \cos 30}=0.34169 \ldots$ $\text { so } 0.342 \text { (3 s. f.) }$ | B1 <br> M1 <br> A1 <br> M1 <br> A1 <br> [5] | Allow $8 a^{2}$ as $M$ throughout <br> Attempt to use N2L with all terms (allow a missing g). Allow sign errors <br> Used correctly |  |


| Question |  |  | Answer | Marks | Guidance |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 3 | (a) | (i) | Vertical through C intersects AB at X $\mathrm{BX}=1$ and $\mathrm{XA}=3$ $\uparrow R-Y-60=0$ <br> ac moments about A $\begin{aligned} & 60 \times 4-R \times 3=0 \text { so } R=80 \\ & Y=R-60=20 \text { and } X=0 \end{aligned}$ | B1 <br> B1 <br> B1 <br> B1 <br> [4] | May be implied <br> Must have an correct equation involving $Y$. <br> AG <br> Both. Can be awarded independent of previous B1 MR-1 for $\mathrm{AB}=2$ |  |
| 3 | (a) | (ii) | In the solutions below all internal forces are set as tensions | B1 [1] | All (8 forces, with labelled pairs of arrows for internal forces) present and consistent . $R$ and $Y$ can be used |  |
| 3 | (a) | (iii) | For example: $\mathrm{B} \downarrow 60+T_{\mathrm{BC}} \cos 30=0$ <br> so $T_{\mathrm{BC}}=-40 \sqrt{3}$ (Force of $40 \sqrt{3} \mathrm{~N}(\mathrm{C})$ ) <br> $\mathrm{A} \downarrow 20+T_{\mathrm{AC}} \sin 30=0$ <br> so $T_{\mathrm{AC}}=-40$ Force of $40 \mathrm{~N}(\mathrm{C})$ <br> $\mathrm{A} \leftarrow T_{\mathrm{AB}}+T_{\mathrm{AC}} \cos 30=0$ <br> so $T_{\mathrm{AB}}=20 \sqrt{3}$ Force of $20 \sqrt{3} \mathrm{~N}(\mathrm{~T})$ <br> All three internal forces correct, including T/C | M1 <br> A1 <br> M1 <br> A1 <br> M1 <br> A1 <br> [6] | Attempt an equation for the equilibrium in any direction at any pinjoint (all correct (resolved) terms present, allow sign errors, $s \leftrightarrow c$ <br> Ignore T/C ; sign of force must be consistent with their T/C convention $2^{\text {nd }}$ equilibrium equation attempted <br> Ignore T/C ; sign of force must be consistent with their T/C convention $3^{\text {rd }}$ equilibrium equation attempted <br> Ignore T/C <br> NOTE: Award first A1 for ANY force correct (need not be first one calculated) Award second A1 for a second force correct, FT if dependent on first one. Award third A1 as cao for everything correct, including T/C. |  |


| Question |  |  | Answer | Marks | Guidance |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 3 | (b) | (i) | Take force as $P$ to give + ac moment about B ac moments about B $\begin{aligned} & \cos \theta=\frac{8}{17} \\ & 2 P+68 \times 2 \times \cos \theta-102 \times 4 \times \sin \theta=0 \end{aligned}$ $P=148$ | B1 <br> M1 <br> A1 <br> A1 <br> [4] | Seen or implied, e.g. in $\cos 61.9^{\circ}$ <br> Moments equation with all terms attempted and no extras. Allow $s \leftrightarrow c$ and sign errors <br> Moments about other points must include all relevant forces <br> Substitution of $\sin / \cos$ not required cao |  |
| 3 | (b) | (ii) | Take Q $\rightarrow$ <br> ac moments about B $\begin{aligned} & 2 Q \sin \theta+68 \times 2 \times \cos \theta-102 \times 4 \times \sin \theta=0 \\ & \text { so } Q=167.7333 \ldots \text { so } 168 \text { ( } 3 \text { s. f.) } \\ & \text { Horiz force at B is } 102+167.733 . . \\ & \text { Magnitude is } \sqrt{269.7333 . .^{2}+68^{2}} \\ & =278.172 \ldots \text { so } 278 \mathrm{~N}(3 \text { s. f.) } \end{aligned}$ <br> Alternative for the B1M1A1: finding compts of force at B along and perpendicular to the rod: $\begin{aligned} & Y=102 \sin \theta-68 \cos \theta+Q \sin \theta \\ & X=102 \cos \theta-68 \sin \theta+Q \cos \theta \\ & X=187.06 ; \quad Y=206.34 \\ & \text { Magnitude is } \sqrt{187.06^{2}+206.34^{2}} \\ & =278.172 \ldots \text { so } 278 \mathrm{~N} \text { (3 s. f.) } \end{aligned}$ | M1 <br> F1 <br> B1 <br> M1 <br> A1 <br> B1 <br> M1 <br> A1 <br> [5] | Moments equation with all terms attempted and no extras. Allow $s \leftrightarrow c$ and sign errors <br> Moments about other points must include all relevant forces <br> FT errors in 2,4,cos,sin, sign from part(i) in 2nd and 3rd terms <br> Adding. FT their $Q$ <br> FT their horizontal force at B; Must use 68 <br> cao <br> FT their $Q$ <br> FT their $X$ and $Y$ <br> cao |  |


| Question |  |  | Answer | Marks | Guidance |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 4 | (a) | (i) | KE at A is $1 / 2 \times 10 \times 16.6^{2}=1377.8 \mathrm{~J}$ GPE at $B$ is $10 \times 9.8 \times 14=1372 \mathrm{~J}$ <br> KE at $\mathrm{A}>$ GPE at B so gets beyond B | M1 <br> E1 <br> [2] | Calculate relevant quantities (KE at A and PE at B or $v=1.08$ at B or $h$ = 14.1) <br> Clear argued comparison (e.g. $1377.8>1372$ ) |  |
| 4 | (a) | (ii) | Let speed at D be $v \mathrm{~m} \mathrm{~s}^{-1}$ $\begin{aligned} & \text { A to } \mathrm{D}: \quad \frac{1}{2} \times 10 \times v^{2}-\frac{1}{2} \times 10 \times 16.6^{2} \\ & =-10 \times 9.8 \times 7-25 \times 14 \\ & \left(v^{2}=68.36\right) \\ & \text { so } v=8.2680 \ldots \text { so } 8.27(3 \mathrm{~s} . \mathrm{f}) \end{aligned}$ | M1 <br> B1 <br> M1 <br> A1 <br> A1 | Note: No use of friction can get B1 max <br> Use of WD $=14 x$ $x=25$ <br> WE equation with at least one $\mathrm{KE}, \Delta \mathrm{GPE}$ and WD by friction terms, all of correct form <br> Allow only sign errors |  |
|  |  |  | OR: $\begin{aligned} & \text { B to D: } \frac{1}{2} \times 10 \times v^{2}-1377.8-1372 \\ & =10 \times 9.8 \times 7-25 \times 14 \end{aligned}$ $\begin{aligned} & \left(v^{2}=68.36\right) \\ & \text { so } v=8.2680 \ldots \text { so } 8.27(3 \text { s. f. }) \end{aligned}$ | M1 <br> M1 <br> B1 <br> A1 <br> A1 <br> [5] | WE equation with at least one $\mathrm{KE}, \triangle \mathrm{GPE}$ and WD by friction terms, all of correct form <br> Use of WD $=14 x$ $x=25$ <br> Allow only sign errors <br> cao |  |


| Question |  |  | Answer | Marks | Guidance |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 4 | (a) | (iii) | Consider only the vertical motion. Suppose the object hits the ground at $V \mathrm{~m} \mathrm{~s}^{-1}$ and rises $h \mathrm{~m}$ $\begin{aligned} & V=\sqrt{2 \times 9.8 \times 7}(11.7) \text { AND } \frac{1}{2} V=\sqrt{2 \times 9.8 \times h} \\ & (5.86) \\ & \text { so } h=1 / 4 \times 7=1.75 \end{aligned}$ | M1 <br> M1 <br> A1 <br> [3] | Use of $v^{2}=2 g s$ oe Must be 7 in $V$. Using ' 8.27 ' as u gives M0 $e$ used appropriately: must use their attempt at a vertical velocity cao <br> [Award SC 2 if 1.75 seen WWW] |  |
| 4 | (b) |  | Driving force $(D)=\frac{P}{50}$ $P=50 F(D=F)$ <br> N 2 L along the road $\begin{aligned} & \frac{0.8 P}{50}-F=1500 \times-0.08 \\ & \text { so } 0.8 P-50 F=-6000 \end{aligned}$ <br> Solving gives $F=600 \quad P=30000$ | B1 <br> B1 <br> M1 <br> A1 <br> M1 <br> A1 <br> [6] | Use of $P=$ force x velocity. May be implied e.g. by sight of $0.8 P / 50$ or $0.2 P / 50$ in N2L <br> Accept any form <br> Use of N2L with all terms attempted and consistent with power reduction. Allow sign errors. <br> Accept any form <br> Attempt to solve 2 equations each involving $P$ and $F$. Dependent on N2L equation attempted with 3 terms. <br> cao both <br> [Taking $80 \%$ reduction in $P$ gives $P=7500$ and $F=150$ for $5 / 6$ ] |  |

## 4762 Mechanics 2

## General Comments:

The standard of the solutions presented by candidates was generally pleasing. There was the usual wide spread of marks, but most candidates were able to make a reasonable attempt at most parts of the paper. There was some evidence that candidates felt rushed towards the end of the paper and the final part of the last question proved to be a stumbling-block for many, both because it was unusual and because of the time pressure.

As always, candidates should be encouraged to draw clear and labelled diagrams when appropriate, particularly when dealing with forces or velocities. A lot of potentially very good work was marred by sign errors that perhaps could have been avoided by a clear diagram.

A particular issue revealed itself this session in the need for a clear use and understanding of notation. In Question 2(iv) many candidates used the letter $F$ both to represent force in Newton's second law and to represent friction and almost invariably managed to confuse themselves. Similarly in Question 4(b), $F$ was defined to be the resistance, but candidates chose also to use $F$ as the total force in $F=m a$.

## Comments on Individual Questions:

Question No. 1
Momentum and Impulse
(a)(i) Many candidates produced a diagram with the masses and velocities all marked clearly and these candidates usually scored full marks in the subsequent calculations. A significant minority of candidates, however, seemed to confuse themselves because of an unclear sign convention. Others made sign errors when writing down the conservation of linear momentum equation.
(a)(ii) Candidates had no problems in writing down the fact that the impulse was equal to the change of momentum, but relatively few scored both marks. A significant number of candidates calculated the impulse of Q on P , without realising that a sign change was required to obtain the requested impulse of $P$ on $Q$.
(b)(i) Most candidates were able to form a pair of simultaneous equations based on motion parallel and perpendicular to the motion $R$. A very common error was a sign error in the second of these equations. Other errors resulted from mixing sine and cosine when resolving and from the omission of the masses in all or part of the conservation of momentum equations.
(b)(ii) Almost all candidates who had obtained values for $u$ and $v$ in part (i) were able to calculate the corresponding increase in kinetic energy.

Question No. 2
Centres of mass
(i) The vast majority of candidates were able to find the $z$-coordinate of the centre of mass of the box A. A few candidates chose to consider either a closed box or a bottomless box, even though the question gave two separate and clear indications that the box was open.
(ii) Many of the solutions to this part were of a high quality, with candidates presenting their work in a clear and concise way. Few candidates used symmetry to find the x-coordinate of the centre of mass of B, preferring instead to use a vector method to find all three coordinates.
(iii) Many candidates produced completely correct solutions using the geometry of the situation. A minority of candidates chose to take moments about the point of tipping, usually successfully.
(iv) A significant number of candidates confused the $F$ in $F=m a$ with the frictional force $F$ in $F=\mu R$ and this often led to the omission of any meaningful attempt at applying Newton's second law; it was also common to find $g$ omitted from the reaction force $R$.

Question No. 3

## Forces

(a) (i) This part was usually answered competently, with many candidates scoring the full four marks. The most common error was to ignore the fact that the length of $B C$ was given in the question, as 2 metres. This omission led to some candidates either assuming the length of $A B$ was 2 metres or guessing its value. In such cases, candidates were able to gain the remainder of the marks with accurate use of resolution of forces and/or taking moments.
(ii) Candidates were asked to show all of the forces acting on the pin-joints and most did so. Internal forces should be shown with a pair of arrows, either as a tension or a compression, and also with a label, for example, $T_{A B}, T_{B C}$, and $T_{A C}$, The external forces, $X, Y$ and $R$ needed to be shown, either as letters or with the values calculated in part (i).
(iii) Many candidates scored full marks in this part, offering accurate and concise solutions. Most errors that occurred were as a result of taking moments in directions other than horizontally and vertically. Less often, arithmetic and algebraic errors crept in when simplifying the moments equations.
(b) The two parts of this question were the least well done on the whole paper, with many errors in taking moments and also in understanding what was required in part (ii).
(i) Candidates needed to realise that B was the only sensible point about which to take moments. Almost all those who opted for taking moments about A, G or C omitted to include the force at the hinge at $B$ and so made no creditable progress. Of those candidates who did take moments about $B$, a significant number made errors in identifying the correct distances for some of the moments and/or in confusing sine and cosine.
(ii) Very few candidates realised that $Q=P / \sin \theta$ and the majority simply repeated their work as in part (i), with all of its errors. Follow-through marks were awarded for Q, where possible. The majority of candidates did not attempt to find the force exerted on the rod by the hinge at B . Of those candidates who did make an attempt, most found only the component of the force at right angles to the rod. The simplest method of solution was to write down the horizontal and vertical components of this force ( $(Q+102) \mathrm{N}$ and $X \mathrm{~N}$ and then use Pythagoras' theorem to find the magnitude of the total force.

Question No. 4
Work and Energy
(a) (i) The majority of candidates used an energy method, finding the kinetic energy at A $(1378 \mathrm{~J})$ and the potential energy at $B(1372 \mathrm{~J})$ and noting that the first exceeded the second. Other candidates calculated the speed of the object at $B$, noting that it was positive, or found the height at which the object would come to rest as 14.1 m , noting that it exceeded 14 m .
(iii) Most candidates made a good attempt at calculating the work done, using the distance of 25 m correctly calculated by use of Pythagoras' theorem. They then wrote down a work-energy equation, enabling them to find a value for the required velocity of the object at D . Unfortunately, a significant number of candidates had wrong or missing terms in their equation, usually because of some confusion with their reference points. It was equally satisfactory to consider energy changes from A to $C$ or from $B$ to $C$, but not a mixture of the two.
(iv) Although some candidates grasped what was required in this part, and almost all of these candidates scored full marks, many other candidates seemed convinced that they had to use their answer to part (ii) in some way. The key point of understanding was to realise that the initial vertical velocity at $D$ was zero. The speed with which the object reached the ground could then be found from a simple application of a suvat equation, with $u=0$.
(b) Only a minority of candidates scored more than two of the six marks available in this part of the question. These two marks were awarded for the equation $P=50 F$. Most candidates struggled to find another equation involving $P$ and $F$ and many seemed confused about how to deal with the percentage reduction in the power. Candidates also confused the $F$ in $F=m$ a with the resistance force $F$ given in the question. Having said this, some very neat and fully correct solutions were seen where candidates realised that $20 \%$ of the driving force was equal to the mass times the acceleration.

| Unit level raw mark and UMS grade boundaries June 2014 series AS GCE / Advanced GCE / AS GCE Double Award / Advanced GCE Double Award |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| GCE Mathematics (MEI) |  |  |  |  |  |  |  |  |
|  |  | Max Mark | a | b | c | d | e | $u$ |
| 4751/01 (C1) MEI Introduction to Advanced Mathematics | Raw | 72 | 61 | 56 | 51 | 46 | 42 | 0 |
|  | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 4752/01 (C2) MEI Concepts for Advanced Mathematics | Raw | 72 | 57 | 51 | 45 | 39 | 33 | 0 |
|  | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 4753/01 (C3) MEI Methods for Advanced Mathematics with Coursework: Written Paper | Raw | 72 | 58 | 52 | 47 | 42 | 36 | 0 |
| 4753/02 (C3) MEl Methods for Advanced Mathematics with Coursework: Coursework | Raw | 18 | 15 | 13 | 11 | 9 | 8 | 0 |
| 4753/82 (C3) MEI Methods for Advanced Mathematics with Coursework: Carried Forward Coursework Mark | Raw | 18 | 15 | 13 | 11 | 9 | 8 | 0 |
| 4753 (C3) MEI Methods for Advanced Mathematics with Coursework | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 4754/01 (C4) MEI Applications of Advanced Mathematics | Raw | 90 | 68 | 61 | 54 | 47 | 41 | 0 |
|  | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 4755/01 (FP1) MEI Further Concepts for Advanced Mathematics | Raw | 72 | 63 | 57 | 51 | 45 | 40 | 0 |
|  | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 4756/01 (FP2) MEI Further Methods for Advanced Mathematics | Raw | 72 | 60 | 54 | 48 | 42 | 36 | 0 |
|  | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 4757/01 (FP3) MEI Further Applications of Advanced Mathematics | Raw | 72 | 57 | 51 | 45 | 39 | 34 | 0 |
|  | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 4758/01 (DE) MEI Differential Equations with Coursework: Written Paper | Raw | 72 | 63 | 56 | 50 | 44 | 37 | 0 |
| 4758/02 (DE) MEI Differential Equations with Coursework: Coursework | Raw | 18 | 15 | 13 | 11 | 9 | 8 | 0 |
| 4758/82 (DE) MEI Differential Equations with Coursework: Carried Forward Coursework Mark | Raw | 18 | 15 | 13 | 11 | 9 | 8 | 0 |
| 4758 (DE) MEI Differential Equations with Coursework | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 4761/01 (M1) MEI Mechanics 1 | Raw | 72 | 57 | 49 | 41 | 34 | 27 | 0 |
|  | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 4762/01 (M2) MEI Mechanics 2 | Raw | 72 | 57 | 49 | 41 | 34 | 27 | 0 |
|  | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 4763/01 (M3) MEI Mechanics 3 | Raw | 72 | 55 | 48 | 42 | 36 | 30 | 0 |
|  | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 4764/01 (M4) MEI Mechanics 4 | Raw | 72 | 48 | 41 | 34 | 28 | 22 | 0 |
|  | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 4766/01 (S1) MEI Statistics 1 | Raw | 72 | 61 | 53 | 46 | 39 | 32 | 0 |
|  | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 4767/01 (S2) MEI Statistics 2 | Raw | 72 | 60 | 53 | 46 | 40 | 34 | 0 |
|  | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 4768/01 (S3) MEI Statistics 3 | Raw | 72 | 61 | 54 | 47 | 41 | 35 | 0 |
|  | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 4769/01 (S4) MEI Statistics 4 | Raw | 72 | 56 | 49 | 42 | 35 | 28 | 0 |
|  | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 4771/01 (D1) MEI Decision Mathematics 1 | Raw | 72 | 51 | 46 | 41 | 36 | 31 | 0 |
|  | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 4772/01 (D2) MEI Decision Mathematics 2 | Raw | 72 | 46 | 41 | 36 | 31 | 26 | 0 |
|  | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 4773/01 (DC) MEI Decision Mathematics Computation | Raw | 72 | 46 | 40 | 34 | 29 | 24 | 0 |
|  | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 4776/01 (NM) MEI Numerical Methods with Coursework: Written Paper | Raw | 72 | 54 | 48 | 43 | 38 | 32 | 0 |
| 4776/02 (NM) MEI Numerical Methods with Coursework: Coursework | Raw | 18 | 14 | 12 | 10 | 8 | 7 | 0 |
| 4776/82 (NM) MEI Numerical Methods with Coursework: Carried Forward Coursework Mark | Raw | 18 | 14 | 12 | 10 | 8 | 7 | 0 |
| 4776 (NM) MEI Numerical Methods with Coursework | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 4777/01 (NC) MEI Numerical Computation | Raw | 72 | 55 | 47 | 39 | 32 | 25 | 0 |
|  | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 4798/01 (FPT) Further Pure Mathematics with Technology | Raw | 72 | 57 | 49 | 41 | 33 | 26 | 0 |
|  | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| GCE Statistics (MEI) |  |  |  |  |  |  |  |  |
|  |  | Max Mark | a | b | c | d | e | $u$ |
| G241/01 (Z1) Statistics 1 | Raw | 72 | 61 | 53 | 46 | 39 | 32 | 0 |
|  | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| G242/01 (Z2) Statistics 2 | Raw | 72 | 55 | 48 | 41 | 34 | 27 | 0 |
|  | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| G243/01 (Z3) Statistics 3 | Raw | 72 | 56 | 48 | 41 | 34 | 27 | 0 |
|  | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |

