A-LEVEL
FURTHER MATHEMATICS

MM04 Mechanics 4
Report on the Examination

6360
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General

The overall quality of written solutions was very good. Students generally gave clear step by step explanations throughout. The strongest responses were for the topics of moments of inertia of particles, three dimensional moments, angular momentum and centres of mass.

Question 1

This proved to be a very successful starter question. Almost all students were able to correctly state the moment of inertia of a particle to be md^2. However a number of students didn't spot that d as a distance needs to be positive and therefore lost a mark. The most common incorrect approach was to find the centre of mass of the particles and then set up the moment of inertia equation using the distance to the centre of mass, an invalid approach.

Question 2

Almost all students scored at three marks in part **(a)** by taking moments at E.

Part **(b)** proved to be much more challenging with a number of students unable to calculate the magnitude of the force in BD correctly, often incorrectly attempting to use symmetry of forces. Students still confuse themselves by being inconsistent in their approach to signs of forces, with tensions being a mix of positive and negative.

In part **(c)** many students realised that AB needed to be in compression for equilibrium to be preserved and the best reasons were often supported with a clear diagram to further justify their answer.

Question 3

The topic of centres of mass is very well understood by students and there were many excellent solutions to this question. Almost all students scored full marks in part **(a)**. A few students incorrectly quoted and used two dimensional formulas and hence scored no marks.

Although there were many correct solutions to part **(b)**, some students slipped up with a number of incorrect fractions stated as being equal to tan θ. The most common ones using the distance calculated in part **(a)**, failing to realise that it needed to be subtracted from $9h$.

Question 4

This question was well attempted and students displayed sound understanding of conservation of angular momentum. This was a notable improvement on attempts at similar questions in the past. The best solutions clearly stated the moments of inertia of the rod and combined rod/particle before forming an equation and then solving it to establish the correct expression for d. A small number of students again attempted to use conservation of energy, an invalid approach.

Question 5

This question was done very successfully. Almost all students were able to correctly use $\mathbf{r} \times \mathbf{F}$ three times and sum these to find the resultant moment. There were fewer errors than in the past although the common ones were:

- using $\mathbf{F} \times \mathbf{r}$
- having the wrong sign in at least one of the **j** components

The final mark required students to show an understanding of 'independent' by explicitly referring to p cancelling out in order to score full marks.

Question 6

This question provided a range of differentiated solutions. Many students struggled with part **(a)** either because they did not form correct expressions for the mass of their elemental pieces or then using the incorrect moment of inertia for that elemental piece. Once set up correctly the integration was almost always correct. A number of students also tried to 'fudge' an answer when it was clear that the stated result was not going to be established.

Part **(b)(i)** was generally done very well with students correctly using the parallel axis theorem to establish the correct moment of inertia.

Part **(b)(ii)** was less successful with a number of minor errors occurring regularly:

- using incorrect expressions for mass or radius of each of the spheres
- not taking into account the moment of inertia of at least one of the three components
- not using the parallel axis theorem to obtain the moment of inertia of the larger sphere.

Part **(b)(iii)** was generally done well and students could recover some marks from incorrect working earlier. Students were able to use conservation of energy, forming correct expressions for kinetic energy and potential energy before forming the relevant equation. Students were equally successful whether they considered the change in potential energy of each body (spheres and rod) or by finding the position of the centre of mass first and considering the body as a whole. Minor slips included forgetting to take the square root, omitting g or r in the final expression or using the wrong distance with potential energy.

Question 7

This proved to be a very challenging question that resulted in a range of differentiated responses from 0 to 12 marks. Responses to part **(a)** were very mixed, although a significant number demonstrated their understanding of direction vectors and the connection with the lines of action of forces.

Part **(a)** did however prove successful in helping students to develop a strategy for solving part **(b)**. Many students took the hint to correct state and use an appropriate format for $\mathbf{F}_2$. A small number of students still used the letter 'a' as the parameter though and consequently could progress much further. The principle of taking moments was understood although many failed to have the correct sign for the **clockwise** moment of 39 Nm, hence $8b - 17a = 39$ was a common sight. A number of students then progressed no further because they didn't appreciate how the components of the forces could be used to establish two more equations. Many students who did establish sufficient equations went on to solve them correctly and those who had already made errors could recover some marks if they finished by identifying the two forces concerned from their values.

Question 8

This question was well answered and allowed students to demonstrate their understanding of rotational dynamics. Part **(a)** was done well and having the printed answer enabled students to correct any errors to establish the correct result. Part **(b)** was done well with students generally preferring to differentiate $\dot{\theta}^2$ rather than applying $C = I\ddot{\theta}$ to correctly find $\ddot{\theta}$. The latter approach proved more fruitful as errors were sometimes made in differentiating both sides of the equation. A small number of students formed an equation using Newton's Second Law but this was wrongly applied in the perpendicular direction to that required. There were far less errors than in the past with many students able to obtain the correct answer.

Use of statistics

Statistics used in this report may be taken from incomplete processing data. However, this data still gives a true account on how students have performed for each question.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.

Converting Marks into UMS marks

Convert raw marks into Uniform Mark Scale (UMS) marks by using the link below.
UMS conversion calculator