A-LEVEL
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 three dimensional moments, equivalent forces and centres of mass.

Question 1

This proved to be a more challenging starter question than those in the past. Almost all students were able to score at least one mark by identifying the correct moment of inertia of the particle after it stuck to the disc as $0.6(0.25)^2$. The most common incorrect approach was to attempt to use conservation of energy. However, a significant number of students provided concise solutions to this question, displaying secure knowledge about conservation of angular momentum.

Question 2

This question was done very successfully. In part (a), almost all students correctly found the vector $\overrightarrow{PM}$ and were able to correctly use $\mathbf{r}\times\mathbf{F}$ to find the resultant moment and hence the required magnitude.

Many attempts at part (b) resulted in errors such as mixing up scalar product and vector product methods, giving an obtuse angle as the answer and not rounding their final answer to the nearest degree.

Question 3

This proved to be a challenging frameworks question with a number of students unable to calculate angles correctly, thinking rod BC made an angle of 25° with the horizontal at B. Almost all students scored at least one mark in part (a) by taking moments at B and forming an equation with $20(1.5)$ on one side. However, an incorrect angle on the other side of the equation proved to be very costly.

Part (b) was done well, with most students realising that they had to add 20 N to their answer from part (a).

By far the most successful approach to part (c) was to consider forces at A first and then find the forces in the rods in the order AC, AB and BC. There is a lesson to be learnt here in that initial working out does then not depend on previous calculated answers. More students than usual appeared to have difficulties in identifying the nature of the forces in each rod. A clear, consistent labelling approach is required to avoid students confusing themselves.

Question 4

The topic of centres of mass is well understood by students and there were many excellent solutions to this question.

Almost all students scored full marks in part (a), although on occasions two marks were lost for not fully showing how to obtain $\frac{16\pi}{15}$. When a printed answer is given, full working needs to be shown.

Although there were many correct solutions to part (b), some students slipped up with the fractions involved in the integration. Requisite formulae are well known by students and only a few students quoted an incorrect formula or attempted to start from a first principles argument. Part (c) was less successful than expected with a number of incorrect fractions stated as being equal to $\tan\theta$. The most common ones being $\frac{2}{\bar{X}}$ or $\frac{\bar{Y}}{\bar{X}}$.

Question 5

This question very successfully allowed students to demonstrate their understanding of couples and of moments in two dimensions. Approaches were split equally between utilising $\mathbf{r}\times\mathbf{F}$ to obtain each required moment and utilising force × distance for each component. There was excellent understanding of how to set up the required equation for equivalent forces**.** On occasions,there were errors involving incorrect signs with clockwise/anticlockwise moments, but these were rare. A few students provided a very elegant solution by considering moments around (–4 , 6).

Question 6

This question provided solutions that differed widely in quality.

Part (a) was done well, with students able to adjust and/or combine standard moment of inertia results for rods and the hoop.

Part (b)(i) proved more challenging, with a significant number of students losing marks due to incorrectly stating potential energy lost as $8mga$; omitting to include the kinetic energy of the particle; failing to differentiate correctly; misapplying $C = I\ddot{\theta}$ by using $4mg$ instead of T; and making algebraic errors when solving simultaneous equations. Energy approaches were on the whole far less successful as they were incomplete.

Part (b)(ii) was more successful, with students able to recover from errors in (b)(i).

Question 7

This question proved to be challenging, but allowed students to demonstrate understanding of rotational dynamics and differentiated appropriately.

Part (a) was generally done very well. It was expected that students would use the parallel axis theorem to find the required moment of inertia, and most did so correctly. However, in addition, other approaches included using integration or combining adjusted results for two rods of length $3a$ and $5a$.

Part (b)(i) was done well, although a number of students identified the potential energy lost as $mga\sin\theta$ and then incorrectly changed their answer to part (a) in order to obtain the printed result.

Part (b)(ii) was done well, with students equally divided between differentiating $\dot{\theta}^2$ or applying $C = I\ddot{\theta}$. The latter approach proved more fruitful as errors were sometimes made in differentiating both sides of the equation.

Part (c) proved, rightfully so, to be the most challenging aspect of the paper, although a number of excellent solutions were seen. Common errors were attempting to take moments; using incorrect expressions for mass or radius; reversing signs in the resultant force expression; using a mixture of incorrect resultant forces such as $mg\cos\theta$ or $mg\sin\theta$; mixing up the perpendicular and parallel directions, thus resulting in incorrect accelerations; and misapplying the law of friction. This is one area of the specification where many students would be well advised to improve their understanding of forces at the axis of rotation.

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