# A-LEVEL
# Mathematics

## MM03 – Mechanics 3
## Report on the Examination

6360
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## General Comments

There were many excellent responses to this paper. A high proportion of students attempted all questions and demonstrated a sound grasp of the relevant knowledge and skills. Some parts of the paper proved to be too demanding for a number of students. A significant number of students were not able to resolve velocity and apply the law of restitution correctly. Many students showed a high level of competency with the methods required for tackling problems on relative motion. Students seemed to manage their time very well with very few incomplete scripts seen.

## Question 1

The responses to part (a) were very good. Almost all students were familiar with the kinematics equations for the motion of a projectile from a horizontal plane. A small number of students took a less direct approach by finding and using the angle of projection. Almost all students gained the method mark in part (b) by substituting $4$ for $x$ in the equation of the trajectory. But most students gave the height of the point $A$ above the point $O$ rather than above the surface of the tennis court. All students were able to answer part (c) with the exception of a small minority who stated that the ball was a particle.

## Question 2

This question was answered well by a great majority of the students. A minority of the students were unable to correctly state and use the dimensions of the impulse. All students correctly expressed the dimensions of the physical quantities in terms of $\mathrm{M}$, $\mathrm{L}$ and $\mathrm{T}$ rather than in terms of the units $\mathrm{kg}$, $\mathrm{m}$ and $\mathrm{s}$.

## Question 3

In part (a) it was pleasing to see that almost all students understood how to find the impulse of a variable force. No students used the alternative method. In part (b) apart from a very small minority of students who could not write a valid impulse-momentum equation, scoring full marks here was very common. Some students were able to benefit from follow-through marks here. Part (c) was answered quite well. Only a small number of students gained no marks for this part-question by using one momentum term, viz. $0.5\times 20$, in their impulse-momentum equation. Some students chose to integrate the acceleration and used the correct boundary conditions to arrive at the quadratic in $\mathrm{T}$. Very commonly students solved their quadratic equation by correctly factorising it.

## Question 4

The great majority of students were able to answer part (a) correctly. There were different approaches to find the relative velocity but the most common approach was finding the velocities of $A$ and $B$ and then subtracting the latter from the former to find the required answer. However, a small number of students made errors when they tried to divide each displacement vector by $0.5$.

Almost all students were familiar with the form $\mathrm{r} = \mathrm{r}_0 + A^v B^t$ and they answered part (b) very well.

Most students who answered part (c) correctly used differentiation. The common method of differentiation seen was using the chain rule. A minority of students who expanded the brackets in order to differentiate the resulting polynomial made errors in simplifying their expression. Some students were able to gain full marks by correctly using the scalar product of the relative position vector and the relative velocity to answer this part. Part (d) was answered well. Some students were able to score a follow-through method mark.

## Question 5

In part (a) to gain both marks here, the students needed to state that the component of the velocity parallel to the plane did not change and justify this by referring to the smoothness or to the lack of friction parallel to the plane. Many students scored only one mark because of giving an insufficient reason. Many students showed lack of clear understanding of what was required in part (b) and they were not able to find the correct components. Many students who were successful in part (b) were able to proceed well and answer part (c) correctly. Very few students made sign errors in their equations but a significant number used the wrong component of the acceleration.

## Question 6

Almost all students in part (a) understood that the velocity of $A$ perpendicular to the line of centres did not change after the collision and many scored full marks. However, having found the component of the velocity of $A$ parallel to the line of centres after the collision, some students did not proceed any further to find the required speed. The answer in surd form or correct to three significant figures were both acceptable.

Many students lost the accuracy mark in part (b) because of not giving the answer to the nearest degree. Some students were able to score the method mark as a follow-through mark from their work in part (a).

Generally part (c) was answered very well and again some students were able to score the method mark as a follow-through mark.

Most students in part (d) considered the change in momentum of *B* due to the collision. But a very small number of students used the mass of $A$ instead of the mass of $B$ and scored zero. A similar proportion of students lost the accuracy mark because they gave the impulse rather than giving its magnitude as requested.

## Question 7

Part (a) was answered very well. Only a very small number of students scored zero because of using the mass of $B$ instead of using the mass of $A$.

Many students in part (b) were able to gain full marks for this part. A very small number of students made a sign error when applying the law of restitution.

Follow-through method marks were available in part (c) for students using their incorrect ${}^{v}B$ from part (b). To find the time taken by $B$ to collide with the wall, a small number of students divided $s$ instead of dividing $s$-$r$ by ${}^{v}B$.

Part (d) proved to be too challenging for the great majority of students. Many students who found the speed of $B$ after rebounding from the wall appreciated that $A$ and $B$ were moving towards each other with the same speed but they were unable to use the appropriate mathematics to follow this idea through to its logical conclusion. The majority of students who were successful here first subtracted $3r$ from the distance given in part (c), they then halved the resulting expression and finally added $r$ to arrive at the correct answer.

## 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** www.aqa.org.uk/umsconversion