A-LEVEL

Mathematics

Mechanics 3
Report on the Examination

MM03
June 2015

Version: 1.0

General Comments

The paper provided sufficient challenge for the most able candidates, whilst allowing the weaker candidates to demonstrate basic skills. There were many excellent responses to the paper. A high proportion of candidates attempted all of the questions with confidence, demonstrating sound grasp of the relevant knowledge and skills but some parts of the paper proved to be too demanding for some candidates. Some candidates lacked the ability to use a geometric approach to deal with questions on relative motion. The great majority of the candidates showed an understanding of the principle of conservation of linear momentum and of the experimental law of restitution.

There was no evidence of lack of time for candidates to answer all of the questions.

Question 1

This question was answered generally very well. Candidates were familiar with the concept of dimensional analysis. Some candidates made mistakes because they did not carry out the step of collecting indices for the right hand side of the equation. There were cases where candidates used M instead of L for the dimension of length or distance. A small minority of the candidates used kg, m and s instead of using M, L and T respectively.

Question 2

(a) Almost all candidates were familiar with the equations of motion of projectiles and they were able to use them to show the given equation of the trajectory of the projectile.

(b) (i) Most candidates interpreted the context of the question correctly in relation with the given co-ordinate axes and they were able to make the appropriate substitutions into the equation of the trajectory. However, a significant number of candidates substituted s for both x and y in the equation of the trajectory instead of s for x and $-s$ for y respectively.

(ii) This part proved more challenging for some candidates. Those who answered this part correctly were able to find the vertical component of the velocity of the projectile at the instant of reaching *B*. These candidates understood that the horizontal component of the velocity was constant ($21\cos 55^\circ$) throughout the motion of the projectile. These candidates were then able to use trigonometry to find the required angle. Some candidates lost an accuracy mark for not giving the answer to the nearest degree. A small number of candidates used calculus to find the gradient of the tangent to the trajectory at the point *B* and hence find the required angle.

Question 3

(a) The majority of the candidates who answered this question correctly used Pythagoras' theorem to write a correct equation for the speeds. There were many incorrect answers to this question. The common mistake was attempting to find a change in momentum without paying attention to the direction of its constituent parts [e.g. 0.5(5)-0.5(3)]. Only a small minority of the candidates used a vector equation to find the required impulse.

(b) It was rather surprising to see that some of the candidates who had not answered part (a) of the question correctly were able to answer this part of the question correctly. The candidates who answered this part correctly understood that the speed of the disc parallel to the wall did not change after the application of the impulse.

Question 4

(a)(i) This question was well attempted with many candidates scoring full marks. Candidates were able to use the principle of conservation of linear momentum and Newton's experimental law correctly to answer this part of the question.

(ii) The majority of candidates lost one mark here because they gave a negative result for the speed of *A* immediately after the collision.

(b) Many candidates were able to use the conservation of linear momentum and Newton's law of restitution correctly for the spheres *B* and *C*. Most of these candidates were able to solve the two equations simultaneously to find the speed of *B* after the second collision. However, many candidates were unable to write a correct inequality between the speeds of *A* and *B* which was necessary and sufficient for a second collision. Some candidates' inequalities were based on the need for *B* to travel in the same direction as *A* for a second collision. These candidates failed to appreciate that this was a necessary but not a sufficient condition for a second collision.

(c) To gain full marks here, candidates needed to make a comment about the spheres' having equal radii and their velocities being parallel to the line of centres. The great majority of candidates only commented about the smoothness of the spheres and the surface which did not score any marks.

Question 5

A great majority of candidates were able to consider motion along the line of centres and write correct momentum and restitution equations. Many of these candidates were able to solve their equations to find the velocities of *A* and *B* along the line of centres after the collision. Most of these candidates then proceeded to find the speeds of *A* and *B*. However, a small number of candidates did not go any further than giving the velocity components along the line of centres.

A small number of candidates did not gain any marks for this question as they considered motion perpendicular to the line of centres. These candidates did so perhaps because the sine of the angles α and β were given in the question.

Question 6

(a)(i) Many candidates used the sine rule correctly to find one angle and one bearing but failed to identify the second angle and the bearing associated with it. Some candidates did everything correctly but failed to give the bearings to the nearest degree, thereby losing one accuracy mark. A small number of candidates gained full marks by using a scalar product method (not in the specification).

(ii) Many candidates were able to identify their angle for the shorter time for the frigate to intercept the ship. It was also acceptable for candidates to use both angles and choose the shorter time from their working. Most candidate used the sine rule to find the speed of the frigate relative to the ship and then used distance over speed to find the required time.

(b) This part proved too difficult for the great majority of candidates. These candidates often used an incorrect right-angled velocity triangle or a non-right-angled velocity triangle to attempt to answer this question. The most common answer given by candidates was 28.9 kmh^{-1}.

Question 7

(a) Evidently, some candidates failed to recognise that the angle α was above the horizontal and not above the inclined plane, even though this information was printed in bold in the stem of the question. Almost all candidates were familiar with the kinematics of motion on an inclined plane. Most candidates set the perpendicular height of the particle above the plane to zero to find the time taken by the particle to travel from *O* to *A*. A small number of candidates set the velocity of the particle perpendicular to the plane to zero to find the half-time and then they doubled that to give the required time. There were many correct responses to this part of the question.

(b) This part proved too challenging for many candidates. The key here is the statement that the particle is moving horizontally (and not parallel to the plane) when it strikes the plane at *A*. Because of the misinterpretation of this situation, many candidates were not able to answer this part correctly. The most common answer seen here was $\tan\alpha = \tan\theta$. The candidates who answered this part correctly and efficiently considered the horizontal component of the velocity of the particle and set this to zero. There were other candidates who were able to gain full marks here by considering the components of the velocity of the particle parallel and perpendicular to the plane and relating these to $\tan\theta$.

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