Examiners' Report
Principal Examiner Feedback

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General Intoduction

The majority of students made a strong start in their solutions to this paper and were able to demonstrate their skill and understanding of the topics covered. Most students offered solutions to all seven questions, but a minority offered no attempt at some or all parts of some questions, usually 5 and 7(c). Many students scored highly in questions 1, 2, and 3, but there was a much greater spread of marks for the remaining questions.

The best work was clearly set out and well explained. Students should be aware that if they misuse a formula, and their working does not include a correct statement of the formula they are trying to use, then they will gain no credit. Similarly, students who use a calculator to integrate or solve equations need to be particularly careful - if they show no evidence of method and they give an incorrect answer then they will score no marks.

A clearly labelled diagram improves the clarity of the solution and can help the candidate to avoid using the same name for more than one variable.

Several students are still losing marks through inappropriate accuracy in their final answers - as stated in the rubric, after the use of 9.8 as an approximate value for g, the final answer should be given to either two or three significant figures.

Reports on Individual Questions:

Question 1

This proved to be an accessible start to the paper for the vast majority of the students, with many achieving full marks. Very few students misquoted the impulse - momentum formula. The most common reason for losing marks was a sign error or an algebraic slip in finding the velocity of the ball after receiving the impulse. In attempting to find the gain in kinetic energy, a small number of students substituted the velocities in the wrong order or attempted to square vectors in order to find the kinetic energy. A few students used the incorrect formula $\frac{1}{2}mv$ for kinetic energy.

Question 2

This question was a good source of marks for students who worked through with care and considered the significance of the factorised form given for v.
(a) Many students scored full marks here, but there were several errors in multiplying out the brackets before differentiating.

(b) Those students who did not recognise that the particle changed direction when $t = \frac{1}{2}$ scored at most two marks here. Although this is a very straight forward function to integrate, several students gave answers with no evidence of working. Many of these gave the incorrect final answer $\frac{1}{6}$ and therefore scored no marks at all. Students who sketched a diagram of the given quadratic recognised the need to use the absolute value of the integral. A few students gave a negative value for the final answer, not recognising that the distance travelled must be positive. A small number of students attempted to use *suvat* equations, and scored no marks.

Question 3

(a) There were many fully correct solutions to this part of the question. The most common approach was to subtract the smaller triangle from the surrounding rectangle; although splitting into two rectangles and one triangle was also very common. An occasional attempt was made to find the centre of mass of a trapezium, but this was rarely successful. The most common errors were in the mass ratios, or in finding the centre of mass of the triangle.

Occasionally the a was missing in the final answers.

(b) This part of the question proved to be more challenging, and some students offered no attempt at all. A clear diagram was often a key part of a successful solution. Once the correct triangle was identified, most students worked their way to the required angle successfully. Those who used the cosine rule often made slips in their working.
The most common error was to assume $\tan\alpha = \dfrac{6a - \bar{x}}{6a - \bar{y}}$ or $\tan\alpha = \dfrac{\bar{x}}{\bar{y}}$. Some students formed a triangle using points C, B and the centre of mass but then assumed, incorrectly, that this was a right-angled triangle. The question asks for the answer to be given to the nearest degree, but some students did not notice this.

A very rare, but efficient, method was to use scalar product to find the angle.

Question 4:

(a) A clear diagram showing the directions of motion of both particles before and after the collision was often the key to success here. The students were clearly familiar with considering conservation of momentum and the impact law, but there were many errors in setting up and solving these equations. Several students used inconsistent signs for the directions of the particles in their two equations. The speed of approach of P and Q was often given as $2u$. Some students had the two particles passing through each other as a result of the collision. Many students did obtain correct expressions for the velocities of P and Q after the collision, but it was very common to lose at least one mark for not giving the speeds of the two particles.

(b) The most efficient way to answer this was to start with an inequality relating to the velocity of P. Many students simply substituted a couple of values for e, rather than consider a general argument. Some students stated a correct inequality but did not explain how this confirmed the required result.

(c) Several students used f to obtain a correct expression for the speed of Q after impact with the wall and went on to set up a correct inequality for the second collision to occur. A common error was to omit the upper bound for f in the final answer. A minority of students did not understand the condition for the second collision and went on to form a pair of equations to determine the velocities of P and Q after their second collision.

Question 5

(a) A significant number of students did not attempt this question at all. For those that did, taking moments about A was the only method seen. This often resulted in the correct answer. A surprising number of students did not use the right angle between the radius and the tangent of the circle, which led to many errors in the distance from A to the point of contact between the rod and the cylinder, the most common being $13b$. A small number of students did not understand that the reaction at the point of contact was perpendicular to the rod. Other errors included the occasional use of Wg for the weight and confusion between sine and cosine.

(b) There were several concise, correct solutions, but also many blank responses. The most common, and most successful, approach here was to find the vertical and horizontal components to the resultant force by resolving horizontally and vertically. Most students used two separate components for the reaction at A, but the occasional use of the resultant reaction resolved with α was also successful. The most common cause of confusion was to assume that the angle between the rod and the horizontal was also α.

Attempts to find the components of the reaction at A perpendicular and parallel to the rod were mostly incorrect, often missing terms or involving incorrect resolving. Few of those who obtained the correct components were able to proceed any further.

Some students attempted to take moments at various points on the rod, but they did not obtain enough independent equations to reach a conclusion.

Question 6:

(a) This was a good source of marks for many students. A clearly labelled diagram helped to avoid confusion between masses and forces. Almost all students understood the relationship between the driving force and the rate of work of the engine. Most students formed a combined equation of motion for the car and the trailer, but the alternative using separate equations was seen. The most common errors in the equation of motion were confusion between weight and resistance, and omission of one or more terms from the equation. At the very end, some students did not express their final answer in kilowatts, and several made errors in dividing by 1000.

(b) This part of the question did not depend on a correct solution to (a) and there were several fully correct solutions. The common errors were to quote a dimensionally incorrect equation, usually by using an incorrect expression for the kinetic energy, or by using 200 rather than $200d$. The gain in potential energy was often included twice, once as gain in potential energy, and once as work done against the weight. Some students tried to write down an equation for the system as a whole, not just for the trailer. The final mark was often lost for given the answer to more than three significant figures.

Question 7

(a) This was a well known piece of theory, and completed successfully by many students. The most common error was a sign error in the equation for the vertical distance. Some students did not explain the step from $\frac{1}{\cos^2\alpha}$ to $1+\tan^2\alpha$.

(b) This was often done well. Many recognised the need to use Pythagoras' theorem with U as the horizontal speed but a surprising number did not use $U_y = 0$. A minority of students considered energy but did not complete their solution correctly. Some overlooked the requirement for an expression in U, g and T and gave an answer containing h.

(c) Very few students made any significant progress with this part of the question. Only the strongest students were able to combine the information about the two options for projection correctly. Several students were able to form an equation for the path of the second projectile, either by using the result from part (a) or by working from first principles. This equation often started with a sign error, with h in place of $-h$. The common error was to assume that the time taken for both projectiles was the same, so the majority did not use $d = UT$ or $h = \frac{1}{2}gT^2$ from the information about the first projectile.

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