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Examiners' Report
Principal Examiner Feedback

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WME02 Examiners' Report

This paper offered well-prepared candidates an opportunity to demonstrate their understanding of the syllabus, containing many questions of a familiar style. The candidates showed a good general understanding of the material studied, with more than half gaining full marks in questions 1, 2 and 4. What some of them appeared to lack was the experience of extended practice and problem solving – many solutions were longer and more complicated than necessary.

Candidates should not overlook the importance of basic arithmetical and algebraic skills – many marks were lost in solving equations after the mechanics had been applied correctly.

In calculations the numerical value of g which should be used is 9.8 m s^{-2}. Final answers should then be given to 2 (or 3) significant figures – more accurate answers will be penalised, including fractions.

If there is a given or printed answer to show, as in questions 3(a) and 4(a), then candidates need to ensure that they show sufficient detail in their working to warrant being awarded all of the marks available and in the case of a printed answer, that they end up with **exactly** what is printed on the question paper.

As usual, the best solutions comprised clearly set out work, with an explanation of what the candidate was trying to do. A candidate who says what they are trying to do, but makes a slip, is more likely to gain credit for the work than a candidate who leaves the examiner guessing what an equation represents. In all cases, as stated on the front of the question paper, candidates should show sufficient working to make their methods clear to the examiner and correct answers without working may not score all, or indeed any, of the marks available.

If a candidate runs out of space in which to give their answer than they are advised to use a supplementary sheet – if a centre is reluctant to supply extra paper then it is crucial for the candidate to say whereabouts in the script the extra working can be found.

Question 1

(a) There were many fully correct responses. Some candidates used $m\mathbf{u} - m\mathbf{v}$ in place of $m\mathbf{v} - m\mathbf{u}$ but this was accepted as the question requires the magnitude of the impulse. Some candidates stopped at $\mathbf{I} = 0.6\mathbf{i} + 2.1\mathbf{j}$, either forgetting to use Pythagoras, or simply not realising that they needed to. A minority of candidates found the magnitude of $7\mathbf{i} + 7\mathbf{j}$ before attempting to find the impulse.

(b) There were many fully correct solutions. Most solutions contained $\tan\theta = \frac{2.1}{0.6}$. A few started with $\tan\theta = \frac{0.6}{2.1}$, which is a relevant angle, but they did not all go on to find the required angle. Some candidates found the angle between the impulse and the wrong velocity. Most responses used the tangent of an angle, but a few used the scalar product of the two vectors.

Question 2

The candidates showed confidence with this topic and there were many fully correct solutions. Only a minority tried to make inappropriate use of the *suvat* equations.

(a) The integration was usually performed correctly. Some errors were made when substituting $t = 2$ and some candidates forgot to use the given boundary conditions to find the constants of integration. After correct work, there were several errors in simplifying to obtain the position vector.

(b) There were a lot of fully correct solutions. The most common errors were due to placing -2 on the wrong side of the equation, or to equating the given velocity to $\mathbf{i} - 2\mathbf{j}$. Some candidates introduced a variable to represent the ratio – this usually worked successfully, but it involved more work.

(c) Here again, there were many fully correct solutions. There were a few slips in the differentiation, and a few in substituting $t = 2.5$. The question requires an exact answer, so candidates who only gave the decimal equivalent did not score the final mark. Others, having correctly obtained $\mathbf{a} = 15\mathbf{i} - 10\mathbf{j}$, went on to use Pythagoras incorrectly, calculating $15^2 - 10^2$ instead of $15^2 + 10^2$.

Question 3

(a) This was, by far, the least successful question on the paper, with many candidates struggling to find a method of solution. Dozens of methods were seen, many of which were convoluted and poorly explained. Dissections were often very unclear, as was a lot of the working. For those candidates who did make a legitimate attempt, most took moments about *PQ* – a sensible choice because *d* is measured from that line. There was also a good awareness of where the centre of mass of a triangle lies. However, many did not see the question as involving just the two triangles. Those who used a trapezium were expected to use, or to attempt to find, the correct position of its centre of mass. Several responses falsely stated that the centre of mass of the trapezium was $1.5y$ from *PQ*, with no justification.

(b) Several of the candidates who scored no marks in part (a) were able to use the given result to score full marks here. Many used the symmetry of the figure to obtain the distance of the centre of mass from *P*, but there were several who chose to use a second moments equation. The use of 3*x* in place of 2*x* was a common error.

Question 4

(a) In order to obtain the given answer, it is necessary to use the impulse. Some candidates started with a correct equation for the impulse on *P* and obtained the result very quickly. Candidates who started with an equation for the impulse on *Q* needed to form a second equation in order to eliminate *k*. Some candidates started by writing down the equation for conservation of momentum, but they scored no marks until they also had an equation for the impulse on one of the particles. There were several sign errors, and candidates usually went on to "fudge" the given answer rather than find the source of their error.

(b) Most candidates used the equation for conservation of momentum, but a second use of the impulse was common. Sign errors were also common.

(c) The majority of candidates applied the impact law correctly for their value of *k*. A minority offered no solution, or applied the impact law the wrong way round. Those candidates who remember the impact law as a formula, rather than as a relationship between speed of separation and speed of approach, were more likely to make sign errors.

(d) Most candidates scored a mark for using an appropriate expression for the total loss of kinetic energy. However, errors were often made when substituting their values and / or simplifying them. Some candidates used $\frac{1}{2}m(v-u)^2$ instead of $\frac{1}{2}mv^2 - \frac{1}{2}mu^2$, and some considered only one particle. Some used *m* in place of 3*m* and 5*m*.

Question 5

(a) Most candidates took moments about *A* in order to find the normal reaction between the beam and the wall. Apart from confusion between sine and cosine, the common error was to leave out the term for the friction acting at *B* or to have it acting in the wrong direction (suggesting a lack of understanding). Nearly all produced equations that were dimensionally correct. A few assumed the required reaction was perpendicular to the beam rather than the wall. A correct answer rounded to 2 or 3 significant figures was required for the final mark following the use of $g = 9.8$ ms^{-2}.

(b) The most straight-forward approach was to resolve vertically and horizontally, then use the answer from part (a) in combination with $F = \mu R$ to deduce the value of μ. An incorrect answer from part (a) could score all except the final mark here. The minority who chose a more difficult route such as using moments about B or resolving parallel and perpendicular to the beam were often less successful. A common error was to obtain the answer $\mu = 0.131$ rather than 0.13 or 0.130: this was usually as a result of premature approximation earlier in the working.

Question 6

(a) Almost all candidates produced a correct equation of motion for the van travelling along a horizontal road and then used $P = Fv$ correctly to find the required speed.

(b) There were many correct solutions. The majority wrote down an equation of motion for the whole system, but some preferred separate equations for the van and the trailer. The most common errors were to omit g from the weight components, or not to resolve these components. An answer to 2 or 3 significant figures was required following the use of $g = 9.8\,\text{m s}^{-2}$, so those who gave their answer $\frac{73}{160}$ did not score the final mark.

(c) This part of the question proved to be more challenging. The work-energy principle was specified in the question so any solutions using constant acceleration formulae gained no credit. The common errors in the work energy equation were to miss out the work done against resistance or to include the change in GPE and the work done against gravity as two separate terms. Some equations used 900 kg or 1600 kg in place of 700 kg for the mass, and some omitted the distance from the formula for work done against resistance.

Question 7

(a) Most candidates followed the question and considered energy to find the speed with which the ball hit the ground. Those who used a *suvat* method gained no credit. As the working requires the use $g = 9.8\,\text{m s}^{-2}$ those who left the answer as a surd did not score the final mark.

(b) There were various approaches seen for finding the direction of motion. It was acceptable to give this as an angle with the horizontal or vertical, or as a vector. The simplest method was to use the horizontal component of the velocity and the answer from part (a), but many preferred to find the vertical component of the velocity at the ground and then used trig to calculate an angle. It was required to state a conclusion about the direction in words or using a diagram. Those who chose to give their answer as a vector usually did so correctly.

(c) There were many correct solutions for the time to travel from A to B. Most candidates used a single *suvat* equation for the vertical motion, but some preferred to find the time to the maximum height and add that to the time from the maximum height to the ground. Some candidates confused the speed and the vertical component of the velocity.

(d) This part of the question proved to be more challenging. Those who used a scalar product to find the perpendicular velocity were usually successful. Some assumed that the vector perpendicular to $3\mathbf{i} + 2\mathbf{j}$ was $3\mathbf{i} - 2\mathbf{j}$, and some others did not use the fact that the horizontal component remains unchanged. Those who attempted to use angles often got confused about exactly what they were finding. A few who reached a correct answer for the displacement from *A* did not go on to subtract their answer from 20 to find the required height.

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