Examiners' Report
Principal Examiner Feedback

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In Mechanics M1 (WME01) Paper 01

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General

The paper seemed to work well with the majority of candidates able to make attempts at all eight of the questions. There was some evidence of time issues on the last question for weaker candidates, but it wasn't always clear whether they had run out of time or run out of ideas. There were some excellent scripts but there were also some where the standard of presentation left a lot to be desired. This, in some cases, made it difficult for examiners to follow the working.

Question 1 was by far the best answered question, with 73% of candidates able to score 4 of the 5 marks available. Question 4 was by far the worst with nearly half unable to score. Interpreting which parts of the motion were involved in the first two parts of Question 5 also caused severe problems making it the second worst. The remainder of the questions all performed at a very similar level.

In calculations the numerical value of g which should be used is 9.8. Final answers should then be given to 2 (or 3) significant figures – more accurate answers will be penalised, including fractions but exact multiples of g are usually accepted.

If there is a given or printed answer to show, as in 3(a) and 6(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.

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 his/her answer than he/she is 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 is going to be done.

Report on individual questions

Question 1

Part (a) was well answered with most candidates applying the Conservation of Linear Momentum to the whole system. This usually led to a correct equation and correct value for the final speed. So long as the ratio of masses was maintained, then the equation was acceptable. Occasionally candidates formed an equation by equating the two impulses. Common errors were mainly sign related or using incorrect mass ratios. Candidates need to be reminded that the final answer needed to be positive as speed was required.

Part (b) was also well done with many candidates gaining 2 or 3 marks here out of the 3 available. Successful candidates tended to apply the Impulse-Momentum principle to one of the trucks. In this part the allowable values for the masses were 20000 or 30000 or 20 or 30 leading to acceptable answers of 48000 or 48. However the final mark required 48000 together with the correct units of Ns or kg m s^{-1}. Errors here included including g, incorrect signs and units.

Question 2

In part (a), a significant number of candidates did not appreciate that the tension in the string at C would be zero and so were unable to make any progress. A few assumed equal tensions or two unknown tensions and some candidates confused themselves with poor notation by using m or M for both masses, leading to errors. Candidates were far more comfortable with part (b) as this was a 'conventional' moments problem and there were many correct solutions, usually by taking moments about D. The most common errors were on signs and inconsistent use of g. A number of scripts seen gained full marks in part (a) with nothing in (b), or vice versa. It was very rare to see correct solutions in either part when candidates chose to use two simultaneous equations.

Question 3

Part (a) was a 'Show that' question and so candidates were expected to provide a complete set of reasoned accurate statements which support the argument, together with a correct conclusion. There were a variety of approaches used. Some candidates resolved parallel to the plane producing a correct equation, leading to $F = 0$ and a conclusion that there was no frictional force. Others implicitly assumed $F = 0$ and then showed that this led to $X = 14.7$ However, those adopting this approach often did not have a clear valid explicit conclusion and lost the final mark. Candidates who used an angle approximation for α, say 36.9°or 37° had not used accurate statements and were penalised as were those who used $g = 9.81$ instead of 9.8. Some candidates produced an expression for the normal reaction in this part, which was not required.

In part (b) the most common approach was to resolve parallel to the plane and perpendicular to the plane to produce two equations and then use $F = 0.5R$ to find the value of X. A few candidates resolved vertically and horizontally. The most common error was having the frictional force acting down rather than up the plane. Other errors included sin/cos confusion, an incorrect value for g and use of a non-zero acceleration.

Question 4

In part (a), many candidates attempted an equation of motion for the lift but omitted the reactions from the two occupants.

In part (b), most realised that they needed an equation for Alan but many just equated the reaction to the weight, ignoring the fact that the lift was accelerating or equated it to ma, ignoring the weight. Those who carried forward an incorrect answer from (a) could achieve two out of the three available marks and a fair number did so.

A few candidates produced "*a correct answer" in part*" (a) by using the weights rather than the forces acting on the lift.

Question 5

Candidates would be advised on these types of questions to make greater use of diagrams when analysing he information and to think clearly about which parts of the motion are involved at each stage.

Part (a) required candidates to deal with the motion when the ball had a speed of less than 14.7 m s^{-1}. Successful candidates realised that this is the top section of the vertical trajectory. Some found the distance from the top down to when the speed was 14.7 m s^{-1} and then, using the symmetry, doubled it. Other methods involved finding the times taken to reach a speed of 14.7 m s^{-1} going up and then down, with an initial speed of 29.4 m s^{-1}, then using these times to find distance to the top and back. Others found the distance from the start to reach a speed of 14.7 m s^{-1}, then distance to the top, found their difference and doubled.

Part (b) required candidates to deal with the motion when the ball had a speed of more than 29.4 m s^{-1}. Successful candidates realised that this was the section of the motion from when the ball passed *A*, on the way down, down to the ground. So, using the symmetry, the question becomes how long does it take a particle, with an initial speed of 29.4 m s^{-1} downwards to travel 19.6 m? Some found the time to return to *A* and the total time taken to travel initially from A to the ground and then found the difference. Others found the speed when it reached the ground and then found the time to travel the last section of the motion.

In part (c), a *speed time* graph was required not a *velocity time* graph. So successful candidates produced a "v" shaped graph, with equally inclined gradients and the second section longer than the first part. The graph needed to include a starting point of 29.4 on the line, passing through the point with coordinates (3, 0). Often a straight line was produced, as if it were a velocity time graph, and some students still mistakenly drew a continuous vertical line at the final end of the graph (a dotted line would be acceptable).

Question 6

In part (a), although the vast majority of candidates achieved the first mark for adding the two forces and collecting **i** and **j** terms, some went on to *equate* coefficients with those of the parallel vector, proceeded to solve the resulting simultaneous equations and achieved no further credit. The majority, however, did realise that the coefficients of **i** and **j** are in the *same ratio* for parallel vectors and correctly used this to derive the given expression. Some used a constant to set up two simultaneous equations. Others set the resultant force equal to $0.5a$ at the start, but then went on to form and solve a correct ratio. Since candidates were asked to show a printed answer, in order to achieve the final mark, it was important that the final expression was written in *exactly* the form stated and followed from entirely correct working.

In part (b) there were some good solutions seen. Virtually all found a value for *q* and then deduced a correct resultant force. There was sometimes confusion as to whether a particular vector represented a force, an acceleration or a velocity, and the initial velocity was not always taken to be zero. Of those who completed a correct solution to find the velocity, a few failed to use this to find the speed as required.

Question 7

In part (a), many wrote down an equation of motion for *P* and an equation of motion for *Q* and used $F = \mu R$ to obtain $F = \mu mg$. A few used an equation of motion for the whole system. Then successful candidates were able to use their equations to find *k* in terms of μ. Common errors were incorrect signs and algebraic slips and a significant number found μ in terms of *k*.

Part (b) proved to be more challenging, and the question asked for an answer in terms of *d*, *g* and μ. Those candidates who included *k* were penalised. In this part most used their work from part (a) to form an expression for the acceleration of the system, but only a few were able to make further progress. Successful candidates needed to use a complete *suvat* method to find the required time. Many left their final answers in unsimplified algebra, but credit was given if it was equivalent to the required answer.

In part (c), many candidates correctly stated that *P* or *Q* or the system would stay at rest and not move. However, the reasoning to support this was often overcomplicated or incorrect. Candidates needed to realise that the tension in the string would be less than the maximum friction or an equivalent statement involving acceleration etc.

Question 8
In part (a), almost all candidates found the correct speed from the given velocity vector but there were a few who just added 3 + 12 or gave the answer as 12.36.

Part (b) was generally well done. Most set up correct expressions for $\boldsymbol{r}_A$ and $\boldsymbol{r}_B$ but a few multiplied $(-9\mathbf{i} + 6\mathbf{j})$ or $(16\mathbf{i} + 6\mathbf{j})$ by t. Occasionally the position vectors of A and B were added rather than subtracted to obtain **AB** and there were sometimes sign errors within the final expression. Most realised that they needed to compare their **AB** with the given expression, but a number of candidates omitted the minus sign from $-9\mathbf{j}$ or made a sign error when collecting terms so that t didn't cancel. A few found **AB** but didn't know how to proceed. However, many identified two correct equations in p and q and solved to find the correct numerical values.

Most who attempted part (c) were able to equate the magnitude of **AB** to 15 as required, leading to a quadratic in t. A small minority ignored the i and j and just added their coefficients but there were a few who subtracted $(9t)^2$ instead of adding. Errors in multiplying out brackets or failing to square the 15 sometimes led to an incorrect value for t. Not all realised that, to find the bearing, it was necessary to find **AB** (or equivalent). Several attempted to find the angle between **OA** and **OB**. Those who successfully used **AB** to find a relevant angle (generally using arctan) often failed to achieve the final mark by not identifying the actual required bearing or giving an over accurate answer instead of to the nearest degree.

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