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AS/A LEVEL GCE

Examiners' report

MATHEMATICS

3890-3892, 7890-7892

4728/01 Summer 2018 series

Version 1

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Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates. The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report. A full copy of the question paper can be downloaded from OCR.

Paper 4728/01 series overview

This AS Level Mechanics paper was taken predominantly by Year 13 candidates taking a full A Level in mathematics. As such, the level of mathematical competence was higher than usual, and more careful reading of the questions could have resulted in improved performance by many candidates.

Candidates generally performed well on questions 1 (constant acceleration equations of motion), 2 (cosine and sine rules or components of force) and 6 (calculus).

Candidates tended to not perform as well on questions 3 (iii), 4 (ii), 5 (ii) and 7 (ii). In Q3 (iii) the difficulty was in correctly finding the acceleration of the particle from two forces. Q4 (ii) posed a different situation than Q4 (i) which not all candidates took into consideration; they also did not successfully consider the physical movement of particle *B* after the collision. In Q5 (ii) the further motion of the lighter particle was often ignored and as Q7 (ii) was again a different situation from Q7 (i); this meant a fresh start was necessary in order to be successful at this part of the question.

Question 1 (i)

1 A small object moves with constant acceleration along a straight line from A to B. Its speed at A is $0.4\,\text{m s}^{-1}$ and its speed at B is $6.9\,\text{m s}^{-1}$. The object takes 2.5 s to travel from A to B.

(i) Show that the acceleration of the object is $2.6\,\text{m s}^{-2}$. **[2]**

Question 1 (ii)

(ii) Find the distance from A to B. **[2]**

Question 1 (iii)

(iii) Find the distance travelled by the object in the first 0.2 s of the motion. **[2]**

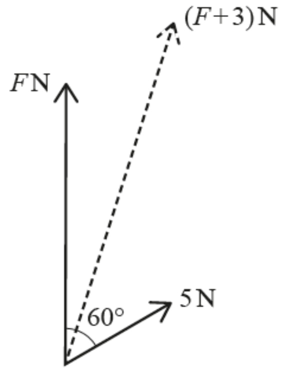
Question 1 (iv)

(iv) Find the distance travelled by the object in the final 0.2 s of the motion. **[2]**

This question was well answered and candidates who "corrected" exact decimal values by rounding to 3 significant figures were not penalised. Q1 (iv) was designed to test candidates' knowledge of the formula $s = vt - \frac{at^2}{2}$. About half the scripts had less direct solutions, the most popular being to calculate the distance travelled in the first 2.3 s, and subtract the total from the answer to Q1(ii).

Question 2 (i)

2



Two horizontal forces of magnitudes F N and 5 N act on bearings 000° and 060° respectively. The resultant of these two forces has magnitude $(F + 3)$ N, as shown in the diagram.

(i) Show by calculation that $F = 16$. **[4]**

Q2 (i) was usually well attempted, using the cosine rule correctly. The alternative approach using components was also successful, but less commonly used.

Question 2 (ii)

(ii) Calculate the bearing of the line of action of the resultant. **[4]**

In Q2 (ii) the simplest approach was to target the bearing angle directly, though those finding a different angle usually then went on to successfully find the bearing. Candidates who used the cosine rule in (i) very rarely employed it in (ii), much preferring to use the sine rule.

Question 3 (i) (a)

3 A particle P of mass 0.2 kg rests in limiting equilibrium on a plane inclined at $\theta°$ to the horizontal. The coefficient of friction is 0.3.

(i) State in terms of θ

(a) the magnitude of the component of the weight of P parallel to the plane, **[1]**

A significant number of candidates answered (i) (a) with an incorrect trigonometric ratio, possibly from those who confuse parallel, perpendicular, horizontal and vertical.

Question 3 (i) (b)

(b) the magnitude of the frictional force acting on P. **[2]**

Question 3 (ii)

(ii) Calculate θ. **[3]**

Q3 (ii) was often completed successfully by those who had made earlier mistakes.

Question 3 (iii)

P is now projected with initial speed $4\,\text{m s}^{-1}$ up the plane along a line of greatest slope.

(iii) Calculate the time for which P moves up the plane. **[4]**

Q3 (iii) presented unexpected difficulties. Newton's Second Law often lacked a force, while some candidates used a force (not an acceleration) in the formula $v = u + at$ to find the time to come to rest. Used correctly, the acceleration should be negative in this equation when the value for u is (positive) 4.

Question 4 (i)

4

Two particles A and B move on the same straight line on a smooth horizontal table. A has speed $6\,\mathrm{m\,s^{-1}}$ and is moving towards B. The speed of B is $2\,\mathrm{m\,s^{-1}}$ and B is moving in the opposite direction to A (see diagram). After A and B collide the speed of A is $3\,\mathrm{m\,s^{-1}}$ in its original direction of motion. The particles A and B have masses 0.5 kg and m kg respectively.

(i) It is given that $m = 0.2$. Find the distance between A and B at time 2 s after the collision. **[4]**

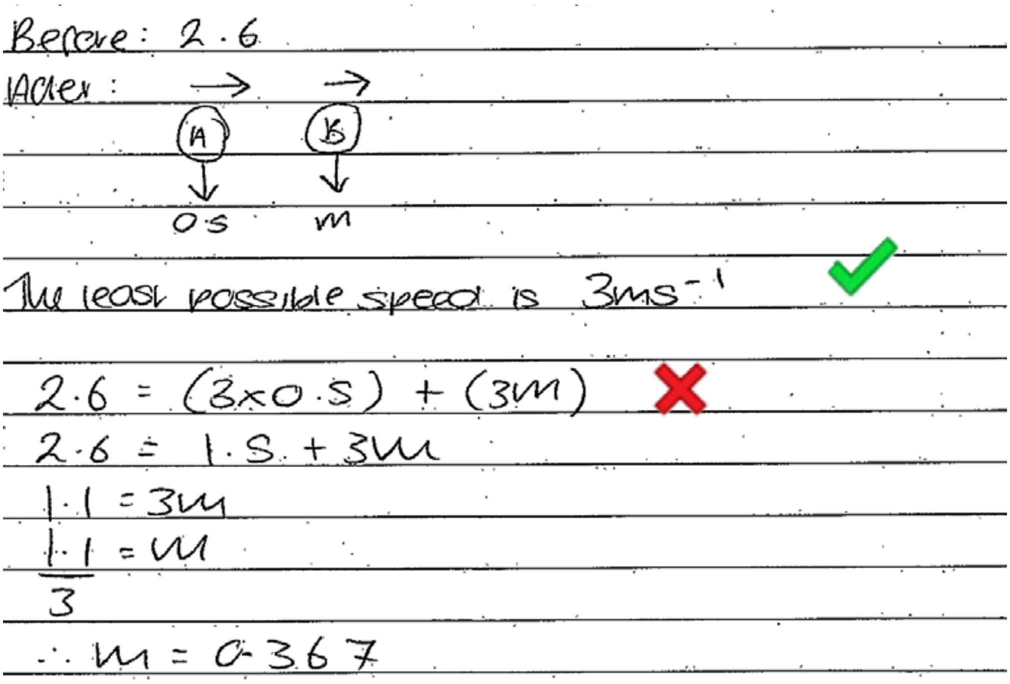
Q4 (i) presented few problems to candidates, until the request for the separation of the particles after 2 seconds. Some ignored this, while others chose excessively complex answers to a basically simple problem.

Question 4 (ii)

(ii) It is given instead that B moves with its least possible speed after the collision. State this speed, and hence find the value of m. **[5]**

It was Q4 (ii) which presented the first real test on the paper. Very many candidates re-used the value for "before" momentum employed in (i). More candidates ignored the physical reality of the situation described, and did not appreciate that *B* could not be at rest after the collision; its speed must be at least $3\,\mathrm{m\,s^{-1}}$. In few answers was this the initial statement, though the first thing requested.

Exemplar 1


Before: 2.6
After: → →
(A) (B)
0.5 m
The least possible speed is 3ms⁻¹
2.6 = (3×0.5) + (3m)
2.6 = 1.5 + 3m
1.1 = 3m
1.1/3 = m
∴ m = 0.367

This response correctly identifies the least possible speed after the collision as $3\,\text{m}\,\text{s}^{-1}$ and is credited the first B1 mark. The value of 2.6 is the "before" momentum from (i) which is incorrect as the mass of *B* is now not 0.2 kg but is a value to be determined. This results in the loss of the next B mark and the M mark, as momentum conservation has not been applied correctly for this situation. As the M mark is not earned, the A marks are not available.

Question 5 (i)

5 Two particles of masses 0.3 kg and 0.2 kg are attached to opposite ends of a taut light inextensible string which passes over a small smooth pulley. The particles are released from rest and move vertically.

(i) For the time while both particles are in motion, calculate the magnitude of the acceleration of the particles, and find the magnitude of the force exerted on the pulley by the string. **[7]**

This was the first of two connected particles questions on the paper. In the second all the motion is in the same direction, but in this earlier context, the particles move in different directions.

In (i) most candidates adopted the logical approach, starting with two separate equations of motion for the two particles. These were successfully solved, and – though not an explicit request – the tension in the string was found. The final 2 marks, for finding the force on the pulley, were credited in only a minority of cases. The problem was either overlooked, or the "obvious" response of 4.9 N given.

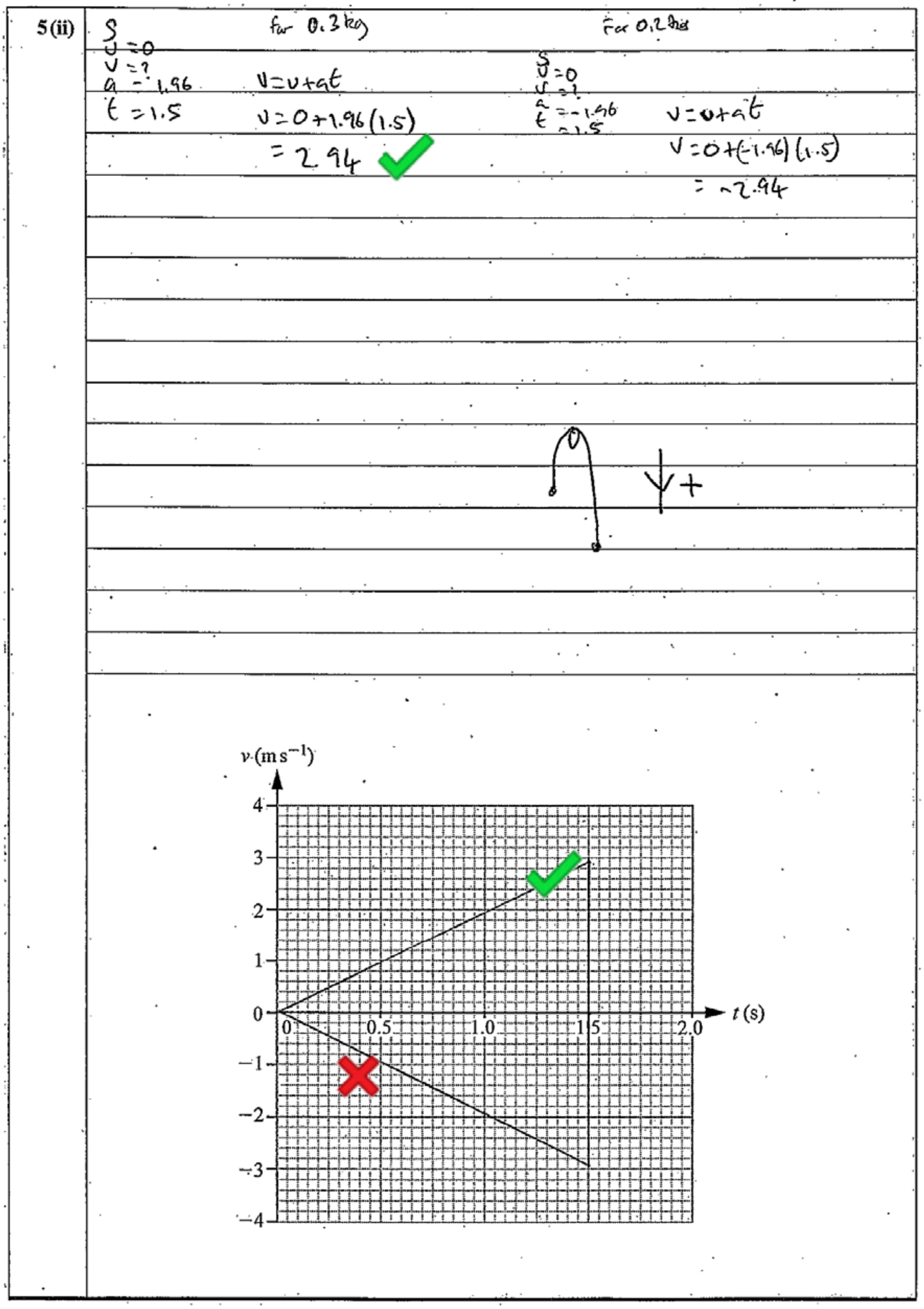
Question 5 (ii)

After the particles have been moving for 1.5 s, the particle of mass 0.3 kg reaches the ground and remains at rest. The particle of mass 0.2 kg subsequently comes to instantaneous rest at a point A below the pulley.

(ii) Draw the (t, v) graphs for the motion of the two particles from the instant of initial release from rest until the 0.2 kg particle reaches A. Show clearly all necessary calculations. **[5]**

Q5 (ii) was rarely credited with full marks. It was common for the continuing motion of the lighter particle (after the heavier hits the ground) to be ignored. Often the graph depicted the motion of only one particle. When candidates did draw graphs for both particles, the point (1.8, 0) was sometimes plotted at (1.65, 0) or (1.9, 0) by candidates who did not appreciate the scale of the horizontal axis. When candidates lacked a sharp pencil and/or a straight edge, it was unclear which point was being joined to the origin, and whether the graph was linear.

Exemplar 2



This response correctly identifies the speed of the heavier particle on reaching the ground as 1.94 m s^{-1} and is credited the first B1 mark, and a further B1 mark for drawing a correct (t, v) graph for this particle. The further motion of the lighter particle has been ignored and an incorrect graph drawn for this particle, resulting in the loss of M, A and B marks.

Exemplar 3

5(ii)

0.2kg ↓ : $u = 0$ $a = 1.96$ $t = 1.5$

$v = u + at$ ∴ $v = 1.96 \times 1.5$

$v = 2.94 \text{ ms}^{-1}$

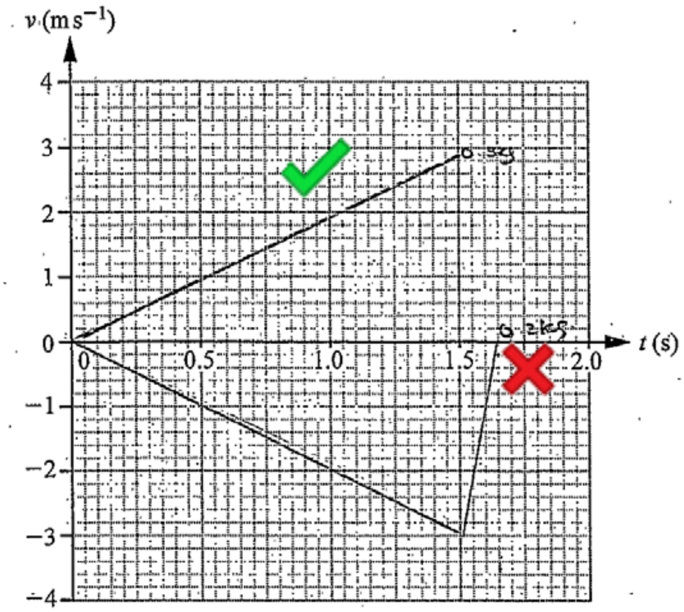
0.2kg ↑ : $u = 2.94$ $v = 0$ $-0.2g = 0.2a$

$a = -9.8$ $a = -9.8$

$v = u + at$

$0 = 2.94 + (-9.8)t$

$t = 0.3$



This response has correctly identified the motion of both particles and gains B1, M1 and A1 marks for their working. They also draw a correct (t, v) graph for the heavier particle to gain a further B1 mark. Their error when drawing the graph for the lighter particle is in plotting the point (1.8, 0) at (1.65, 0) and therefore the final B mark is not credited.

Question 6 (i)

6 A particle P moves in a straight line on a horizontal surface. At time t s the velocity of P is $v\,\text{m s}^{-1}$ and the displacement of P from a fixed point O on the line is x m. For $0 \leqslant t \leqslant 3$ it is given that $v = 2 + t^2$. The particle is at O when $t = 0$.

(i) Find x when $t = 3$. **[3]**

Question 6 (ii)

For $t \geqslant 3$ it is given that $x = a + bt + ct^4$, where a, b and c are constants.

(ii) Find expressions for the acceleration of P for each of the cases $0 \leqslant t \leqslant 3$ and $t \geqslant 3$. Hence, by considering the acceleration at $t = 3$, show that $c = \frac{1}{18}$. **[5]**

Question 6 (iii)

(iii) Find the values of a and b. **[4]**

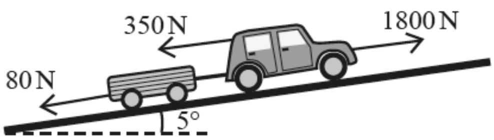
Question 6 (iv)

(iv) Calculate the value of t for which $v = 25$. **[2]**

It was apparent that nearly all candidates were familiar with calculus, and had a strategy for solving the question in full. Unexpectedly, it was incorrect powers of *t* which caused many errors in calculations.

Question 7 (i) (a)

7



A car and a trailer are moving together along a straight road up a hill inclined at 5° to the horizontal. The car has a driving force of magnitude 1800 N and a resistance to motion of 350 N. The trailer has a resistance to motion of 80 N. A light rigid tow-bar parallel to the road joins the trailer to the car (see diagram). The mass of the car is 1250 kg and the mass of the trailer is 150 kg.

(i) (a) Calculate the acceleration of the car and trailer. **[4]**

The simplest and most successful solutions were based on the notion that, since all motion is in the same direction, (i) (a) could be answered by considering a single object of mass 1400 kg. Nearly all answers paid full regards to the resisting forces of 350 N and 80 N. The components of the weights of the car and trailer were often omitted from the equation(s) of motion, or erroneously given as 1250sin5 and 150sin5. Some candidates lost a mark by giving the response for acceleration as 0.12 m s^{-2}. One unexpected error was adopting equations of motion for the two parts separately (without regards to tension) and finding different accelerations for the car and the trailer.

Question 7 (i) (b)

(b) Find the magnitude of the force in the tow-bar. **[3]**

Finding the magnitude of the force in the tow-bar in Q7 (i) (b) proved quite simple for most candidates. A rigid bar can transmit either a tension or a thrust, and some erroneous solutions might have been avoided if candidates had appreciated why the word "tension" had not been used.

Question 7 (ii)

On another occasion an object of weight W N is in the trailer when the car and trailer again move up the hill. The magnitudes of the driving force and resistance to motion of the car are unaltered. The resistance to motion of the trailer is increased by $0.05W$ N.

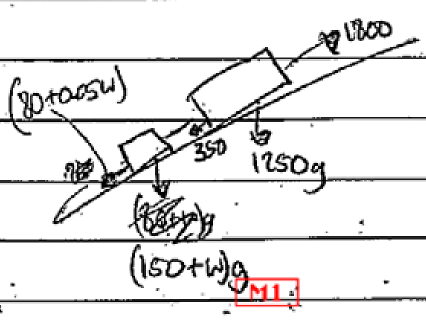
(ii) Calculate the value of W for which the car and trailer move at constant speed. **[4]**

Q7 (ii) was difficult to answer totally correctly. The new context meant that answers to (i) (a) or (i) (b) could not be used. Candidates were likely either to overlook the *W*sin5 component of the load put into the trailer, or include *g* with this term. A smaller number treated the extra resistance of 0.05*W* as a coefficient of friction, and created a force of magnitude 4*W* from $0.05W \times 80$.

Exemplar 4

7(ii)

Constant speed = when forward force = backwards force.



(Take as whole system (one object))

M1 M1 M1

$F_B = F_F$

$(80+0.05W) + 350 + (1400+W)9.8(\sin 5) = 1800$

$80 + 0.05W + 1400 \, 9.8 \sin 5 + W 9.8 \sin 5 = 1450$

$0.05W + W 9.8 \sin 5 = 1450 - 80 - 1400 \, 9.8 \sin 5$

$W(0.05 + 9.8 \sin 5) = 174.2$

$W = \frac{174.2}{0.05 + 9.8 \sin 5}$

$W = 192.698$ A0

$= 193$ N

On this response, the only error was to use *Wg*sin5 rather than *W*sin5 as the weight component of the load. This meant the 3 method marks were credited and just the final A mark was lost.

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