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AS LEVEL

Examiners' report

FURTHER MATHEMATICS B (MEI)

H635
For first teaching in 2017

Y411/01 Summer 2019 series

Version 1

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 Y411 series overview

Y411 is one of six available options. Candidates must take Core Pure (Y410) and then choose at least two of the optional papers to be credited AS Level in Further Mathematics B (MEI). Candidates are expected to know the content of AS Level Mathematics (H630) and Y410.

After a fairly easy start in Questions 1 and 2, this paper proved difficult for almost all candidates, with most questions having something to challenge even the most able.

	AfL	As in 2018, very few candidates took the trouble to include a description of what they intended to do in their solutions. For example, writing things like 'resolving perpendicular to the plane' in Question 3(a), or 'taking moments about A for the equilibrium of the rod' in Question 7 would make it clear what candidates are attempting to do, and possibly also help candidates as they work through the question.

Common mistakes were for candidates to miss some of the acting forces, for example when a box is on a slope as in Question 3 and when a car is travelling up an incline as in Question 5, so perhaps these questions should have posed less challenge than the scores suggest.

Whilst there were no questions using the bold statement '**In this question you must show detailed reasoning**' on this paper, the command words 'Show that' (Q2 (b)), and 'Determine' (Q2 (a), Q2 (d), Q3 (b) and Q6 (a)) were used to indicate that the response needed to include clear working for full credit. Although the command words 'Find' and 'Calculate' do not require supporting evidence for full marks to be awarded for a correct final answer, partial credit for correct working may be available where a final correct answer is not obtained.

	OCR support	A poster detailing the different command words and what they mean is available here: https://teach.ocr.org.uk/italladdsup

Question 1

1 A child is pulling a toy block in a straight line along a horizontal floor.
The block is moving with a constant speed of $2\,\mathrm{m\,s^{-1}}$ by means of a constant force of magnitude 20 N acting at an angle of $\theta°$ above the horizontal.

The work done by the force in 10 s is 350 J.

Calculate the value of θ. **[3]**

There were many completely correct responses to this question. Most candidates used 'Work done = Force × distance' and so showed a distance of 20 m, although a small number then wrongly used $F\sin\theta$ as the component of the force in the direction of motion. Some candidates answered this question by first working out a value for the power.

Question 2 (a)

2 The surface tension of a liquid allows a metal needle to be at rest on the surface of the liquid.
The greatest mass m of a needle of length l which can be supported in this way by a liquid of surface tension S is given by the formula

$$m = \frac{2Sl}{g}$$

where g is the acceleration due to gravity.

(a) Determine the dimensions of surface tension. **[3]**

Candidates are expected to know the dimensions of g. Those that did had little trouble with this part.

Question 2 (b)

Surface tension also allows liquids to rise up capillary tubes. Molly is experimenting with liquids in capillary tubes and she arrives at the formula $h = \frac{2S}{\rho g r}$, where h is the height to which a liquid of surface tension S rises, ρ is the density of the liquid, and r is the radius of the capillary tube.

(b) Show that the equation for h is dimensionally consistent. **[3]**

Most candidates knew the dimensions of density, and so were able to show convincingly that the dimensions of the right hand side of the formula were equal to those of the left (that is, L). Some candidates rearranged the formula at some point in their response and then showed that the rearranged sides had the same dimensions; this is quite acceptable. Candidate who did not know the dimensions of g, and so had the wrong dimensions for S in part (a), were allowed partial credit.

Question 2 (c)

In SI units, the surface tension of mercury is $0.475\,\text{kg}\,\text{s}^{-2}$ and its density is $13\,500\,\text{kg}\,\text{m}^{-3}$.

(c) Find the diameter of a capillary tube in which mercury will rise to a height of 10 cm. **[2]**

There were fewer completely correct responses to this question. Some candidates had the wrong order of magnitude, because they had substituted '10' (centimetres) rather than '0.1' (metres) into the formula for surface tension; others were wrong because they gave the radius of the tube, rather than the diameter. Partial credit was available to those who made either or both of these errors.

Question 2 (d)

In another experiment, Molly finds that when liquid of surface tension S is poured onto a horizontal surface, puddles of depth d are formed. For this experiment she finds that

$$d = kS^{\alpha}\rho^{\beta}g^{\gamma}$$

where k is a dimensionless constant.

(d) Determine the values of α, β and γ. **[4]**

Almost all candidates were able to set up this situation in terms of M, L and T, and most were able to give 3 simultaneous equations in α, β and γ. However, some candidates with the correct initial set up made errors in deriving the equations and some candidates with the correct equations were not able to solve them correctly. Partial credit was available to candidates who had earlier made errors in the dimensions of g, S or density.

Question 3 (a)

3 A box weighing 130 N is on a rough plane inclined at 12° to the horizontal.
The box is held at rest on the plane by the action of a force of magnitude 70 N acting up the plane in a direction parallel to a line of greatest slope of the plane.
The box is on the point of slipping up the plane.

(a) Find the coefficient of friction between the box and the plane. **[5]**

There were many completely correct responses to this question. However, some candidates omitted the component of the weight of the box when finding the friction force, and others had the force of magnitude 70 N acting in the wrong direction.

Question 3 (b)

The force of magnitude 70 N is removed.

(b) Determine whether or not the box remains in equilibrium. **[2]**

The command word 'determine' is intended to convey to candidates that a calculation may well be needed to justify their response. A considerable number of candidates fully appreciated this and compared the component of the weight of the box down the plane (which they gave as 27 N) with the maximum possible friction force (43 N) from part (a). Most then explained that since the maximum friction force was greater than the weight component the box would remain in equilibrium. A number of candidates wrongly concluded that, since the two forces quoted were not equal the box would not remain in equilibrium.

Question 4 (a) (i)

4 A shovel consists of a blade and handle, as shown in Fig. 4.1 and Fig. 4.2. The dimensions shown in the figures are in metres.
The blade is modelled as a uniform rectangular lamina ABCD lying in the Oxy plane, where O is the mid-point of AB. The handle is modelled as a thin uniform rod EF. The handle lies in the Oyz plane, and makes an angle α with Oy, where $\sin\alpha = \frac{7}{25}$. The rod and lamina are rigidly attached at E, the mid-point of CD.
The blade of the shovel has mass 1.25 kg and the handle of the shovel has mass 0.5 kg.

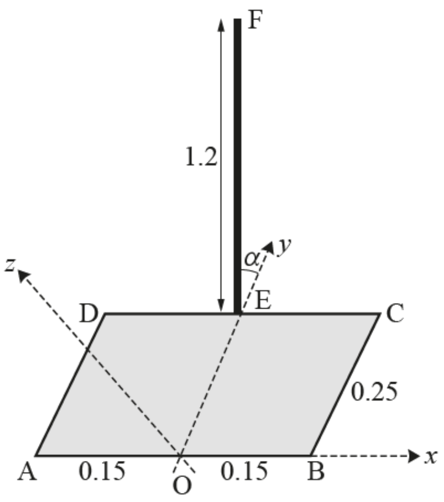


Fig. 4.1

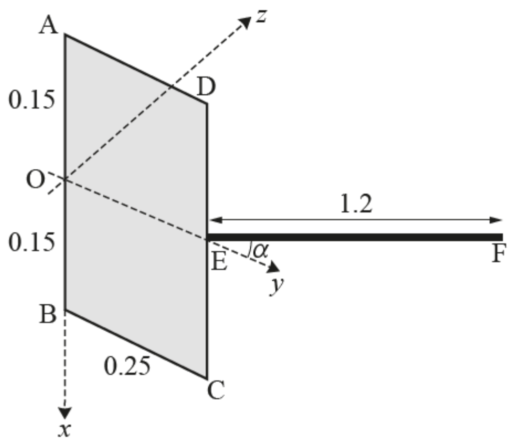


Fig. 4.2

(a) Find,

(i) the y-coordinate of the centre of mass of the shovel, **[5]**

Most candidates were able to tackle this question in the usual fashion, using $M\bar{y} = \sum my$, although a significant minority omitted all parts of this question. Few of the candidates who tackled the question had any problem finding $1.75\bar{y}$ for the shovel or 0.125 × 1.25 for the blade, but only a minority of candidates used the correct value for the y-component of the distance of the centre of mass of the handle from O; 0.25 and $0.25 + 1.2\cos\alpha$ were common wrong attempts.

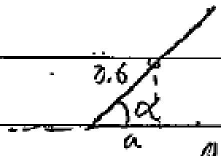
A correct response to this part question is shown in Exemplar 1.

Exemplar 1

COM of blade y-coord:

$\bar{y} = 0.125m$

COM of handle y-coord:



$\cos\alpha = \frac{a}{0.6}$

$0.6\cos\alpha = a$

$\cos\alpha = \sqrt{1-\sin^2\alpha}$

$\cos\alpha = \sqrt{1 - \frac{49}{625}} = \frac{24}{25}$

$a = 0.6 \times \frac{24}{25} = 0.576$

~~0.576~~ $0.576 + 0.25 = 0.826$

COM of shovel y-coord:

$\bar{y} = \frac{(0.125 \times 1.25) + (0.826 \times 0.5)}{1.25 + 0.5} = 0.325m$

Question 4 (a) (ii)

(ii) the z-coordinate of the centre of mass of the shovel. **[2]**

This part was usually answered correctly only by those with part (i) correct; a common wrong response was 0.096, which comes from using $1.2\sin\alpha$ for the distance, rather than half this value.

Question 4 (b)

The shovel is freely suspended from O and hangs in equilibrium.

(b) Calculate the angle that OE makes with the vertical. **[2]**

This part was omitted or answered incorrectly by many candidates – even some who had got both parts of (a) correct. Many candidates gained a method mark for stating that the required angle was the inverse tangent of a fraction comprising their answers from part (a).

Question 5 (a)

5 A car of mass 4000 kg travels up a line of greatest slope of a straight road inclined at an angle of θ to the horizontal, where $\sin\theta = 0.1$.
The power developed by the car's engine is constant and the resistance to the motion of the car is constant and equal to 850 N. The car passes through a point A on the road with speed $18\,\text{m s}^{-1}$ and acceleration $0.75\,\text{m s}^{-2}$.

(a) Calculate the power developed by the car. **[5]**

Most candidates were successful on this part.

The most usual error made on this part was to omit one of the terms, either the 850, $400g\sin\theta$ or the 4000×0.75, or to omit g from the weight term.

Question 5 (b)

The car later passes through a point B on the road with speed $25\,\text{m s}^{-1}$. The car takes 17.8 s to travel from A to B.

(b) Find the distance AB. **[5]**

Only a small minority of candidates assumed that this question could be solved using the equations of motion for constant acceleration; no credit was given for such attempts.

As in part (a), many candidates did not use all the terms required for the work-energy equation; partial credit was given for stating the change in KE and the change in PE. Credit was also given for the work done by the car following through the answer from part (a).

Question 6 (a)

6 Three particles, A, B and C are in a straight line on a smooth horizontal surface.
The particles have masses 5 kg, 3 kg and 1 kg respectively. Particles B and C are at rest. Particle A is projected towards B with a speed of $u\,\text{m s}^{-1}$ and collides with B. The coefficient of restitution between A and B is $\frac{1}{3}$.

Particle B subsequently collides with C. The coefficient of restitution between B and C is $\frac{1}{3}$.

(a) Determine whether any further collisions occur. **[7]**

Many candidates applied the Law of Conservation of Momentum and Newton's Experimental Law correctly for both collisions, although some made sign errors and others made mistakes solving their simultaneous equations. A small number of candidates wrongly involved the mass of the particles when applying Newton's Experimental Law. Some candidates were inconsistent in their use of variables for the subsequent speeds, for example v_1 being used both for the speed of A after the first collision and the speed of B after the second.

Most candidates found the speeds of A and B after the first collision and the speeds of B and C after the second collision in terms of the initial speed of A, u m s^{-1}. It is then fairly straightforward to determine whether any further collisions occur, and to give the relevant values to show this. It is, of course, also possible to express the speeds after the collisions in terms of the speed of A after the first collision, or the speed of B after the first collision, and some candidates did this. However, such candidates did not always succeed in presenting a complete argument to show that there could be no further collisions.

Question 6 (b)

(b) Given that the loss of kinetic energy during the initial collision between A and B is 4.8 J, find the value of u. **[4]**

This question was not attempted by a considerable number of candidates, and many others did no more than give the initial kinetic energy of A. Some candidates who did make more of an attempt at this part did not consider the kinetic energy of both A and B after the collision. Even so, there were some concise, well-presented correct responses.

Question 7

7

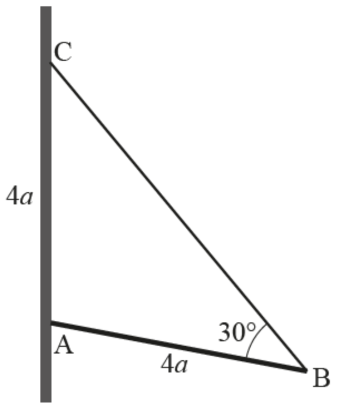


Fig. 7

Fig. 7 shows a uniform rod AB of length $4a$ and mass m.
The end A rests against a rough vertical wall. A light inextensible string is attached to the rod at B and to a point C on the wall vertically above A, where $AC = 4a$. The plane ABC is perpendicular to the wall and the angle ABC is 30°.

The system is in limiting equilibrium.

Find the coefficient of friction between the wall and the rod. **[8]**

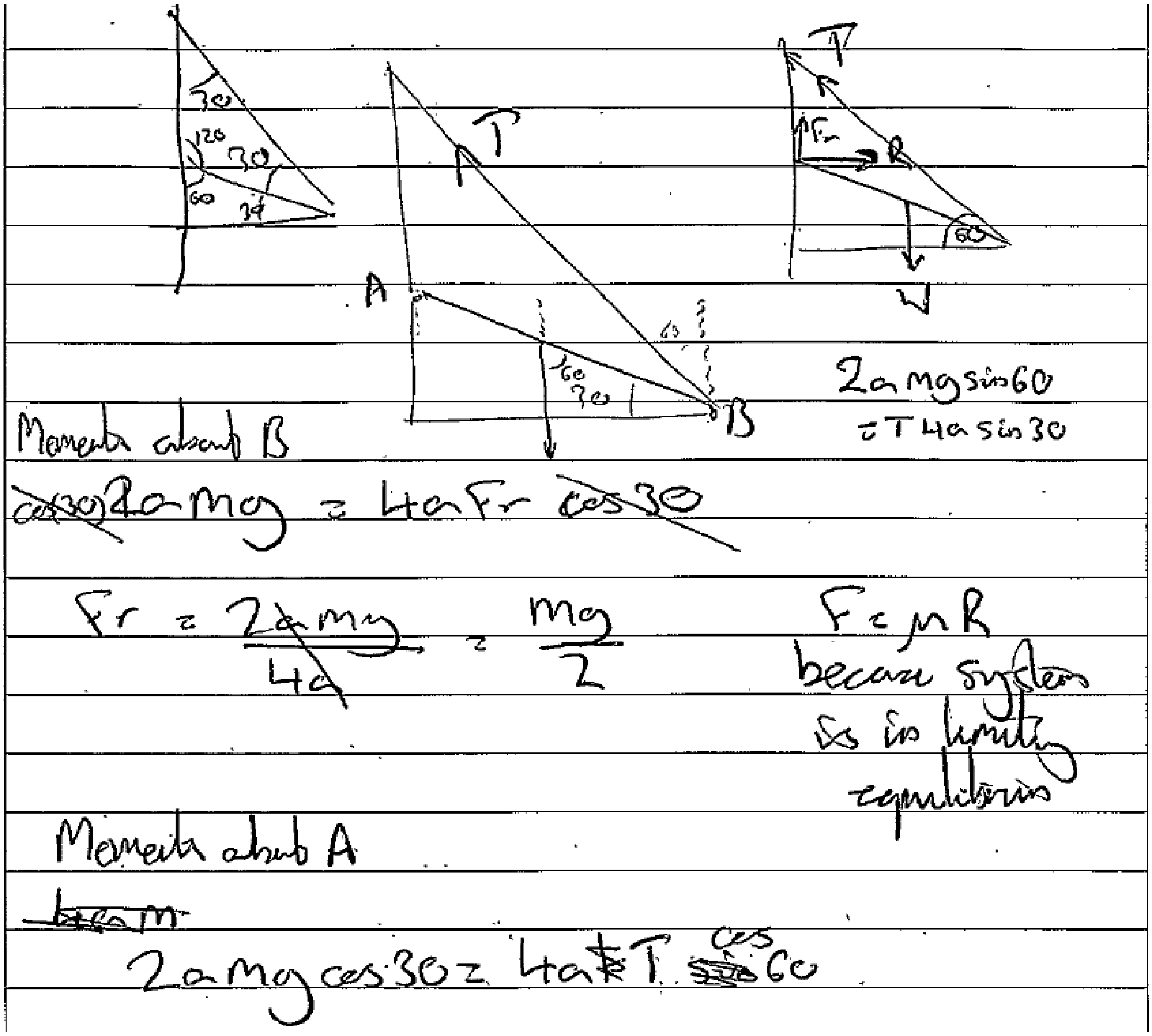
Many candidates found this question too challenging, with a considerable number not attempting it or just drawing a diagram, working out the angles, and perhaps writing something like $F = \mu R$

A small number of candidates introduced forces at C, often friction and normal reaction. Some candidates would have benefitted from a clearly labelled force diagram (including angles) and also clear indications of what each force was.

Most attempts at this question that gained some credit involved the tension in the string BC. To be successful, candidates needed to take moments about A and to resolve vertically and horizontally for the equilibrium of the rod, or something equivalent to this. They then needed to find expressions for the friction force and the normal reaction force at A, and hence find the coefficient of friction. Only a small minority of candidates attempted all parts of this method, and those that did usually made mistakes like resolving incorrectly (e.g. using $\cos 30$ when they should have used $\sin 30$) or omitting a trigonometric factor or missing out distance in one term when taking moments.

The answer to this question is equal to $\tan 30$. This final answer was sometimes seen from erroneous working. Full credit is only given for a correct response produced by fully correct working.

Exemplar 2


30
120
30
60
30
T
A
60
30
B
T
Fr
R
60
W
2amgsin60
=T4asin30
Moments about B
~~cos30~~ 2amg = 4aFr ~~cos30~~
Fr = 2amg/4a = mg/2
F=μR
because system is in limiting equilibrium
Moments about A
~~beam~~
2amg cos30 = 4aT cos60

~~$\cos 30 = \sin 60$~~ ~~$2amg = 4aT$~~

$T = \frac{2amg\cos 30}{4a\cos 60}$ ~~$T = \frac{2amg}{4a} = \frac{mg}{2}$~~

$T\sin 60 + Fr = W$

$T\cos 60 = R$

$T\sin 60 + \mu T\cos 60 = mg$

$\frac{mg - T\sin 60}{T\cos 60} = \frac{mg}{T\cos 60} - \tan 60$

$T = \frac{mg\cos 30}{2\cos 60}$ $\quad \frac{mg}{\left(\frac{mg\cos 30}{2\cos 60}\right)\cos 60} = \frac{2}{\cos 30} = \frac{4}{\sqrt{3}}$

$\frac{4}{\sqrt{3}} - \sqrt{3} = \frac{4\sqrt{3}}{3} - \frac{3\sqrt{3}}{3} = \frac{\sqrt{3}}{3} = \frac{1}{\sqrt{3}}$

coefficient of friction $= 0.57735$

coefficient of friction $= 0.58$

Exemplar 2 shows a fully correct response. The candidate starts by taking moments about B (omitting the normal reaction term at A) but then abandons this approach. The candidate goes on to take moments about A and to resolve vertically and horizontally for the equilibrium of the rod; these equations are correct. The work to find the coefficient of friction is not at all elegant nor explained well, but it is fully correct and so gains full marks. Notice that this question has simply asked candidates to 'Find the coefficient of friction'.

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