MAS156: Mathematics (Electrical and Aerospace)
MAS161 (General Engineering Mathematics)

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Monday 30th March 2020, 12pm
Diamond LT1

End of year exam

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Here are some details about the exam, and tips for how to do well on maths exams.

Exam format

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To pass the module comfortably, you will need to do well on Section B

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- Section A: 12 compulsory questions, 3 marks each;
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Section A questions are intended to be straightforward tests of skills. Section B questions will require a bit more thought.

To pass the module comfortably, you will need to do well on Section B as Section A only carries 36 marks.

Past papers and formula sheet

There are two past papers on the course webpage with solutions.

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Also on the course webpage is the formula sheet which will be provided to you in the exam. You can use any results from this formula sheet without proof.

Calculators

Remember that you need to have an approved calculator for use in the exam.

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But please note that we expect to see fully worked solutions to all questions.

Unfair means

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Preparing for maths exams

Practice

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If you have questions on the problems on the exercise sheets, feel free to ask in your problem class or post on the discussion board.

Past papers (again)

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However, you should not expect the questions to be identical to the ones from last year!

Presentation

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- link together equal expressions with $=$-signs, and line them up if possible;
- avoid floating answers;
- avoid backwards reasoning;
- write concluding statements.

Make sure all the steps in your calculations are clearly presented.

Activity. Look at the two sets of genuine student solutions to questions on material from this course. In pairs, discuss what score (out of 10) you think they got.

I'll reveal the questions and the marks shortly.

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(i) Give the first 4 terms in the binomial expansions of (a) $(1-3x)^5$; (b) $(8+x)^{\frac{1}{3}}$. (7 marks)

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Maths Coursework

A

1) i) a) $(1-3x)^5 = 1 + (-3x) + (-3x)^2 + (-3x)^3$

$= 1 - 3x + 9x^2 - 27x^3$

b) $(8+x)^{\frac{1}{3}} = 8^{\frac{1}{3}}\left(1+\frac{1}{8}x\right)^{1/3} = 2\left(1+\frac{1}{8}x\right)^{1/3}$

~~$= 2\left(1 + \left(\frac{1}{8}x\right)^{1/3} \ldots\right)$~~

$= 2\left(1 + \frac{1}{3}\left(\frac{1}{8}x\right) + \underbrace{\frac{\left(\frac{1}{3}\right)\left(\frac{-2}{3}\right)\left(\frac{1}{8}x\right)^2}{2}} + \underbrace{\frac{\left(\frac{1}{3}\right)\left(\frac{-2}{3}\right)\left(\frac{-5}{3}\right)\left(\frac{1}{8}x\right)^3}{6}}\right)$

$= 2\left(1 + \frac{1}{24}x - \underbrace{\frac{2}{9}\left(\frac{1}{64}x^2\right)}_{2} + \underbrace{\frac{10}{27}\left(\frac{1}{512}x^3\right)}_{6}\right)$

$= 2 + \frac{1}{12}x - \frac{1}{9}\left(\frac{1}{64}x^2\right) + \frac{5}{27}\left(\frac{1}{512}x^3\right)$ (3)

$= 2 + \frac{1}{12}x - \frac{1}{576}x^2 + \frac{5}{41472}x^3$

ii) $x = 0.1$

$2 + \frac{1}{12}(0.1) - \frac{1}{576}(0.1)^2 + \frac{5}{41472}(0.1)^3$

$= 2 + \frac{1}{120} - 1.7361 \times 10^{-5} + 1.2056 \times 10^{-7}$

$= 2.0083$

B

① (i) a) $(1-3x)^5 = 1 + \frac{5(-3x)}{1!} + \frac{(5)(4)(-3x)^2}{2!} + \frac{(5)(4)(3)(-3x)^3}{3!}$

$= 1 - 15x + \frac{(20)(9x^2)}{2} - \frac{(60)(27x^3)}{6}$

Answer $= 1 - 15x + 90x^2 - 270x^3$

b) $(8+x)^{\frac{1}{3}}$

$= 8^{\frac{1}{3}}\left(1+\frac{x}{8}\right)^{\frac{1}{3}}$

$= 2\left[1 + \frac{\left(\frac{1}{3}\right)\left(\frac{1}{8}x\right)}{1!} + \frac{\left(\frac{1}{3}\right)\left(-\frac{2}{3}\right)\left(\frac{1}{8}x\right)^2}{2!} + \frac{\left(\frac{1}{3}\right)\left(-\frac{2}{3}\right)\left(-\frac{5}{3}\right)\left(\frac{1}{8}x\right)^3}{3!}\right]$

$= 2\left[1 + \frac{1}{24}x + \frac{\left(-\frac{2}{9}\right)\left(\frac{1}{64}x^2\right)}{2} + \frac{\left(\frac{10}{27}\right)\left(\frac{1}{512}x^3\right)}{6}\right]$

$= 2\left[1 + \frac{1}{24}x - \frac{1}{576}x^2 + \frac{5}{41472}x^3\right]$

Answer $= 2 + \frac{1}{12}x - \frac{1}{288}x^2 + \frac{5}{20736}x^3$

(ii) $2 + \left(\frac{1}{12}\right)(0.1) - \left(\frac{1}{288}\right)(0.1)^2 + \left(\frac{5}{20736}\right)(0.1)^3$

$= 2 + \frac{1}{120} - \frac{1}{28800} + \frac{1}{4147200}$

$= 2.00829\,8852$

Answer $= 2.0083$ (4 d.p)

E

1ia) $(1-3x)^5$ $1 + -3\times5x - \frac{3\times5\times4x^2}{2!} - \frac{8\times5\times4\times3x^3}{3!}$

$1 - 15x - 30x^2 - 30x^3$

1ib) $(8+x)^{1/3}$ $8^{1/3}(1+\frac{x}{8})^{1/3}$ $1 + \frac{1}{3}\times\frac{1}{8}x + \frac{\frac{1}{8}\times\frac{1}{3}-\frac{2}{3}x^2}{2!}$

$+ \frac{\frac{1}{8}\times\frac{1}{3}\times-\frac{5}{3}\times-\frac{5}{3}x^3}{3!}$ $2\left[1 + \frac{1}{24}x - \frac{1}{72}x^2 + \frac{5}{648}x^3\right]$

$2 + \frac{1}{12}x - \frac{1}{36}x^2 + \frac{5}{324}x^3$

1ii) $x = 0.1$ $2 + \frac{1}{12}\times0.1 - \frac{1}{36}\times0.1^2 + \frac{5}{324}\times0.1^3 = 2.00804$

$\sqrt[3]{8.1} \simeq 2.0080$ (4 d.p)

The students scored

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A: 6,

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A: 6, B: 10, E: 0.

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~~$= 2(1) + \left(\frac{1}{8}x\right)^{1/3}$~~

$= 2\left(1 + \frac{1}{3}\left(\frac{1}{8}x\right) + \underbrace{\frac{\left(\frac{1}{3}\right)\left(\frac{-2}{3}\right)\left(\frac{1}{8}x\right)^2}{2}} + \underbrace{\frac{\left(\frac{1}{3}\right)\left(\frac{-2}{3}\right)\left(\frac{-5}{3}\right)\left(\frac{1}{8}x\right)^3}{6}}\right)$

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ii) $x = 0.1$

$2 + \frac{1}{12}(0.1) - \frac{1}{576}(0.1)^2 + \frac{5}{41472}(0.1)^3$

$= 2 + \frac{1}{120} - 1.7361 \times 10^{-5} + 1.2056 \times 10^{-7}$

$= 2.0083$

B

① (i) a) $(1-3x)^5 = 1 + \frac{5(-3x)}{1!} + \frac{(5)(4)(-3x)^2}{2!} + \frac{(5)(4)(3)(-3x)^3}{3!}$

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$= 2.00829885$

Answer $= 2.0083$ (4d.p)

E

1a) $(1-3x)^5$ $1 + -3\times5x - \frac{3\times5\times4x^2}{2!} - \frac{3\times5\times4\times3x^3}{3!}$

$1 - 15x - 30x^2 - 30x^3$

1b) $(8+x)^{1/3}$ $8^{1/3}\left(1+\frac{x}{8}\right)^{1/3}$ $1 + \frac{1}{3}\times\frac{1}{8}x + \frac{\frac{1}{8}\times\frac{1}{3}-\frac{2}{3}x^2}{2!}$

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1ii) $x = 0.1$ $2 + \frac{1}{12}\times0.1 - \frac{1}{36}\times0.1^2 + \frac{5}{324}\times0.1^3 = 2.00804$

$3\sqrt{8.1} \approx 2.0080$ (4.d.p)

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3) i) $f(x) = \cosh(x-2)$ $\quad a = 2$

A

$f(a) + f'(a)(x-a) + f''(a)(x-a)^2$

$= \cosh(2-2) + \sinh(2-2)(x-2) + \cosh(0)(x-2)^2$

$+ \sinh 0\,(x-2)^3 + \cosh 0\,(x-2)^4$

$= 1 + (x-2)^2 + (x-2)^4$

ii) $1 + (x-2)^2 + (x-2)^4 = 1.1$

$\cosh(x-2) = 1.1$

$1 + (x-2)^2 = 1.1$

$(x-2)^2 = 0.1$ $\quad x - 2 = \pm\sqrt{0.1}$

$x^2 - 4x + 4 = 0.1$ $\quad x = 2 \pm \sqrt{0.1}$

$x^2 - 4x + 3.9 = 0$

$(x-2)^2 + 3.9 - 4 = 0$

$(x-2)^2 - 0.1 = 0$ $\quad (x-2)^2 = 0.1$

$x - 2 = \pm\sqrt{0.1}$

③ (i) $f(x) = \cosh(x-2)$ $\quad$ around $x = 2$ $\quad f(a+x) = \sum_{n=0}^{\infty} \frac{f^{(n)}(a)x^n}{n!}$

$a = 2$

B

$f'(x) = -\sinh(x-2)$ $\quad f'(2) = \sinh(0) = 0$

$f''(x) = \cosh(x-2)$ $\quad f''(2) = \cosh(0) = 1$

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$$f(x) = 1 + \frac{0(x-2)}{1!} + \frac{1(x-2)^2}{2!} + \frac{0(x-2)^3}{3!} + \frac{1(x-2)^4}{4!}$$

Answer: $1 + \frac{(x-2)^2}{2} + \frac{(x-2)^4}{24}$

(ii) $\cosh(x-2) = 1.1$

$\therefore 1 + \frac{(x-2)^2}{2} + \frac{(x-2)^4}{24} = 1.1$

$(\times 24)\ 24 + 12(x-2)^2 + (x-2)^4 = 26.4$

$(x-2)^4 + 12(x-2)^2 - 2.4 = 0$

let $y = x - 2$

$y^4 + 12y^2 - 2.4 = 0$

let $y^2 = z$

$z^2 + 12z - 2.40$

then use quadratic formula: $z = \frac{-30 \pm 8\sqrt{15}}{5}$ $\quad z = \frac{-30 + 8\sqrt{15}}{5}$

must be positive as $z = y^2$

$y = \sqrt{z} = \sqrt{\frac{-30 + 8\sqrt{15}}{5}} = \pm 0.443591427$

$x = y + 2$

$x = 2.443591427$ and 1.556408573

Solutions are: 2.4436 and 1.5564 (4 d.p)

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A: 4, B: 10.

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$+ \sinh 0\,(x-2)^3 + \cosh 0\,(x-2)^4$

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ii) $1 + (x-2)^2 + (x-2)^4 = 1.1$

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$(x-2)^2 + 3.9 - 4 = 0$

$(x-2)^2 - 0.1 = 0$ $\quad (x-2)^2 = 0.1$

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③ (i) $f(x) = \cosh(x-2)$ $\quad$ around $x = 2$ $\quad f(a+x) = \sum_{n=0}^{\infty} \frac{f^{(n)}(a)x^n}{n!}$

$a = 2$

B

$f'(x) = -\sinh(x-2)$ $\quad f'(2) = \sinh(0) = 0$

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$$f(x) = 1 + \frac{0(x-2)}{1!} + \frac{1(x-2)^2}{2!} + \frac{0(x-2)^3}{3!} + \frac{1(x-2)^4}{4!}$$

Answer: $1 + \frac{(x-2)^2}{2} + \frac{(x-2)^4}{24}$

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let $y^2 = z$

$z^2 + 12z - 2.40$

then use quadratic formula: $z = \frac{-30 \pm 8\sqrt{15}}{5}$ $\quad z = \frac{-30 + 8\sqrt{15}}{5}$

must be positive as $z = y^2$

$y = \sqrt{z} = \sqrt{\frac{-30 + 8\sqrt{15}}{5}} = \pm 0.443591427$

$x = y + 2$

$x = 2.443591427$ and 1.556408573

Solutions are: 2.4436 and 1.5564 (4 d.p)

Mathematical exam questions

There are some helpful things to bear in mind when doing maths exams.

Linked parts

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Always think about whether the parts to a question are linked. Often you will find they are.

Hints

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A variation of ‘By using the binomial theorem, or otherwise, show that . . . ’ usually indicates there are other ways to proceed, but again the hint will normally help. But be aware that sometimes other methods can be easier.

Another phrase that is sometimes used is ‘Hence show that. . . ’.

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Look out for these kind of phrases, as they are there to help!

Understanding what's required

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simply requires substituting in for y and $\frac{d^2y}{dx^2}$ in the left-hand side and checking the result is zero.

Some people waste time solving the equation from scratch.

Sensible answers

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Often simple questions like this can help to spot errors and pick up extra marks.

Checking at the end

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If you have time left over, it's a really good idea to check through some of your algebra. An extra few marks can move you up a grade, or stop you from failing.

Still to come

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There will be two drop-in sessions:

- Tuesday, 14th May: 2–5pm (Diamond WR3)
- Thursday, 16th May: 1–4pm (Diamond WR3)

We hope you enjoy the rest of the course!