

**MAS140: Mathematics (Chemical)**  
**MAS153: Mathematics for Materials**

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Thursday 21st March 2019, 1pm  
Arts Tower LT4

**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.

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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

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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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The examples you have worked on in the problem classes should have deepened your understanding of the maths, but to do well on the exam we strongly recommend that you work through the exercise sheets on the course webpage.

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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- avoid floating answers;
- avoid backwards reasoning;
- write concluding statements.

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

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**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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Maths Coursework

(A)

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

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

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

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

$$= 2 \left( 1 + \frac{1}{8} \left( \frac{1}{8}x \right) + \frac{\binom{1/3}{2} \left( \frac{1}{8}x \right)^2}{2} + \frac{\binom{1/3}{3} \left( \frac{1}{8}x \right)^3}{6} \right)$$

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

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

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

ii)  $x=0.1$

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

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

$$= 2.0083$$

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)

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

$$= 2 \left[ 1 + \frac{\frac{1}{24}x}{1} + \frac{\left( -\frac{1}{8} \right) \left( \frac{1}{64}x^2 \right)}{2} + \frac{\left( \frac{10}{27} \right) \left( \frac{1}{512}x^3 \right)}{6} \right]$$

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

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

(ii)  $2 + \left( \frac{1}{12} \right) (0.1) - \left( \frac{1}{288} \right) (0.1)^2 + \left( \frac{5}{20736} \right) (0.1)^3$   
 $= 2 + \frac{1}{120} - \frac{1}{28800} + \frac{1}{4147200}$   
 $= 2.008248852$

Answer = 2.0083 (4.d.p.)

E

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

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

b)  $(8+x)^{1/3} = 8^{1/3} \left( 1 + \frac{1}{8}x \right)^{1/3} = 2 \left[ 1 + \frac{1}{24}x - \frac{1}{576}x^2 + \frac{5}{41472}x^3 \right]$

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

ii)  $x=0.1$   $2 + \frac{1}{12}(0.1) - \frac{1}{288}(0.1)^2 + \frac{5}{20736}(0.1)^3 = 2.00804$

Answer = 2.0080 (4.d.p.)

The students scored

The students scored

A: 6,

The students scored

A: 6, B: 10,

The students scored

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

Maths Coursework

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

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

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

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$$= 2.0083$$

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

$$\text{Answer} = 1 - 15x + 90x^2 - 270x^3$$

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

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

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

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

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

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

$$= 2 + \frac{1}{120} - \frac{1}{28800} + \frac{5}{4147200}$$

$$= 2.008248852$$

$$\text{Answer} = 2.0083 \text{ (4 d.p.)}$$

E

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

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

1) b)  $(8+x)^{\frac{1}{3}} = 8^{\frac{1}{3}} (1 + \frac{1}{8}x)^{\frac{1}{3}} = 2 \left[ 1 + \frac{1}{24}x + \frac{1}{96}x^2 - \frac{5}{384}x^3 \right]$

$$2 + \frac{1}{12}x + \frac{1}{48}x^2 - \frac{5}{192}x^3$$

ii)  $x=0.1$   $2 + \frac{1}{12}(0.1) + \frac{1}{48}(0.1)^2 - \frac{5}{192}(0.1)^3 = 2.00804$

$$\text{Answer} \approx 2.0080 \text{ (4 d.p.)}$$

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- (i) Obtain the first three nonzero terms of the Taylor series expansion of  $f(x) = \cosh(x - 2)$  around  $x = 2$ . (6 marks)
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3) i)  $f(x) = \cosh(x-2)$   $a=2$

(A)

$$f(a) + f'(a)(x-a) + \frac{f''(a)}{2!}(x-a)^2$$

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

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

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

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

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

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

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

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

$$x^2 - 4x + 3.6 = 0$$

$$(x-2)^2 - 0.4 = 0$$

$$(x-2)^2 = 0.4 \quad x-2 = \pm \sqrt{0.4}$$

3) (i)  $f(x) = \cosh(x-2)$  around  $x=2$   $f(0.2) = \sum_{n=0}^{\infty} \frac{f^{(n)}(a)x^n}{n!}$

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

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

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

$$f^{(4)}(x) = \cosh(x-2) \quad f^{(4)}(2) = \cosh(0) = 1$$

(B)

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

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

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

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

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

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

$$\text{let } y = x-2$$

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

$$\text{let } y^2 = z$$

$$z^2 + 12z - 2.4 = 0$$

$$\text{then use quadratic formula: } z = \frac{-30 \pm \sqrt{900}}{5} \quad z = \frac{-30 \pm 30}{5}$$

must be positive as  $z = y^2$

$$y = \sqrt{z} = \sqrt{\frac{-30 + 30}{5}} = \pm 0.4435914268$$

$$x = y + 2$$

$$x = 2.443591427 \quad \text{and} \quad 1.556408573$$

$$\text{Solutions are: } 2.4436 \quad \text{and} \quad 1.5564 \quad (\text{4 d.p.})$$

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

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

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

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

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$$f(a+x) = \sum_{n=0}^{\infty} \frac{f^{(n)}(a)x^n}{n!}$$

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

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

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$$f^{(4)}(x) = \cosh(x-2) \quad f^{(4)}(2) = \cosh(0) = 1$$

(B)

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

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

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

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

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must be positive as  $z = y^2$

$$y = \sqrt{z} = \sqrt{\frac{-30 + 30\sqrt{5}}{5}} = \pm 0.4435914268$$

$$x = y + 2$$

$$x = 2.443591427 \quad \text{and} \quad 1.556408573$$

$$\text{Solutions are: } 2.4436 \quad \text{and} \quad 1.5564 \quad (\text{4 d.p.})$$



# 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.

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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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$$\frac{d^2y}{dx^2} + y = 0$$



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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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- If you have found an indefinite integral, does it differentiate to what you expected?
- If you have found the maximum point on a function, does it look like a maximum?

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!