External assessment 2024

Question and response book

Engineering

Time allowed

- Perusal time — 10 minutes
- Working time — 120 minutes

General instructions

- Answer all questions in this question and response book.
- QCAA-approved calculator permitted.
- Protractor and ruler required.
- QCAA formula book provided.
- Planning paper will not be marked.

Section 1 (10 marks)

- 10 multiple choice questions

Section 2 (33 marks)

- 6 short response written questions

Section 3 (36 marks)

- 6 short response calculation questions

Section 1

Instructions

- This section has 10 questions and is worth 10 marks.
- Use a 2B pencil to fill in the A, B, C or D answer bubble completely.
- Choose the best answer for Questions 1–10.
- If you change your mind or make a mistake, use an eraser to remove your response and fill in the new answer bubble completely.

	A	B	C	D
Example:	●	○	○	○

	A	B	C	D
1.	○	○	○	○
2.	○	○	○	○
3.	○	○	○	○
4.	○	○	○	○
5.	○	○	○	○
6.	○	○	○	○
7.	○	○	○	○
8.	○	○	○	○
9.	○	○	○	○
10.	○	○	○	○

Ensure you have filled an answer bubble for each question.

Do not write outside this box.

Section 2

Instructions

- Write using black or blue pen.
- If you need more space for a response, use the additional pages at the back of this book.
  - On the additional pages, write the question number you are responding to.
  - Cancel any incorrect response by ruling a single diagonal line through your work.
  - Write the page number of your alternative/additional response, i.e. See page …
  - If you do not do this, your original response will be marked.
- This section has six questions and is worth 33 marks.

DO NOT WRITE ON THIS PAGE

THIS PAGE WILL NOT BE MARKED

QUESTION 11 (4 marks)

Explain the purpose of a crowbar using the concepts of mechanical advantage and velocity ratio. Include a sketch to support your response.

Note: If you make a mistake in the sketch, cancel it by ruling a single diagonal line through your work and use the additional response space at the back of this question and response book.

QUESTION 12 (5 marks)

Analyse the information in the table to determine whether polyvinyl chloride (PVC) or polyethylene is the most suitable material for wastewater pipes in the home. Justify your response with four properties from the table.

Properties	PVC	Polyethylene
Mechanical	resistant to abrasion, impact and weathering rigid — limited flexibility, can withstand high pressure	resistant to cracking, impact and environmental stress; strong; durable malleable — highly flexible
Young's modulus	2.41–4.14 GPa	1.08 GPa
Yield strength	40.7–44.8 MPa	26.2–33.1 MPa
Tensile strength	40.7–51.7 MPa	22.1–31.0 MPa
Chemical	excellent chemical resistance (including corrosive chemicals)	good chemical resistance
Thermal	good heat resistance	very good heat resistance
Manufacturing cost	low	high

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QUESTION 13 (6 marks)

Identify two industrial applications of high carbon steel. Describe two mechanical properties of this material that make it suitable for each application.

Application 1: _____

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Application 2: _____

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QUESTION 14 (4 marks)

Explain how the chemical composition of mild carbon steel contributes to its suitability for seamless tubes. Include two properties of mild carbon steel in your response.

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QUESTION 15 (8 marks)

A truth table for the reversing safety system of a forklift is shown.

Inputs				Intermediate signals			Output
A	**B**	**C**	**D**	**E**	**F**	**G**	**X**
0	0	0	0	0	1	0	0
0	0	0	1	0	1	0	0
0	0	1	0	0	0	0	0
0	0	1	1	0	0	0	0
0	1	0	0	1	1	1	0
0	1	0	1	1	1	1	1
0	1	1	0	1	0	0	0
0	1	1	1	1	0	0	0
1	0	0	0	1	1	1	0
1	0	0	1	1	1	1	1
1	0	1	0	1	0	0	0
1	0	1	1	1	0	0	0
1	1	0	0	1	1	1	0
1	1	0	1	1	1	1	1
1	1	1	0	1	0	0	0
1	1	1	1	1	0	0	0

The forklift has a motion sensor on each side at the back. If either sensor detects an obstacle while the forklift is reversing, a safety brake is activated.

Key

Input A = Left sensor (motion detected = 1)

Input B = Right sensor (motion detected = 1)

Input C = Gear (forward selected = 1, reverse selected = 0)

Input D = Engine (engine on = 1)

E, F and G are intermediate input/output signals to the logic gates.

Output X = Safety brake (brake on = 1)

Construct a logic gate circuit, based on the truth table, that meets the requirements for the safety brake to activate. Clearly label all inputs and outputs.

Note: If you make a mistake in the logic gate circuit, cancel it by ruling a single diagonal line through your work and use the additional response space at the back of this question and response book.

QUESTION 16 (6 marks)

During a flood event communities can find themselves isolated, without power and unable to access basic supplies and health care. The risk of further rainfall and submerged roads can hamper rescue efforts.

Explain how mechatronics engineers have used their expertise of control technology, materials science and mechanics to develop machines to benefit communities affected by flood events. Include the type of machine used and two benefits for the community.

Section 3

Instructions

- Respond showing full working for calculations.
- This section has six questions and is worth 36 marks.

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QUESTION 17 (4 marks)

A car with a mass of 1300 kg is parked on a driveway that makes an inclined angle of 25° to the horizontal.
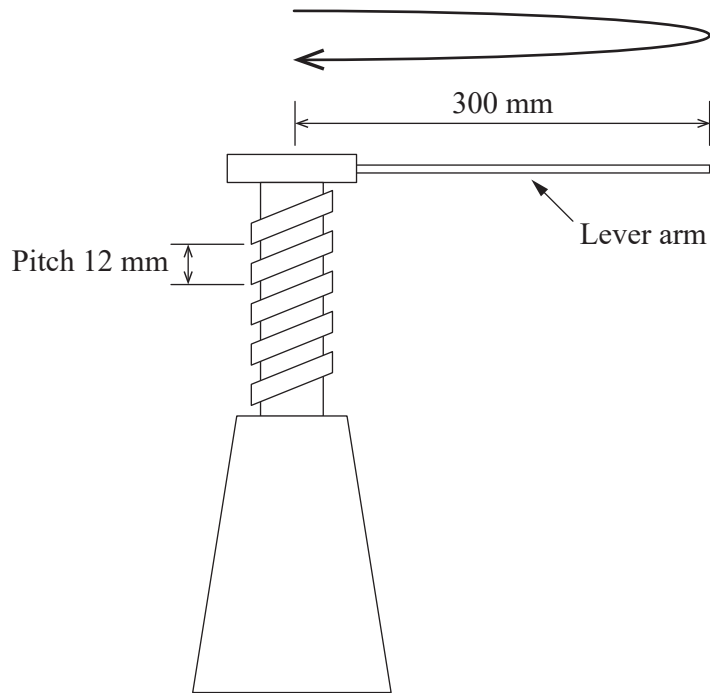
a) Calculate the normal force acting on the car.

[2 marks]

b) Calculate the coefficient of static friction required between the car tyres and the driveway to prevent the car from rolling. *[2 marks]*

An effort of 120 N is applied at the end of the lever arm of a screw jack for 180 seconds to raise an object 150 mm.

Not to scale

300 mm

Pitch 12 mm

Lever arm

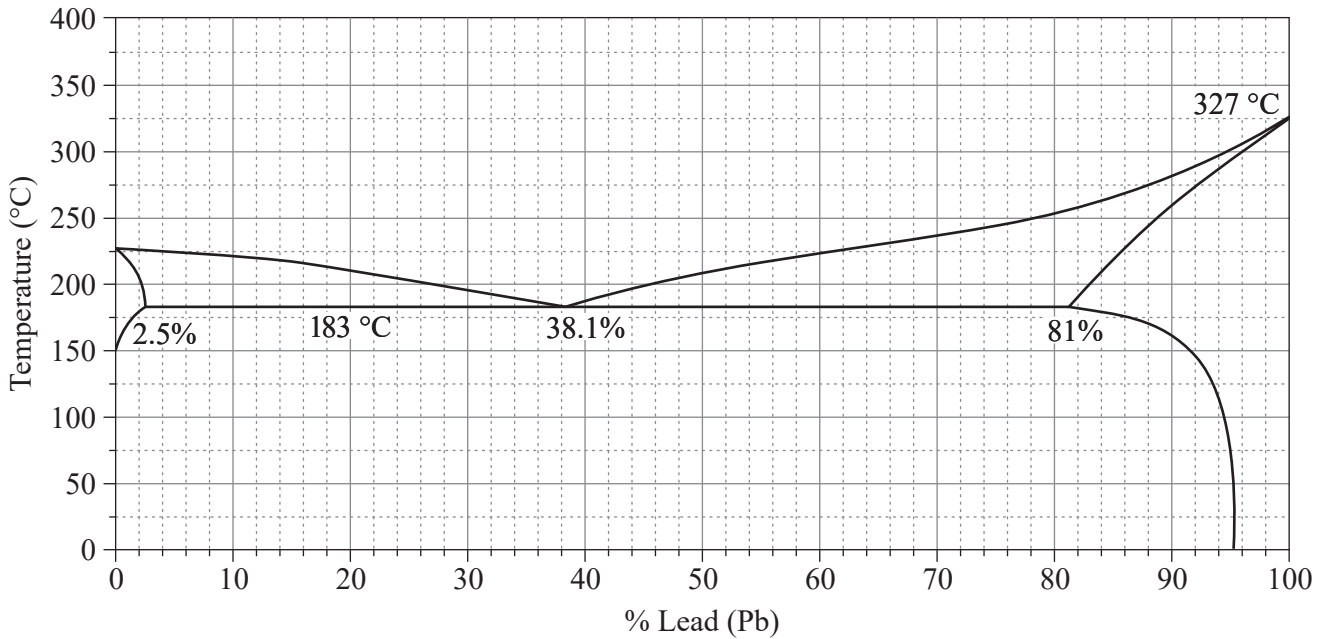a)   Calculate the work done on the lever arm.   *[4 marks]*

b)   Calculate the power input. *[1 mark]*

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QUESTION 19 (5 marks)

A lead–tin thermal-equilibrium diagram is shown.

Note: If you make a mistake in the diagram, cancel it by ruling a single diagonal line through your work and use the additional response space at the back of this question and response book.

a) Determine the composition of the solid and liquid in a 70% lead 30% tin alloy at 200 °C. Annotate the diagram to develop your response. *[3 marks]*

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b) Determine the percentages of solid and liquid in a 70% lead 30% tin alloy at 200 °C. *[2 marks]*

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QUESTION 20 (4 marks)

A parcel slides down an inclined ramp, which is at 20° to the horizontal plane, at a constant velocity.
The parcel experiences a normal force of 98.2 N. A coefficient of kinetic friction of 0.37 and a coefficient of static friction of 0.39 exist between the parcel and the ramp.

Determine the mass of the parcel.

QUESTION 21 (10 marks)

A lift has a total mass of 1000 kg. The lift undergoes uniform acceleration from a stationary position on the ground floor until it reaches a height of 10 m and has a total mechanical energy of 106 kJ. From this point it continues to travel vertically at a constant velocity.

Determine the time taken for the lift to reach its constant velocity.

Do not write outside this box.

QUESTION 22 (8 marks)

A sorting conveyor cart in a recycling plant is initially at rest and has a mass of 5 kg. It is pushed a distance of 3 m up a 30° incline using a force of 60 N parallel to the incline. Assume $\mu_k = \mu_s = 0.58$.

Determine the time taken to move the cart 3 m up the incline. Include a free-body diagram showing all the forces involved.

Note: If you make a mistake in the diagram, cancel it by ruling a single diagonal line through your work and use the additional response space at the back of this question and response book.

END OF PAPER

ADDITIONAL PAGE FOR STUDENT RESPONSES

Write the question number you are responding to.

Do not write outside this box.

ADDITIONAL PAGE FOR STUDENT RESPONSES

Write the question number you are responding to.

Do not write outside this box.

ADDITIONAL RESPONSE SPACE FOR QUESTION 19

If you want this diagram to be marked, rule a single diagonal line through your original response.
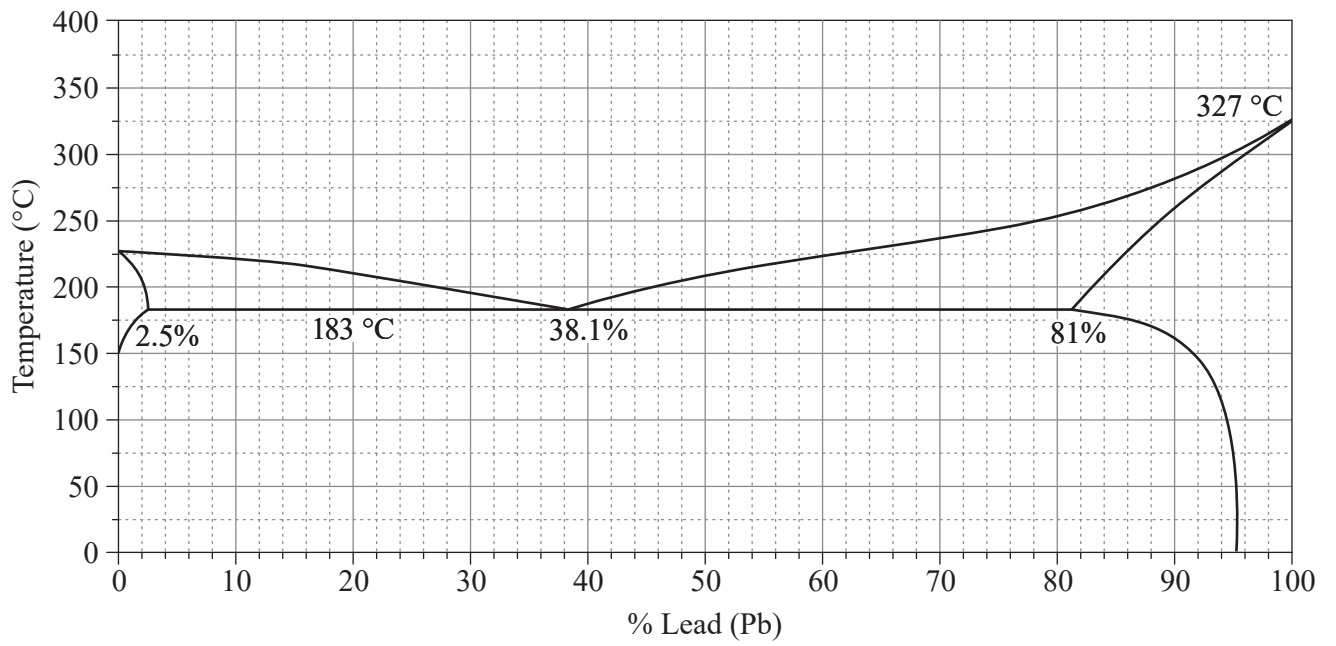
References

Question 12

Adapted from Callister, WD Jr & Rethwisch, DG 2014, Materials Science and Engineering: An introduction, 9th edn, John Wiley & Sons.

Adapted from Petron Thermoplast 2023, 'What are the differences between PVC and HDPE?'. Petron Thermoplast, https://petronthermoplast.com/differences-between-pvc-and-hdpe/#:~:text=Chemical%20 Resistance%3A.

Question 19

Adapted from Woutervermeiren 2006, 'The phase diagram of a lead-tin alloy'. Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Fasediagram_Pb_Sn.png.

Question 21

Adapted from Mathsodology 2017, *A-level Mathematics*, Mathsodology, https://mathsodology.wordpress. com/core-maths-1.