LUI | | | | | | | | | | | School code | | | | |

School name

Given name/s

Family name

Attach your barcode ID label here

Book of books used

External assessment 2025

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 (34 marks)

- 6 short response written questions

Section 3 (33 marks)

- 6 short response calculation questions

Clear zone — margin trimmed off after completion of assessment

Queensland Government | QCAA Queensland Curriculum & Assessment Authority

DO NOT WRITE ON THIS PAGE

THIS PAGE WILL NOT BE MARKED

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

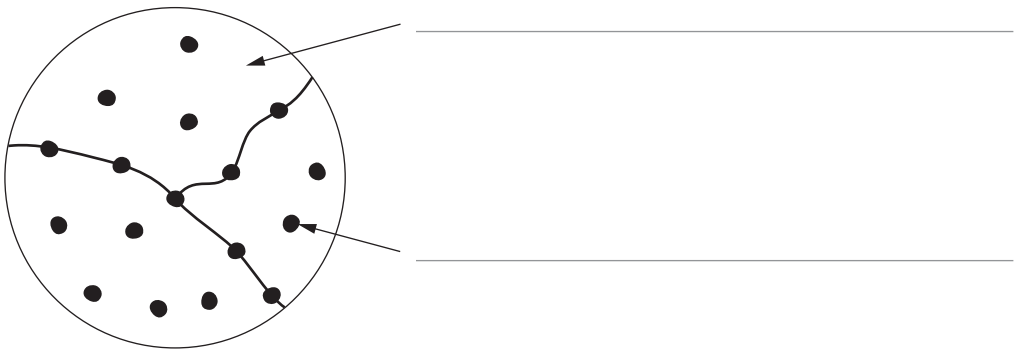
Instructions

- 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 34 marks.

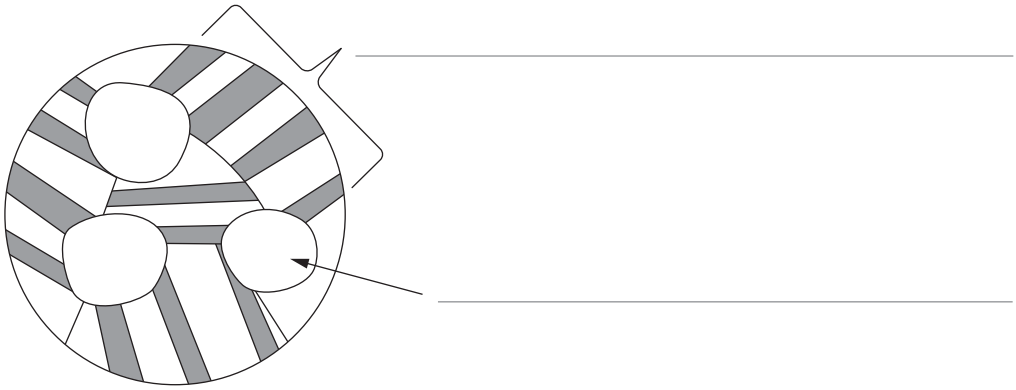
QUESTION 11 (4 marks)

Label the phases present at 100 °C in the microstructures of the lead–tin alloys shown.

a) 10% tin alloy *[2 marks]*



b) 40% tin alloy *[2 marks]*



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QUESTION 12 (5 marks)

An engineer is developing a knife for use in an industrial workshop. They have access to mild carbon steel (0.25% carbon) and high carbon steel (1.1% carbon).

Compare the mechanical properties of the materials to determine the most appropriate choice for the application. Justify your choice with reference to the microstructures.

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QUESTION 13 (6 marks)

An object on an inclined plane is subjected only to its own weight. Describe static friction and kinetic friction in terms of the angle of repose. Draw two force diagrams to support your response.

Static friction

Kinetic friction

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

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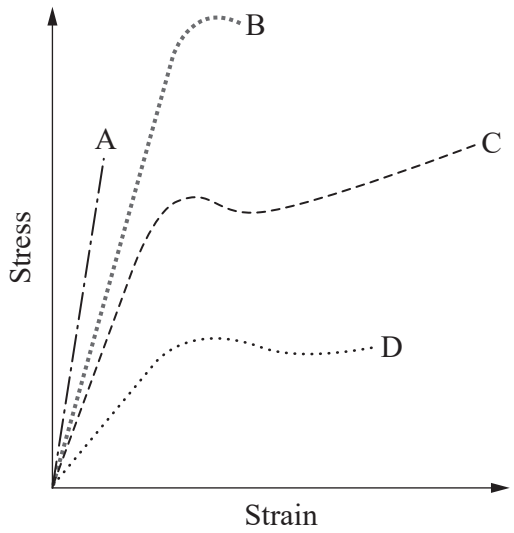
QUESTION 14 (6 marks)

A stress–strain diagram for four polymers is shown.



a) Identify the most suitable polymer for applications that require the ability to withstand high stress before deforming plastically. Use two features of the polymer from the diagram to justify your response. *[3 marks]*

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b) Identify the most suitable polymer for applications that require the ability to absorb energy and withstand stress while deforming plastically without breaking.
Use two features of the polymer from the diagram to justify your response. *[3 marks]*

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QUESTION 15 (6 marks)

Controlling access to premises is an issue that affects many small businesses. Loss or damage to property from unauthorised access can be very expensive and result in loss of business if premises have to close while damage is repaired. Small businesses need to consider how to make it easy for authorised persons to access their premises while deterring, detecting and protecting from unauthorised access and informing police and business owners.

Identify a machine or mechanism solution to help businesses control authorised and unauthorised access to their premises. Explain how engineers have used their expertise in materials science, mechanics and control technology to develop this solution. Include two benefits of the solution for a small business in your response.

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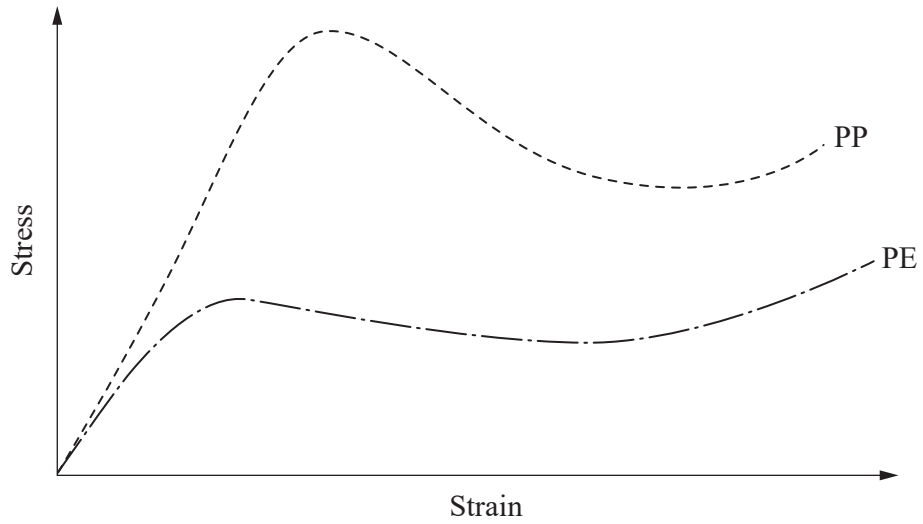
QUESTION 16 (7 marks)

A stress–strain diagram for polypropylene (PP) and polyethylene (PE) and a table comparing their properties are shown.



Properties	Polypropylene (PP)	Polyethylene (PE)
Chemical	excellent chemical resistance (including solvents, alkalis and many acids) non-toxic	good chemical resistance
Thermal	heat resistance up to 135 °C	heat resistance up to 120 °C
Electrical	excellent electrical insulation	excellent electrical insulation

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Identify a suitable application for each material. Justify your response by analysing the stress–strain diagram and the table to identify two properties for each material that make it suitable. Annotate the stress–strain diagram with one of the identified properties.

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

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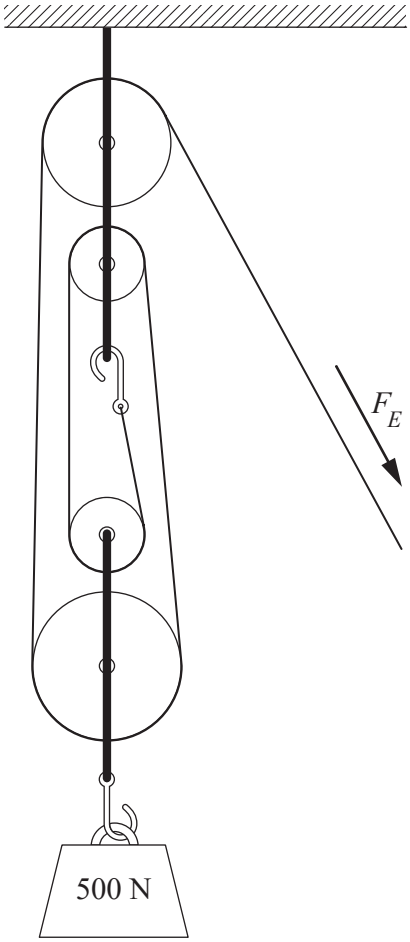
Section 3

Instructions

- Respond showing full working for calculations.
- This section has six questions and is worth 33 marks.

QUESTION 17 (3 marks)

A block and tackle pulley system is shown.



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a) Identify the velocity ratio (VR) of the pulley system. *[1 mark]*

b) Calculate the effort required to raise the load. Assume the system is 100% efficient. *[2 marks]*

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QUESTION 18 (4 marks)

A bottle opener is used to remove the bottle cap from a glass drink bottle. An effort force of 20 N is exerted on the bottle opener to lift the bottle cap by 2.5 mm. The bottle opener has a velocity ratio (VR) of 16 and is 90% efficient.

a) Calculate the load force on the bottle opener. *[2 marks]*

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b) Calculate the work done on the bottle opener to lift the bottle cap. *[2 marks]*

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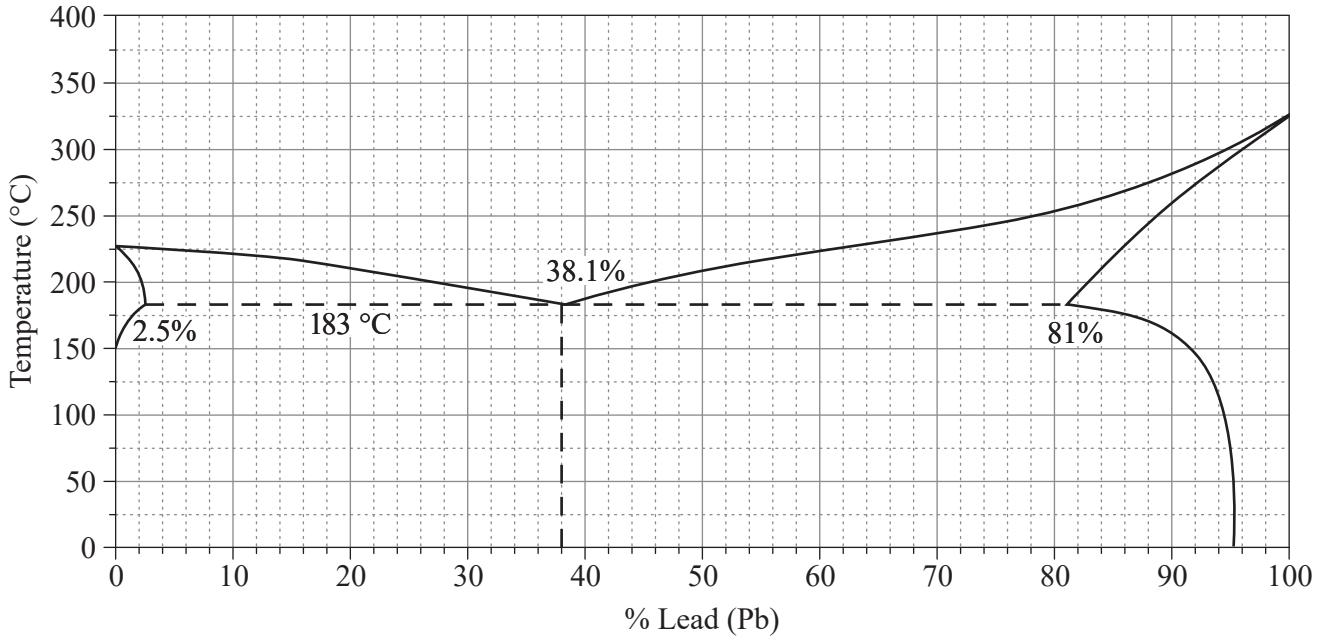
QUESTION 19 (4 marks)

A lead–tin thermal-equilibrium diagram is shown.



a) Identify the percentage of lead in the eutectic composition. *[1 mark]*

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b) Determine the percentages of solid and liquid in a 60% lead alloy at 200 °C using the inverse lever rule. Annotate the diagram to support your response. *[3 marks]*

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

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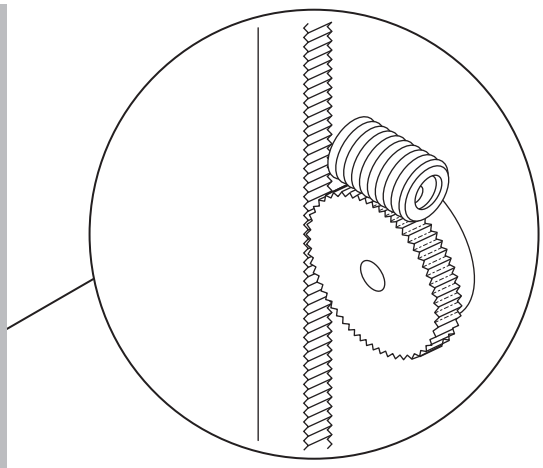
QUESTION 20 (5 marks)

A motor operating a platform lift is connected to a single-thread worm and a worm wheel with 60 teeth and a diameter of 150 mm, as shown. The worm wheel is directly attached to a rack to slowly raise and lower the platform lift. It takes 25 seconds to raise the platform lift to a height of 2 m.

This content has been redacted for copyright purposes.

Redacted image can be viewed online: Redacted image is the diagram of vertical lift from the cover of Serenity Health Care Products (n.d.) *VPL-SH1 Vertical Platform Lift Owner's Manual*, http://www.serenityhcp.com/wp-content/themes/twentyeleven/images/Installation%20Manual%20Standard_Vertical_Lift_Rev%207.pdf



Detail view of worm and gear mechanism

a) Calculate the number of turns of the worm wheel required to raise the platform lift 2 m. *[2 marks]*

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The combined mass of the platform and the load it is lifting is 250 kg.

b) Calculate the work done at the lift to raise the combined mass to a height of 2 m. *[1 mark]*

The motor uses 280 W of power to raise the combined mass to a height of 2 m.

c) Calculate the energy efficiency of the platform lift. *[2 marks]*

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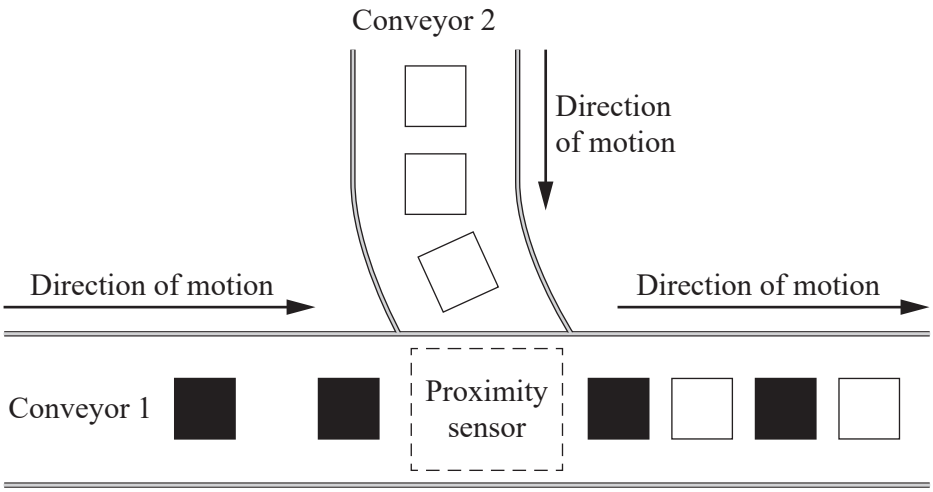
QUESTION 21 (9 marks)

A conveyor belt system is used to transport packages from a factory to a loading bay, as shown.



The conveyor belt system has two conveyors. Conveyor 1 has priority and moves continuously when the conveyor belt system is turned on. Conveyor 2 automatically pauses when the proximity sensor detects a package already travelling on conveyor 1. The conveyor belt system has its own power switch, and the factory also has a main power board to turn off all machines at the end of the day. For the conveyor belt system to operate, both the conveyor belt system and the main power board must be turned on. The conveyor belt system stops when the emergency stop button is activated.

Construct a logic gate circuit for conveyor 2, clearly labelling all inputs and outputs. Complete the corresponding truth table on the next page.

Logic gate circuit

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

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Key

Input A = Main power board (on = 1)

Input B = Conveyor belt system (on = 1)

Input C = Proximity sensor (package detected = 1)

Input D = Emergency stop button (activated = 1)

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

Output X = Power to conveyor 2 (belt on = 1)

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

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

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QUESTION 22 (8 marks)

A child on a sled slides down a snow-covered hill with a 15° incline at an initial velocity of 4 m/s. The combined mass of the sled and the child is 40 kg. The coefficient of kinetic friction between the sled and the snow is 0.35.

Calculate the distance the sled travelled downhill before coming to rest. Include a force diagram to support your response.

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

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END OF PAPER

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ADDITIONAL PAGE FOR STUDENT RESPONSES

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ADDITIONAL RESPONSE SPACE FOR QUESTION 16

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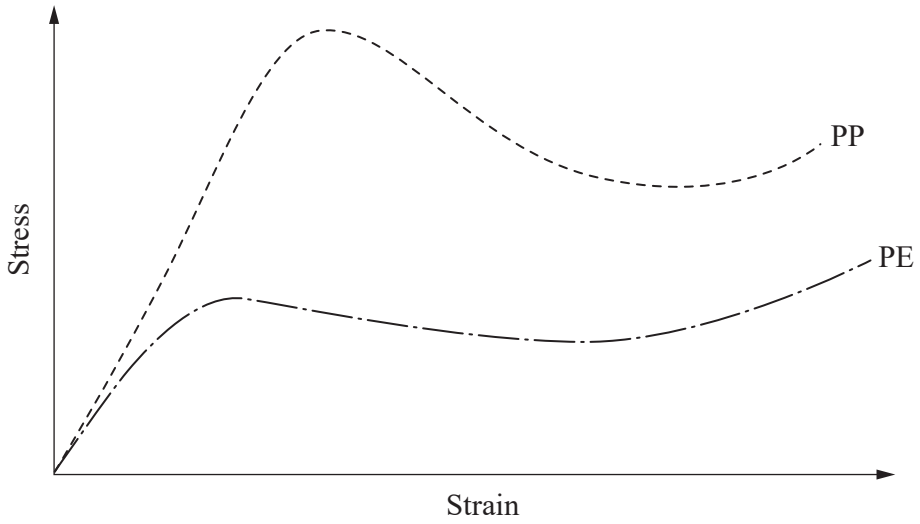

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ADDITIONAL RESPONSE SPACE FOR QUESTION 19

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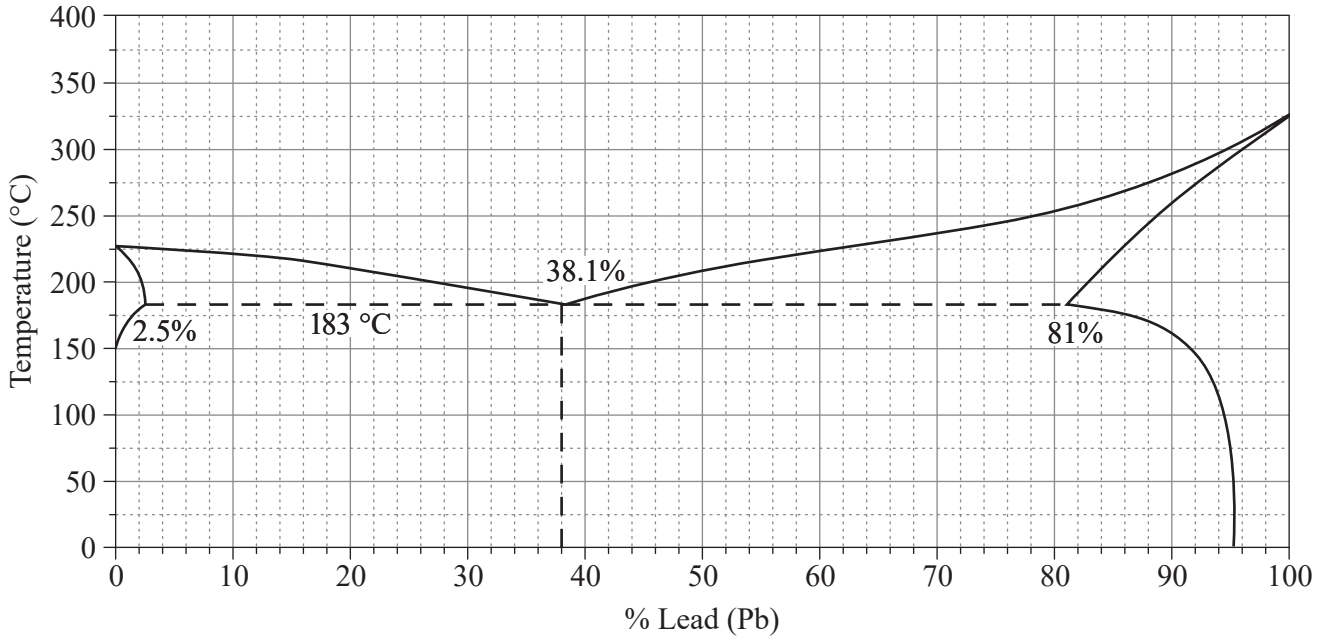

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ADDITIONAL RESPONSE SPACE FOR QUESTION 21

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

Key

Input A = Main power board (on = 1)

Input B = Conveyor belt system (on = 1)

Input C = Proximity sensor (package detected = 1)

Input D = Emergency stop button (activated = 1)

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

Output X = Power to conveyor 2 (belt on = 1)

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

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References

Question 11

Askeland DR, Wright WJ and Fulay PP (2011) The science and engineering of materials, 6th edn, Cengage Learning, Stamford

Callister WD and Rethwisch DG (2013) Materials Science and Engineering. An Introduction, 9th edn, Wiley, New York.

Question 14

Modified from Fig 8 in 'Kok ST, Huat BBK, Noorzaei J, Jaffar MS and Sew GS (2009) 'A Review of Basic Soil Constitutive Models for Geotechnical Application', *Electronic Journal of Geotechnical Engineering*, 14, https://www.researchgate.net/publication/228565882_A_Review_of_Basic_Soil_Constitutive_Models_for_Geotechnical_Application

Question 19

Adapted from Lead Tin phase diagram (Fasediagram) by Woutervermeiren (2006) https://commons.wikimedia.org/wiki/File:Fasediagram_Pb_Sn.png Licensed Creative Commons Attribution-Share Alike 3.0 Unported

Question 20

Serenity Health Care Products (n.d.) VPL-SH1 V*ertical Platform Lift Owner's Manual*, http://www.serenityhcp.com/wp-content/themes/twentyeleven/images/Installation%20Manual%20Standard_Vertical_Lift_Rev%207.pdf