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## External assessment



## 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 and data book provided.
- Planning paper will not be marked.


## Section 1 ( 10 marks)

- 10 multiple choice questions


## Section 2 ( 35 marks)

- 7 short response questions


## Section 3 (40 marks)

- 6 short response questions


## Section 1

## Instructions

- Choose the best answer for Questions $1-10$.
- 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.
- If you change your mind or make a mistake, use an eraser to remove your response and fill in the new answer bubble completely.



## 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 seven questions and is worth 35 marks.


## QUESTION 11 (4 marks)

Explain what is meant by the proportional limit of a material as indicated on a stress-strain diagram. Provide an annotated sketch to support your explanation.
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 on page 20 of this question and response book.

[^0]
## QUESTION 12 (4 marks)

List four properties of polylactic acid (PLA) that make it a useful material for medical implants.
1.
2.
3.
4.

## QUESTION 13 (5 marks)

Explain how the microstructure of a $62 \%$ tin and $38 \%$ lead binary alloy changes during cooling from liquid to solid. Provide an annotated sketch of the microstructure to support your explanation.
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 on page 20 of this question and response book.

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Do not write outside this box.

## QUESTION 14 (6 marks)



Interpret the logic circuit to create the corresponding truth table.
Note: If you make a mistake in the table, cancel it by ruling a single diagonal line through your work and use the additional response space on page 21 of this question and response book.
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## QUESTION 15 (6 marks)

Explain why an engineer would recommend solar-powered water pumps for crop irrigation to a community in a developing country. For three different types of technology knowledge, identify two factors of each to support your explanation.

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## QUESTION 16 (5 marks)



The 15 -tooth gear A drives a gear train used to raise a platform a distance of 1.2 m . The teeth of gear C have a pitch of 10 mm and gear B has 30 teeth. Identify the gear train used and determine the ratio of gear A to gear C. Explain your reasoning.

[^1]
## QUESTION 17 (5 marks)

Explain how the chemical composition of high-carbon steel contributes to two of its mechanical properties in the context of two industrial applications.

[^2]
## Section 3

## Instructions

- Respond showing full working for calculations.
- 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 40 marks.


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## QUESTION 18 (5 marks)

A 900 kg machine is designed to rest without slipping on a slope of up to $30^{\circ}$ on the surface of Mars. The acceleration due to gravity on Mars is one-third of that on Earth.
a) Determine the coefficient of static friction required to keep the machine from slipping on a $30^{\circ}$ incline on Mars. Answer to two decimal places.
[1 mark]
b) Calculate the resulting force of static friction between the machine and Mars' surface. Answer to the nearest whole unit.
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c) Explain what would happen to the coefficient of static friction if the machine was tested on Earth.

## QUESTION 19 (6 marks)

A crane requires 4355 W to vertically lift a full scrap metal bin a distance of 20 m from the ground at constant velocity over a period of 90 s .
a) Determine the mass of the full scrap metal bin to the nearest whole unit.
[3 marks]
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b) Determine the velocity on impact of a 5 kg section of scrap metal that falls to the ground unobstructed from the bin at the top of the lift. Answer to the nearest whole unit.

[^3]
## QUESTION 20 (9 marks)

A double-threaded worm and 40 -tooth worm wheel are used to drive a mechanical winch. The efficiency of the machine is $45 \%$. The pitch of a double-threaded worm is halved.
a) Determine the mass of the load lifted by the winch using an effort of 50 N on the circumference of the worm wheel. Answer to the nearest whole unit.
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b) An effort wheel is added to the worm axle, decreasing the efficiency of the compound machine to $36 \%$. Determine the velocity ratio of the added component. Answer to two decimal places.

## QUESTION 21 (5 marks)



Use and annotate the binary equilibrium diagram for an alloy of metals A and B to calculate the percentage proportion of solid and liquid material present for an alloy of $50 \%$ metal A and B at $1400{ }^{\circ} \mathrm{C}$. Answer to the nearest whole unit.

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 on page 22 of this question and response book.

[^4]
## QUESTION 22 (9 marks)

A bag slides for 3 seconds at a constant velocity of $1 \mathrm{~m} / \mathrm{s}$ down a $20^{\circ}$ luggage chute until it impacts with a cushioning device as shown in the diagram. If the cushioning device is removed, the surface of the chute will need to be modified to slow the bag to a stop at the base of the chute.


Not drawn to scale

Determine the difference between the coefficients of friction for the modified chute and the original with the cushioning device. Answer to two decimal places.
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## QUESTION 23 (6 marks)

An elevator starts from rest and accelerates upwards at a constant rate until the desired velocity of $10 \mathrm{~m} / \mathrm{s}$ is achieved. The mass of the elevator and occupants is 2500 kg . The tension on the elevator cable is 30000 N .
Determine the distance the elevator travels during acceleration to the nearest whole unit (m). Include a force diagram with your working.

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 on page 22 of this question and response book.

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## ADDITIONAL PAGE FOR STUDENT RESPONSES

Write the question number you are responding to.

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## ADDITIONAL PAGE FOR STUDENT RESPONSES

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## ADDITIONAL RESPONSE SPACE FOR QUESTION 11

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## ADDITIONAL RESPONSE SPACE FOR QUESTION 13

If you want this sketch to be marked, rule a diagonal line through the sketch on page 3.


## ADDITIONAL RESPONSE SPACE FOR QUESTION 14

If you want this table to be marked, rule a diagonal line through the table on page 4.
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## ADDITIONAL RESPONSE SPACE FOR QUESTION 21

If you want this diagram to be marked, rule a diagonal line through the diagram on page 12 .


## ADDITIONAL RESPONSE SPACE FOR QUESTION 23

If you want this diagram to be marked, rule a diagonal line through the diagram on page 15 .

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