External assessment 2023

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

Section 1 (10 marks)

- 10 multiple choice questions

Section 2 (30 marks)

- 5 short response written questions

Section 3 (45 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.

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 five questions and is worth 30 marks.

QUESTION 11 (4 marks)

State four contemporary engineering applications for acrylonitrile butadiene styrene (ABS).
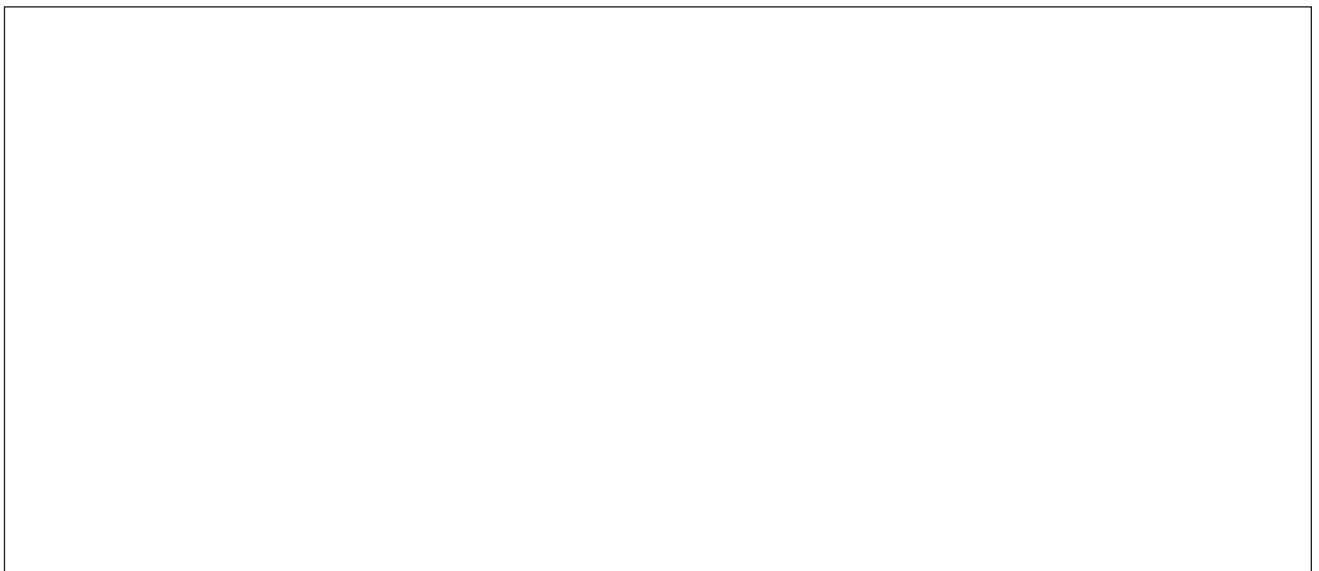
1. _____

2. _____

3. _____

4. _____

QUESTION 12 (5 marks)

Explain how the gearing system on a bicycle provides a mechanical advantage to a cyclist moving up an incline, and the system's effect on the work done on the pedals. Sketch the mechanical components involved to support your response.

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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.

This logic circuit operates an electric motor driven using solar or wind power.
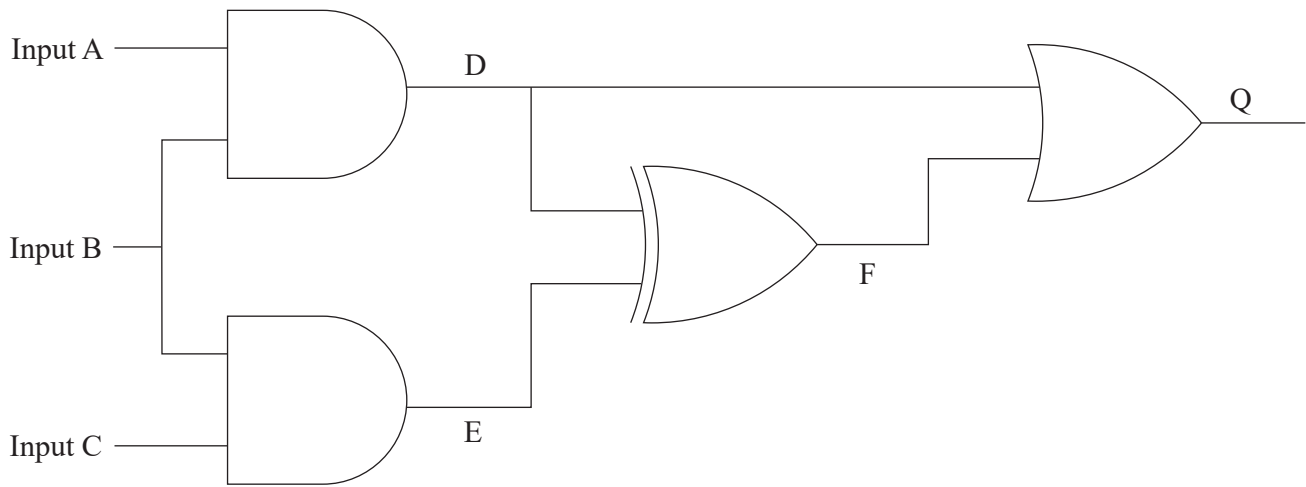
| Key | Input A — solar panel | Input B — timer | Input C — wind turbine |

a)   Complete the corresponding truth table. All inputs to the system are 1 for ON and
     0 for OFF.   *[4 marks]*

A	B	C	D	E	F	Q
0	0	0				
0	0	1				
0	1	0				
0	1	1				
1	0	0				
1	0	1				
1	1	0				
1	1	1				

Note: If you make a mistake in the truth table, 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.

b) Explain how the logic circuit determines which source of power drives the electric motor under each condition for all possible inputs. *[4 marks]*

QUESTION 14 (5 marks)

Explain how a mechanical engineer might use the problem-solving process to develop a solution for automotive components in a production line to be automatically pressed and moved. Support your response with two areas of engineering expertise the engineer could draw on.

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QUESTION 15 (8 marks)

a) Provide an annotated sketch of the microstructures of medium carbon steel at room temperature. *[4 marks]*
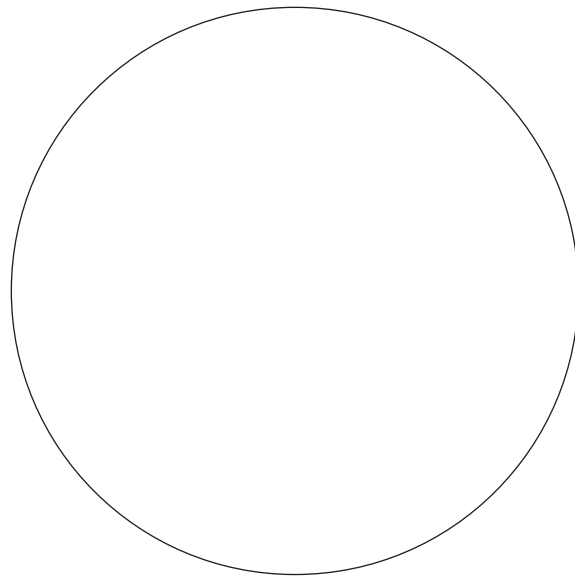
Note: If you make a mistake in the sketch, cancel it by ruling a single diagonal line through your work and use the additional response space at the back of this question and response book.

b) Explain how the microstructures of medium carbon steel demonstrate two mechanical properties that make it a suitable material for train rails. *[4 marks]*

Section 3

Instructions

- Respond showing full working for calculations.
- This section has six questions and is worth 45 marks.

QUESTION 16 (5 marks)

A crane lowers a storage container off the back of a truck at a velocity of 1.5 m/s, giving the container a kinetic energy of 850 J.

Calculate the total mechanical energy of the lowering system when the base of the storage container is 2 m above the ground. Answer to the nearest whole unit.

Do not write outside this box.

QUESTION 17 (9 marks)

A threaded rod with a pitch of 2.5 mm and an outside diameter of 30 mm is used as a mechanism to vertically raise a 40 kg load with a potential energy of 980 J. The threaded rod is directly driven by a variable-speed electric motor with an efficiency of 62%.

Determine the power required from the motor to raise the load in 15 seconds. Answer to one decimal place.

QUESTION 18 (7 marks)

An electric motor with an output force of 600 N is attached to the driver gear of an electric-powered bicycle using a 20 mm diameter drive shaft.

motor drive shaft
20 mm diameter

bicycle wheel
diameter = 700 mm

32-tooth gear
150 mm diameter

8-tooth gear
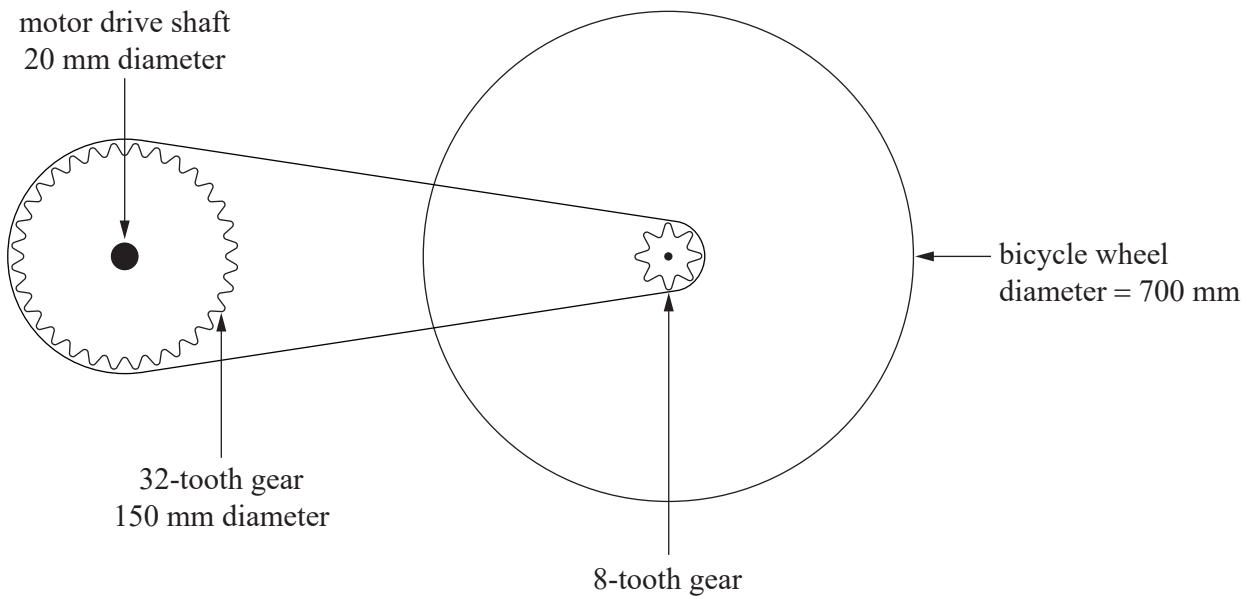
Not to scale

a) Calculate the number of driver gear rotations required for the bicycle wheel to move 15 m. Answer to one decimal place. *[2 marks]*

b) Calculate the number of motor drive shaft rotations required for the bicycle wheel to move 15 m. Answer to the nearest whole unit. *[2 marks]*
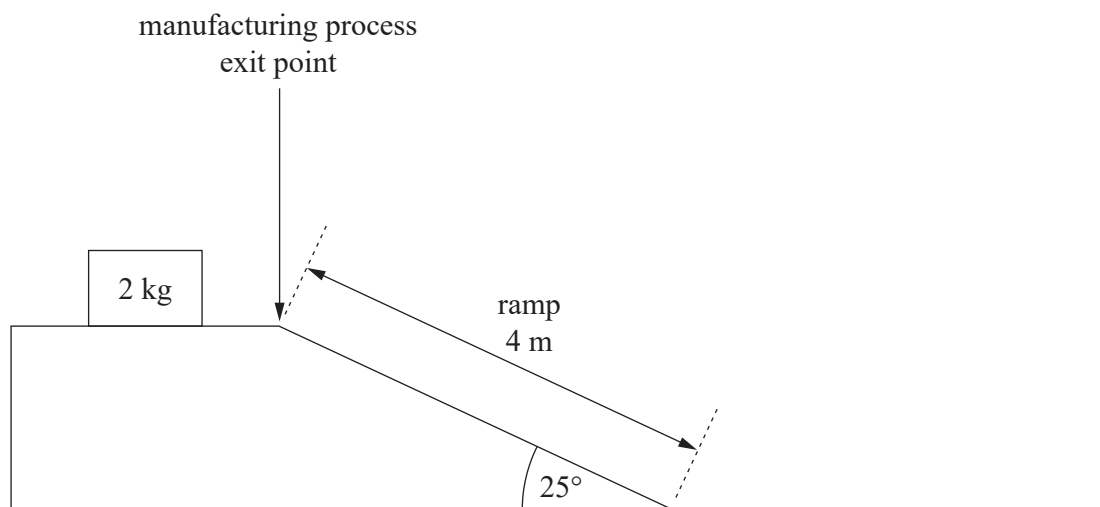
_____

_____

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_____

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c) Determine the output power of the electric motor if the bicycle wheel takes 2 seconds to travel 15 m. Answer to the nearest whole unit. *[3 marks]*

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QUESTION 19 (9 marks)

A 2 kg box exits a manufacturing process at a velocity of 0.5 m/s and then slides down a ramp onto a horizontal surface as shown.

manufacturing process
exit point

2 kg

ramp
4 m

25°

Not to scale

Determine the distance the box slides along the horizontal surface before coming to a complete stop if the coefficient of kinetic friction between the box and all surfaces is 0.35. Answer to the nearest whole unit.

Do not write outside this box.

QUESTION 20 (5 marks)

A 20 kg trolley is pushed up a 10º incline using a force of 160 N.

Determine the coefficient of friction between the trolley and the incline if the trolley is travelling at a uniform velocity. Answer to two decimal places.

QUESTION 21 (10 marks)

A factory uses a two-pump system to vertically lift water into a main reservoir.

The first pump is 80% efficient and lifts 500 litres of water per minute into a holding tank 6 m above the ground. The second pump is 75% efficient and lifts 500 litres of water per minute from the holding tank into the main reservoir 10 m above the ground.

This current system is being replaced with a single-pump system that is 90% efficient and has the same power input as the two-pump system. Determine the rate at which the new system will lift water into the main reservoir. Answer to the nearest whole unit (litres per minute).

Note: 1 litre of water has a mass of 1 kg.

END OF PAPER

ADDITIONAL PAGE FOR STUDENT RESPONSES

Write the question number you are responding to.

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Do not write outside this box.

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ADDITIONAL PAGE FOR STUDENT RESPONSES

Write the question number you are responding to.

Do not write outside this box.

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

A	B	C	D	E	F	Q
0	0	0				
0	0	1				
0	1	0				
0	1	1				
1	0	0				
1	0	1				
1	1	0				
1	1	1				