VCE Systems Engineering 2013–2017

Written examination – November

Examination specifications

Overall conditions

The examination will be sat at a time and date to be set annually by the Victorian Curriculum and Assessment Authority. VCAA examination rules will apply. Details of these rules are published annually in the *VCE and VCAL Administrative Handbook*.

There will be 15 minutes reading time and 1 hour 30 minutes writing time.

The examination will be marked by a panel appointed by the VCAA.

The examination will contribute 30 per cent to the Study Score.

Content

The *VCE Systems Engineering Study Design 2013–2017* is the document used for the development of the examination. All of the key knowledge and key skills that underpin the outcomes are examinable. The examination will assess a representative sample of the key knowledge and key skills.

Format

The examination will be in the form of a question and answer book.

There will be two sections in the examination. All questions will be compulsory.

Section A will consist of 20 multiple-choice questions. Each question will be worth 1 mark. Students will be required to mark their responses on a multiple-choice answer sheet.

Section B will consist of short-answer questions and one extended-answer question (worth 5 marks), and will be worth a total of 80 marks.

The questions in Section B will relate to one or two design/engineering scenarios and the Systems Engineering Process, as illustrated in the study design. There will be a range of question types that will require students to diagrammatically represent systems, perform calculations, plan, design and evaluate. The design scenario(s) in the examination paper will consist of diagrammatic representations and there will be other stimulus material that will take the form of technological systems, equipment, graphs and tables.

There will be one extended-answer question worth 5 marks. This question might relate to the scenario(s) in the examination paper and the Systems Engineering Process or it may be a completely stand-alone question.

All of the questions in the examination paper will relate to previously unseen stimulus material. There will not be any questions directly relating to the student's own work or to the work that was produced for their school-assessed task. However, the key knowledge and key skills related to Units 3 and 4 of Area of Study 2 are examinable.

Approved materials and equipment

A scientific calculator is permitted in this examination.

Advice

The Systems Engineering Process is the basis for developing a systems engineering project. The Systems Engineering Process, as illustrated in the study design, represents the stages in managing and developing a systems engineering project. The process is iterative in that students need to continuously re-evaluate their progress and make necessary modifications after having revisited an earlier stage or activity. The examination will be based on this understanding of the Systems Engineering Process.

The examination will include both mechanical/hydraulic and electrical/electronic systems in approximately equal proportions.

If significant figures are important, they will be asked for in the question. Otherwise, integer or fractional answers will be accepted. The number of significant figures for hydraulics and pneumatics is important.

During the accreditation period for VCE Systems Engineering, examinations will be prepared according to the examination specifications above. Each examination will be an interpretation of these specifications and will test a representative sample of the key knowledge and key skills.

VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education
Year

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER

									Letter
Figures									
Words									

SYSTEMS ENGINEERING

Written examination

Day Date
Reading time: **. ** to **.** ** (15 minutes)**
Writing time: **. ** to **.** ** (1 hours 30 minutes)**

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	20	20	20
B	19	19	80
			Total 100

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied
- Question and answer book of 24 pages including formulas on page 24.
- Answer sheet for multiple-choice questions.

Instructions
- Write your **student number** in the space provided above on this page.
- Check that your **name** and **student number** as printed on your answer sheet for multiple-choice questions are correct, **and** sign your name in the space provided to verify this.
- All calculations must show appropriate formulas and working.
- All written responses must be in English.

At the end of the examination
- Place the answer sheet for multiple-choice questions inside the front cover of this book.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

March 2013

SECTION A – Multiple-choice questions

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.
Choose the response that is **correct** for the question.
A correct answer scores 1, an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.
Unless indicated diagrams are not to scale.

Question 1

A boat winch has a driver gear of 20 teeth and a driven gear of 160 teeth.

What is the gear ratio?

A. 0.125:1
B. 1:8
C. 8:1
D. 16:1

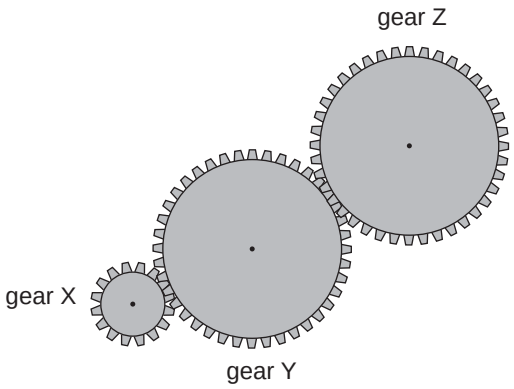
Question 2

When a new product (for example, a new car) is designed for the market, extensive field-testing is usually carried out on the product.

The purpose of this testing is to check whether

A. the product will sell.
B. people will like the product.
C. the product has the right range of colours.
D. the product performs to its design requirements.

Question 3



In the diagram above, if gear X moves clockwise then gear Z will rotate

A. clockwise and faster than gear X.
B. clockwise and slower than gear X.
C. anticlockwise and faster than gear X.
D. anticlockwise and slower than gear X.

Question 4

The correct work sequence to reduce the risk of injury to a person is

A. risk assessment, hazard identification, risk control.

B. hazard identification, risk assessment, risk control.

C. risk assessment, risk control, hazard identification.

D. risk control, hazard identification, risk assessment.

Question 5

A 20-cm-long spanner is used to produce a torque of 60 Nm.

The force applied to the spanner is

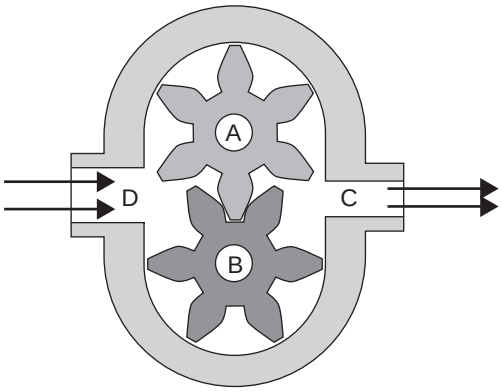
A. 3 N

B. 12 N

C. 120 N

D. 300 N

Use the following information to answer Questions 6 and 7.



Question 6

The hydraulic pump moves fluid from a tank to the outlet.

The rotors A and B have rotary motion that is

A. clockwise for both.

B. anticlockwise for both.

C. clockwise for A and anticlockwise for B.

D. anticlockwise for A and clockwise for B.

Question 7

The fluid pressures are

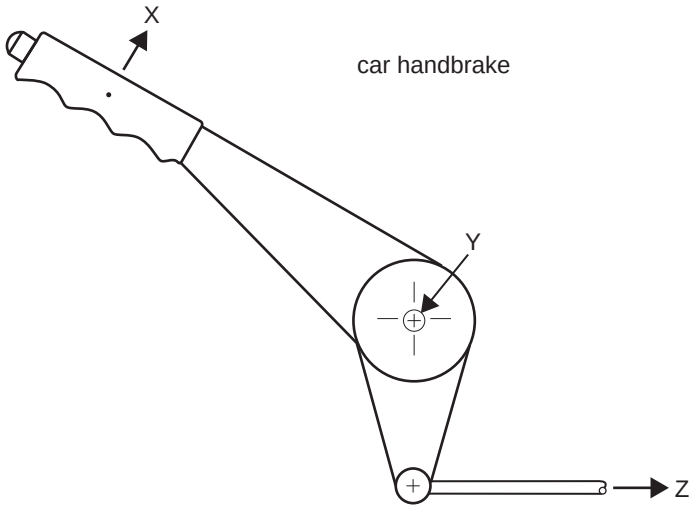
A. zero at point C and point D.

B. the same at point C and point D.

C. high at point C and low at point D.

D. low at point C and high at point D.

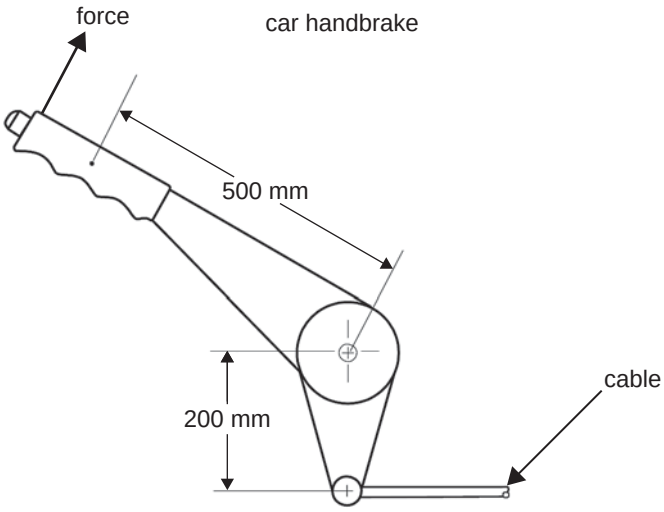
Question 8



On the diagram of the car handbrake lever above, what are the correct positions of the effort, load and fulcrum?

	Effort	Load	Fulcrum
A.	X	Y	Z
B.	Z	Y	X
C.	Y	X	Z
D.	X	Z	Y

Question 9



On the diagram above, the force applied to the handbrake lever by the operator's hand is 40 N.
What is the force applied to the cable?

A. 100 N
B. 200 N
C. 300 N
D. 700 N

Question 10

A semiconductor is used in the construction of

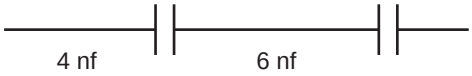
A. a relay.

B. a transformer.

C. a light-emitting diode (LED).

D. an electrolytic capacitor.

Question 11



What is the total capacitance of the circuit shown above?

A. 2 nf

B. 2.4 nf

C. 10 nf

D. 24 nf

Question 12

Batteries can be connected in series or in parallel.

The main reason for connecting batteries in parallel is to increase the

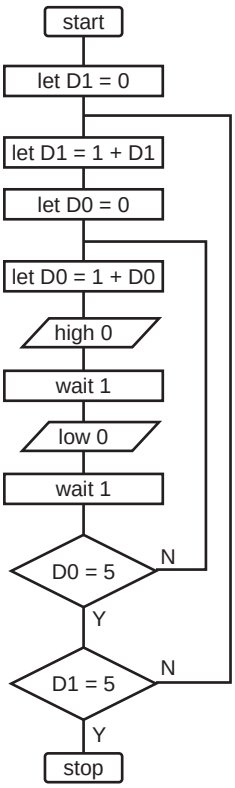
A. current drawn.

B. voltage available.

C. internal resistance.

D. external resistance.

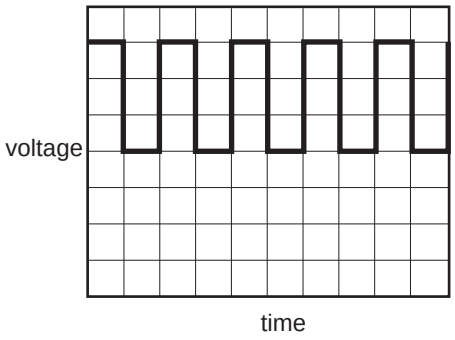
Question 13



A flow chart for a microcontroller program is shown above.
'High 0' turns an LED on. 'Low 0' turns it off. 'Wait 1' is a one-second delay.
How many times will the LED turn on and off in this program?

A. once
B. 10 times
C. 20 times
D. 25 times

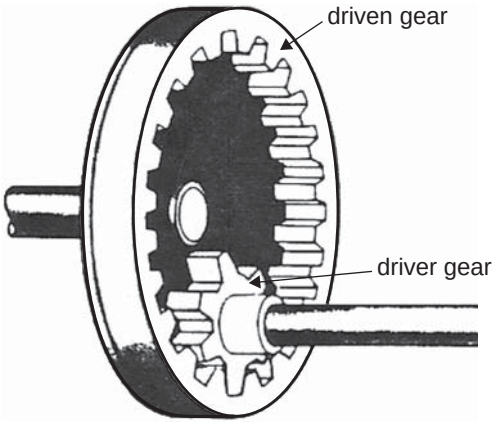
Question 14



The display on a cathode ray oscilloscope is shown above.
Given that the horizontal scale is 0.01 seconds per division and the vertical scale is 2 V per division, the voltage and frequency of the above signal are

A. 3 V and 1 Hz
B. 3 V and 2 Hz
C. 6 V and 50 Hz
D. 6 V and 100 Hz

Question 15



The driver in the gear above has 8 teeth and turns clockwise. The driven gear has 22 teeth.

What is the gear ratio of the driven gear to the drive gear and the direction of rotation of the driven gear?

A. 4:11 clockwise

B. 4:11 anticlockwise

C. 11:4 clockwise

D. 11:4 anticlockwise

Question 16

Solder wire, used in the construction of electronic circuits in the past, contained a metal that is linked to a health hazard.

This hazardous metal was

A. tin.

B. iron.

C. lead.

D. copper.

Question 17

	Forward voltage	**Current drawn**
Green	2.1 V	20 mA
Blue	3.5 V	20 mA

The table above shows the specifications for 5 mm green and 5 mm blue LEDs.

The green LED compared to the blue one

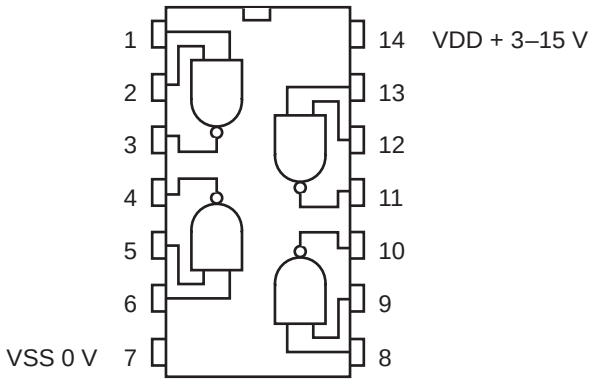
A. has lower resistance.

B. has higher resistance.

C. consumes more power.

D. consumes the same amount of power.

Question 18



The 4011 integrated circuit shown above has four logic gates. To test the logic gate connected to pins 1, 2 and 3, voltage values are measured and recorded as high or low.

Which table below represents the correct operation of that logic gate?

A.

Pin	Voltage
1	low
2	low
3	low

B.

Pin	Voltage
1	high
2	low
3	low

C.

Pin	Voltage
1	high
2	high
3	low

D.

Pin	Voltage
1	low
2	high
3	low

Question 19

An undersized electrical cable is selected to connect a power supply to an operating circuit.

The major hazard that is likely to occur is that the electrical cable will

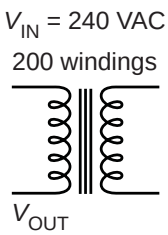
A. break.

B. overheat.

C. short circuit.

D. not have enough resistance.

Question 20



The value of the voltage across the output windings is

A. 12 V

B. 24 V

C. 240 V

D. 2400 V

END OF SECTION A

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided.

Unless indicated the diagrams are not to scale.

The following information relates to Questions 1–18.

A vehicle is to be constructed so that it is powered by an electric engine. There are two main subsystems in the vehicle: the mechanical subsystem and the electrical/electronic subsystem. Two possible outlines of the concept are given in Figure 1.

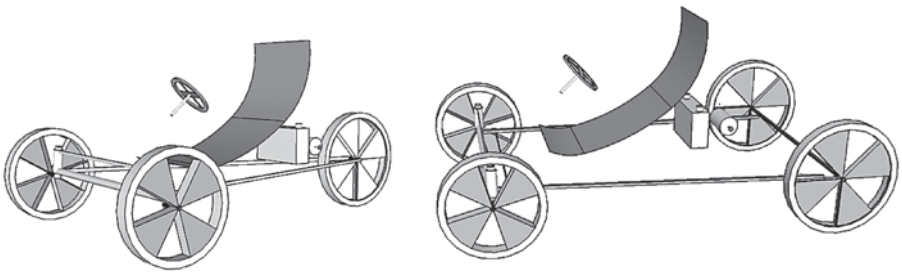


Figure 1

Question 1 (1 mark)

Why is this vehicle considered to be an integrated system?

_____

_____

_____

Question 2 (4 marks)

One performance specification of the vehicle is that it should be able to travel at a constant speed for 140 km.

a. Give two other appropriate performance specifications that could be included in the design brief. 2 marks

1. _____

2. _____

b. Describe a test for one of the performance specifications that you named in **part a.** 2 marks

_____

_____

_____

Question 3 (6 marks)

As shown in Figure 1, the vehicle could be either a three- or four-wheeled vehicle.

a. Discuss **two** issues that would arise when deciding which wheel layout to use. 4 marks

b. The client has decided to construct a three-wheeled vehicle (tricycle).

Give **two** safety considerations that need to be addressed when designing the layout of the tricycle. 2 marks

Question 4 (6 marks)

The builder of the vehicle wants to explore the possibility of powering the vehicle with new technology. He does not want to use fossil fuels. At this stage, the builder does not want to use solar energy.

a. Name two renewable sources of energy (other than solar energy). 2 marks

1. _____

2. _____

b. Explain how one of the renewable sources of energy that you named in **part a.** could be used to power the tricycle. 2 marks

_____

_____

_____

_____

_____

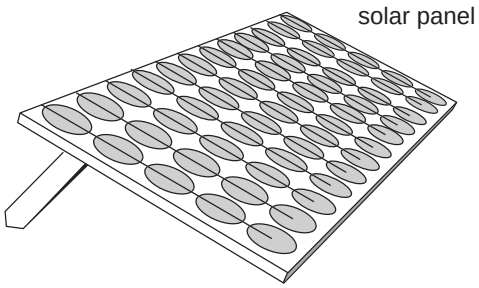
c. Discuss **one** environmental advantage of the renewable source of energy that you described in **part b.** 2 marks

_____

_____

_____

Question 5 (5 marks)



The builder of the vehicle eventually decides to charge the battery using solar panels.

The builder decides to use a 2 m^2 panel that generates a peak output of 100 W.

a. Calculate how many watts of solar power will fall on the solar panel if the solar cells are 20 per cent efficient. 2 marks

The process of charging the battery is 90 per cent efficient. The motor that is used is 85 per cent efficient.

b. Calculate the combined efficiency of the battery system and operating the motor. 1 mark

c. What might be **one** disadvantage of powering the tricycle with solar technology? 2 marks

Question 6 (3 marks)

One design option for the vehicle is to incorporate a self-centring steering mechanism. Another design option is to have the shafts at an angle.

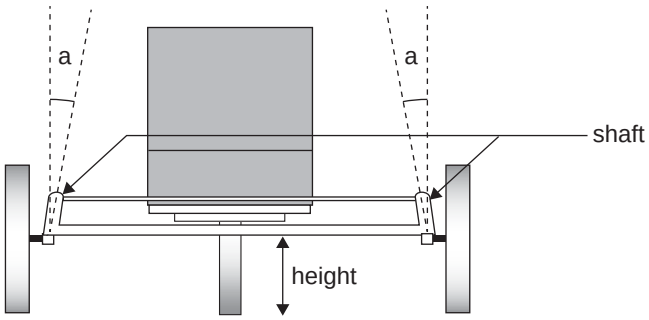


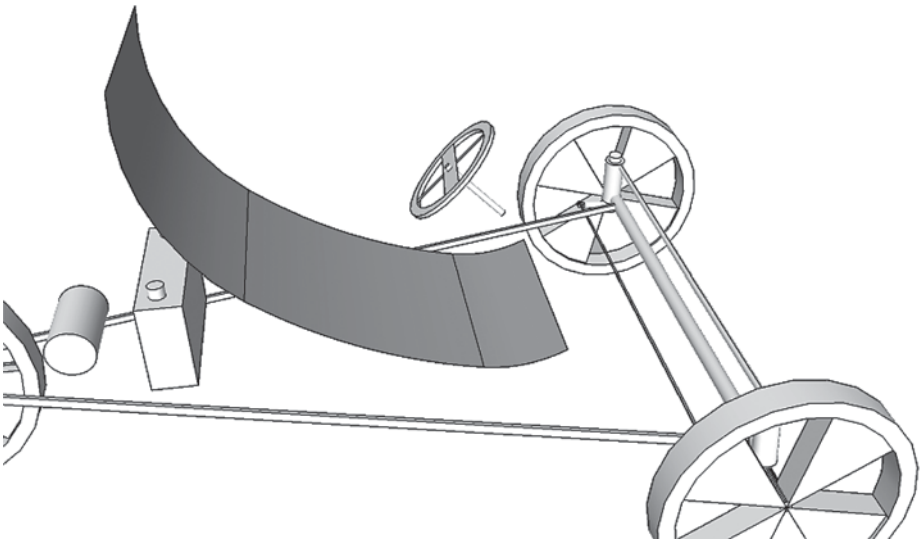
Figure 2

a. What happens to the height of the vehicle when the wheels change direction? 1 mark

b. In terms of potential energy, explain how the self-centring mechanism would work. 2 marks

Question 7 (7 marks)

a. Design a safe steering mechanism for the tricycle. Draw and label the parts on the diagram below. 3 marks



b. List two processes that will be needed to construct the steering mechanism. 2 marks

1. _____

2. _____

c. Give a different safety precaution for each of the processes that you described in **part b.** 2 marks

1. _____

2. _____

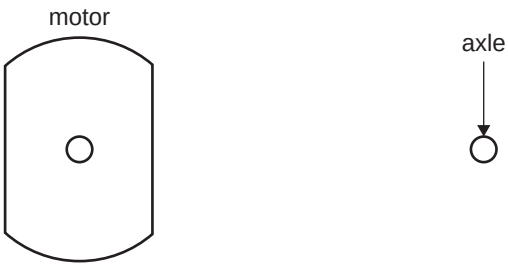
Question 8 (5 marks)

A chain around the two-cog drive system is a design option for the tricycle. Data is shown in the table below.

speed of tricycle	40.0 km/h or 11.1 m/s
rpm of axle	600 rpm
cogs available	teeth from 10 to 60
motor speed	6000 rpm

a. Calculate the circumference of the wheel. 2 marks

b. Draw a drive system on the diagram below that would satisfy the conditions stated in **part a.** and the table above. Give the number of teeth on each cog. Justify your answer by showing relevant calculations. 3 marks



Question 9 (4 marks)

A hydraulic disc braking system is to be used on the vehicle. The diameter of the disc brake cylinder is 60.0 mm and the diameter of the master cylinder is 20.0 mm. The braking system is shown in Figure 3.

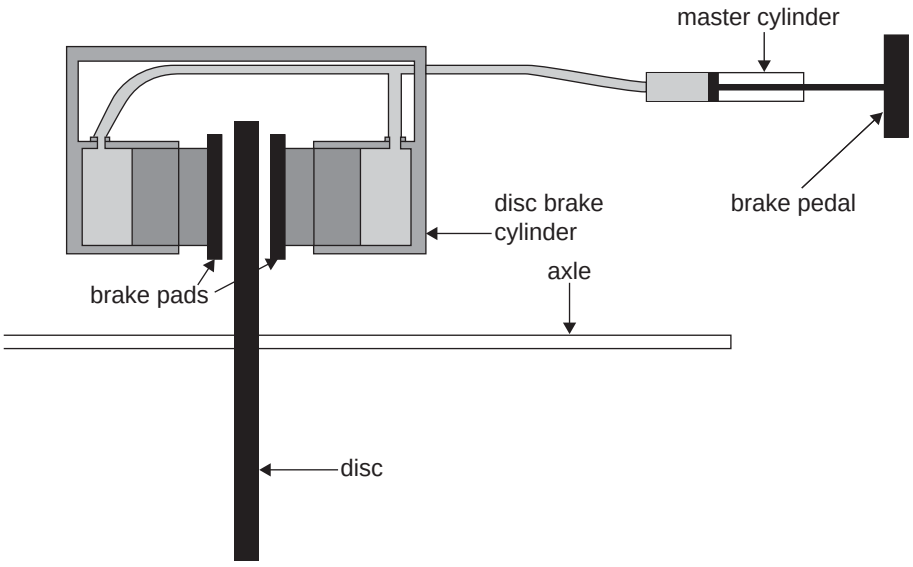


Figure 3

a. Calculate the pressure in the system if a force of 120.0 N is applied to the brake pedal. Include any working and the final units. Give your answer to three significant figures. 2 marks

b. Calculate the force applied to each of the brake pads. Give your answer in newtons (N) and to three significant figures. 2 marks

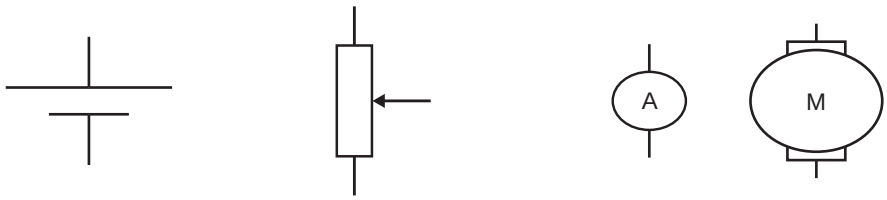
Question 10 (2 marks)

The tricycle is to be powered by a 200 W motor with a supply voltage of 40 V at maximum output. Calculate the current through the motor.

Question 11 (3 marks)

The motor is to be wired up with a switch, battery, ammeter and a potentiometer that is used to vary the speed.

Complete the wiring diagram below.



Question 12 (5 marks)

A graph of power consumption versus speed is given in Figure 4 below.

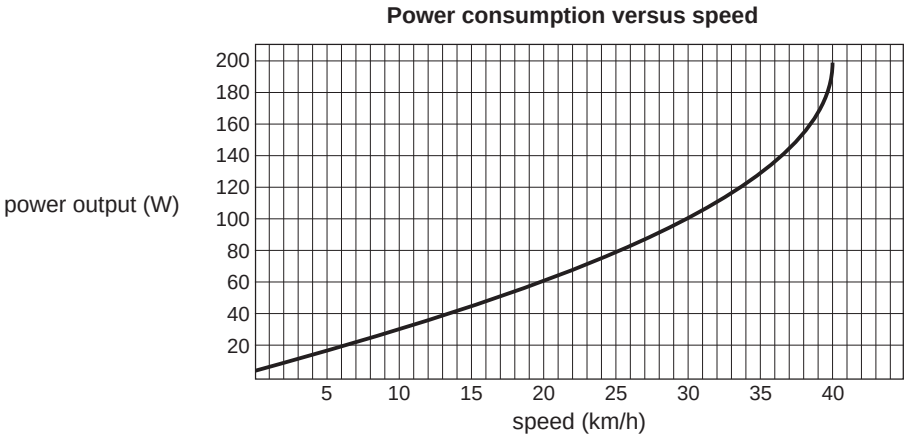


Figure 4

a. Use the information from Figure 4 above to calculate the range of the tricycle if it is to cruise at 25 kmh^{-1}. Assume that a 10 Ah battery is used. 2 marks

b. How far will the tricycle travel at full power? 2 marks

c. Explain why there is a difference in the range of the tricycle at different speeds. 1 mark

Question 13 (4 marks)

The tricycle does not meet the performance specification of having a range of 140 km.

Give two recommendations for changes to the tricycle in order to meet the performance specification above. Justify each recommendation.

1. _____

_____

_____

2. _____

_____

_____

Question 14 (4 marks)

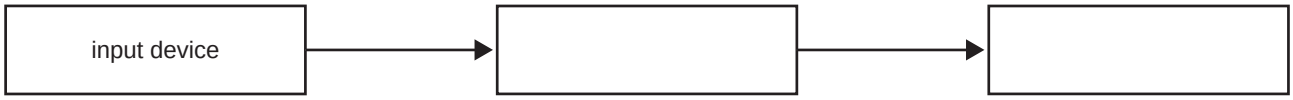
Some of the processes in the construction of the tricycle are shown below.

Using the eight processes given, construct a production sequence for the tricycle.

construction of frame	mounting motor and gearbox
computer-simulation of electronics	simulation of motor and gearbox
construction of steering system	mounting wheels
installation of brakes	wiring the electrical components

Question 15 (7 marks)

In order to maintain the tricycle at a constant speed, a speedometer is required. A systems diagram for a speedometer is given below.



An input device is to be attached to the tricycle to produce the signal shown in Figure 5 below.

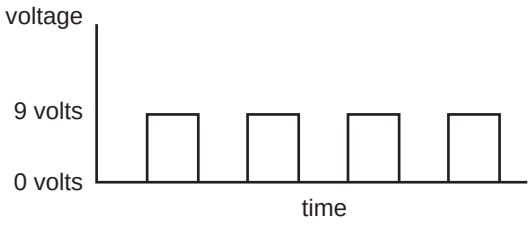
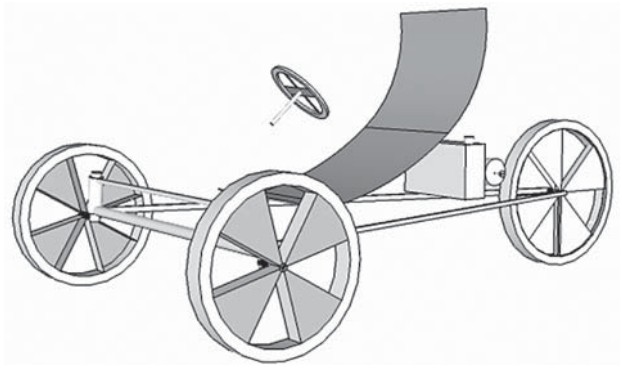


Figure 5

a. Explain why the signal shown in Figure 5 is considered a digital signal. 1 mark

b. Name an input device that can be used on the tricycle to produce the signal shown in Figure 5. 1 mark

c. On the tricycle below, place the input device that was named in **part b.** so that it will generate the signal. 1 mark



d. How many pulses per revolution of the wheel are there for this input device? 1 mark

e. Draw this input device in a circuit diagram so that it will produce the given signal. Label all components. 3 marks

Question 16 (2 marks)

A microcontroller is to be used to convert the signal to give a decimal output that will later be read out on 7-segment displays. The pin configuration of an 18-pin microcontroller is shown in Figure 6.

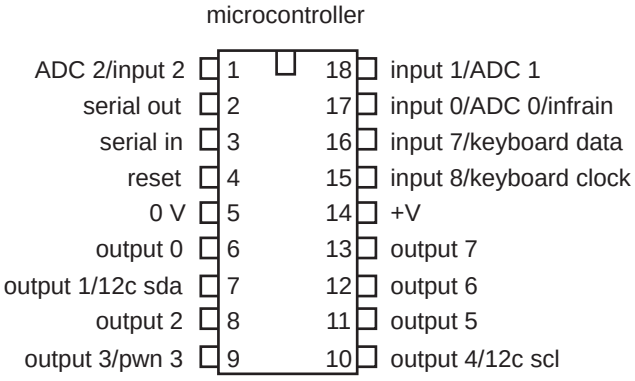


Figure 6

a. Which pin is connected to the voltage supply? 1 mark

_____

b. The signal from the sensor will be connected to a pin.
Name a pin to which the signal can be connected. 1 mark

_____

Question 17 (4 marks)

The microcontroller will need to be programmed to convert the input signal from the sensor into a decimal output that gives the velocity. The input signal is from your input sensor and the circumference of the wheel is 1.2 m.

Draw a flow chart or write a short program to perform the process of converting the input signal from the sensor into a decimal output. Any formula used must be stated.

Question 18 (3 marks)

The microcontroller has a command to convert a decimal output into a 4 bit Binary Count to Decimal (BCD) signal. That is, a binary signal that counts from 0 to 9. Using the 4 bit output pins of the microcontroller, the decimal output can be converted to a BCD signal. (Each decimal digit is represented by a 4 bit byte.)

The pin configuration of the 4511 7-segment driver and a 7-segment display are given below.

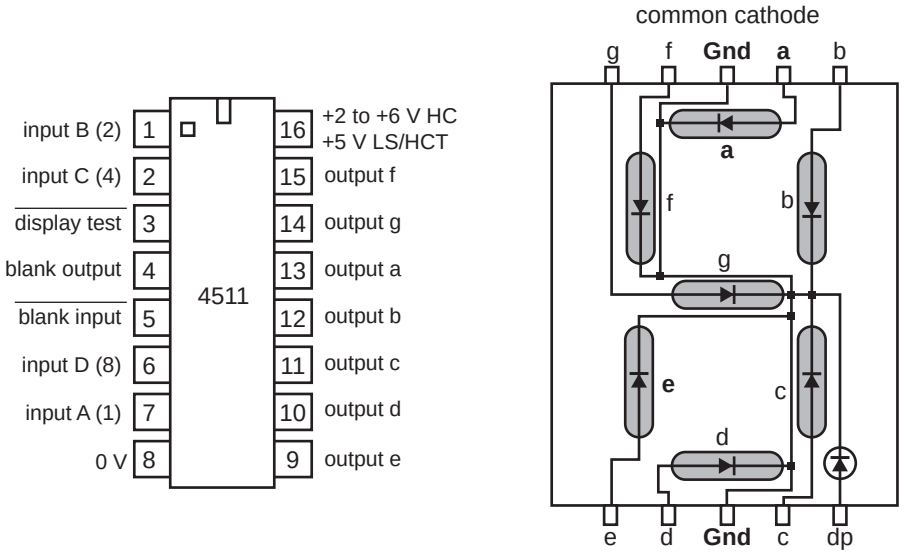
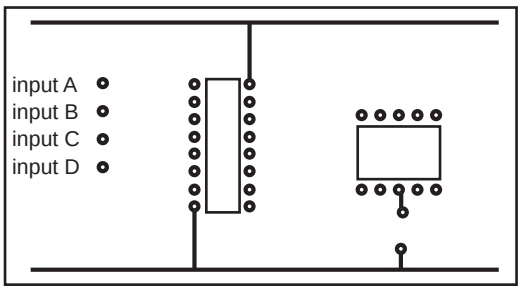


Figure 7

Complete the circuit board diagram below that can convert the microcontroller signal to a 7-segment display. Although not desirable, a single resistor has been put in series with the display.



Question 19 (5 marks)

Emerging technologies include motor vehicles that are considered to be low- or no-emission vehicles. These include the following.

Type 1: Hybrid

A hybrid is powered by a smaller than normal internal combustion engine. Extra power is provided by an electric motor that is supplied by a battery for stop-start city driving and acceleration. This vehicle is considered to be a low-emission vehicle and has a range similar to conventional vehicles.

Type 2: Rechargeable battery

Another type is a vehicle powered entirely by an electric motor that is supplied from a battery and has a range of 80–100 km. The battery can be recharged from mains electricity, therefore emitting no emissions from the vehicle in operation. The vehicle also contains an engine-powered generator that, when activated, can extend the range much further by recharging the battery while being driven. The vehicle is also considered to be low-emission when in the 'engine charging the battery' mode.

Type 3: Mains-only rechargeable battery

A third vehicle on the market is an electric vehicle that is powered entirely by an electric motor that is supplied from a larger battery that gives it a range of approximately 150 km. The battery can be recharged only from mains electricity, therefore emitting no emissions from the vehicle in operation.

Analyse the advantages and disadvantages of using each type of motor in a city environment.

END OF SECTION B

Formula sheet

Gear ratio final = gear ratio 1 × gear ratio 2

$$\text{Efficiency} = \frac{\text{output energy}}{\text{input energy}} \times 100\%$$

Voltage = current × resistance

$$\text{Resistors in parallel: } R_t = \frac{R_1 \times R_2}{R_1 + R_2}$$

Colour codes

Colour	**Value**
black	0
brown	1
red	2
orange	3
yellow	4
green	5
blue	6
violet	7
grey	8
white	9
gold	5%
silver	10%

Resistors in series: $R_t = R_1 + R_2$

Power = voltage × current

Area of circle = πr^2 ($\pi = 3.14$)

Circumference of circle = $2\pi r$

Force = pressure × area

$$\frac{\text{gear A rpm}}{\text{gear B rpm}} = \frac{\text{number of teeth gear B}}{\text{number of teeth gear A}}$$

$$\frac{\text{pulley A rpm}}{\text{pulley B rpm}} = \frac{\text{radius of pulley B}}{\text{radius of pulley A}}$$

$$\text{Speed} = \frac{\text{distance}}{\text{time}}$$

$$\text{Gear ratio} = \frac{\text{number of teeth on driven gear}}{\text{number of teeth on driver gear}}$$

$$\text{Mechanical advantage} = \frac{\text{load}}{\text{effort}}$$

Torque = force × distance

$$\text{Frequency} = \frac{1}{\text{period}}$$

$\text{Efficiency}_{\text{Total}} = \text{Efficiency}_1 \times \text{Efficiency}_2$

END OF QUESTION AND ANSWER BOOK

Answers to multiple-choice questions

Question	Answer
1	C
2	B
3	B
4	B
5	D
6	D
7	B
8	A
9	B
10	C
11	B
12	A
13	D
14	C
15	C
16	C
17	A
18	D
19	B
20	B