Government of **Western Australia**
School Curriculum and Standards Authority

WACE
Western Australian Certificate of Education

Western Australian Certificate of Education Examination, 2012

Question/Answer Booklet

ENGINEERING STUDIES

Stage 3

Please place your student identification label in this box

Student Number: In figures | | | | | | | | | |

In words _____

_____

Time allowed for this paper

Reading time before commencing work: ten minutes
Working time for paper: three hours

Place a tick in one of the following boxes to indicate your specialist field.

Systems and Control ☐
Mechanical ☐
Electronic/Electrical ☐

Number of additional answer booklets used (if applicable): ☐

Materials required/recommended for this paper

To be provided by the supervisor

This Question/Answer Booklet
Multiple-choice Answer Sheet
Document Booklet
Data Book

To be provided by the candidate

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, correction tape/fluid, eraser, ruler, highlighters

Special items: non-programmable calculators approved for use in the WACE examinations, measuring and drawing instruments

Important note to candidates

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

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Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: **Core content** Part A: Multiple-choice Part B: Extended answer	 10 4	 10 3	 10 50	 10 45	 10 25
Section Two: **Systems and Control** Part A: Multiple-choice Part B: Extended answer	 10 4	 10 4	 10 110	 10 105	 10 55
Section Two: **Mechanical** Part A: Multiple-choice Part B: Extended answer	 10 4	 10 4	 10 110	 10 105	 10 55
Section Two: **Electronic/Electrical** Part A: Multiple-choice Part B: Extended answer	 10 4	 10 4	 10 110	 10 105	 10 55
				Total	100

Instructions to candidates

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 12 Information Handbook 2012*. Sitting this examination implies that you agree to abide by these rules.

2. Answer the questions according to the following instructions.

   Sections One and Two, Part A:
   Answer all questions on the separate Multiple-choice Answer Sheet provided. For each question, shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square, then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

   Section One, Part B:
   Write answers in this Question/Answer Booklet. Answer only **three (3)** questions.

   Section Two, Part B:
   You must choose to answer only **one (1)** of the specialist sections.
   Write answers in this Question/Answer Booklet. **All** questions must be answered.

3. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

4. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.
   - Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
   - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

5. The Document Booklet and Data Book are **not** handed in with your Question/Answer Booklet.

See next page

Section One: Core content **35% (45 Marks)**

This section has **two (2)** parts.

Part A: Multiple-choice Answer **all** questions

Part B: Extended answer Answer **three (3)** questions

Suggested working time: 60 minutes.

Part A: Multiple-choice **10% (10 Marks)**

This part has **ten (10)** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided.

For each question shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time: 10 minutes.

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1. An engineering drawing of an object would normally have a scale value shown on the drawing in the form, for example, ‘Scale 1:10’. This can be interpreted as the

   (a) drawing is 10 times larger than the real object.
   (b) drawing is 10 times smaller than the real object.
   (c) dimensions shown on the drawing should be multiplied by 10 when manufacturing the object.
   (d) dimensions shown on the drawing should be divided by 10 when manufacturing the object.

2. The most important aspect of a design solution is its

   (a) safety.
   (b) cost.
   (c) function.
   (d) marketability.

3. The main purpose of a 3D drawing of an object is to

   (a) show the true shape of the object.
   (b) provide a drawing suitable for a machinist to manufacture.
   (c) provide a good impression of the overall shape of the object.
   (d) enable dimensions to be added to the drawing.

See next page

4. A chart used to assist a designer to calculate the total cost for the manufacture of a product made from several component parts should include which columns?

   (a) item, number required, total cost
   (b) number required, unit cost
   (c) item, unit cost, number required and total cost
   (d) item, total cost

5. The safe working load (SWL) shown in a label on a ladder is intended to indicate the

   (a) weight of the ladder.
   (b) maximum weight of the person using the ladder.
   (c) number of times the ladder can be used before being given a safety inspection.
   (d) maximum angle at which the ladder can be placed against a wall.

6. Many components used in engineering design have properties that are labelled with a tolerance, e.g. 100 ± 0.1 mm, 100 ± 5 Ω. The value of the tolerance is intended to

   (a) allow the property to be varied at will in the manufacturing process.
   (b) allow for practical small variations in the manufacturing process.
   (c) indicate to the user that a component may not be fit for purpose.
   (d) require the designer to review the property before manufacturing commences.

7. The selection of the **best** light bulb for use in your bedside reading lamp should be based primarily on its

   (a) power consumption.
   (b) light output.
   (c) life expectancy.
   (d) cost.

8. Items of equipment that are used by people are often designed to meet ergonomic requirements. Ergonomics concerns

   (a) the time taken to perform a task with the equipment.
   (b) the time it takes the user to become proficient with the use of the equipment.
   (c) how the use of the equipment may affect the body of the user.
   (d) the treatment of injuries sustained while using the equipment.

See next page

9. A time line for a manufacturing task describes

(a) a series of dates by which each stage of the task should be completed.
(b) an estimate of the overall time taken to complete the task.
(c) the maximum time before starting on the task.
(d) an estimate of the expected cost to complete each stage of the task.

10. An item of equipment could be described as being recyclable if

(a) it is accepted as waste at the local waste collection depot.
(b) it can be sold on to a new owner.
(c) all of its components can be reused for some other purpose.
(d) all of its components can be reduced to products that can be disposed of in the sewerage system.

See next page

Section One: Core content

Part B: Extended answer **25% (45 Marks)**

This section has **four (4)** questions. Answer **only three (3)** questions. Write your answers in the spaces provided.

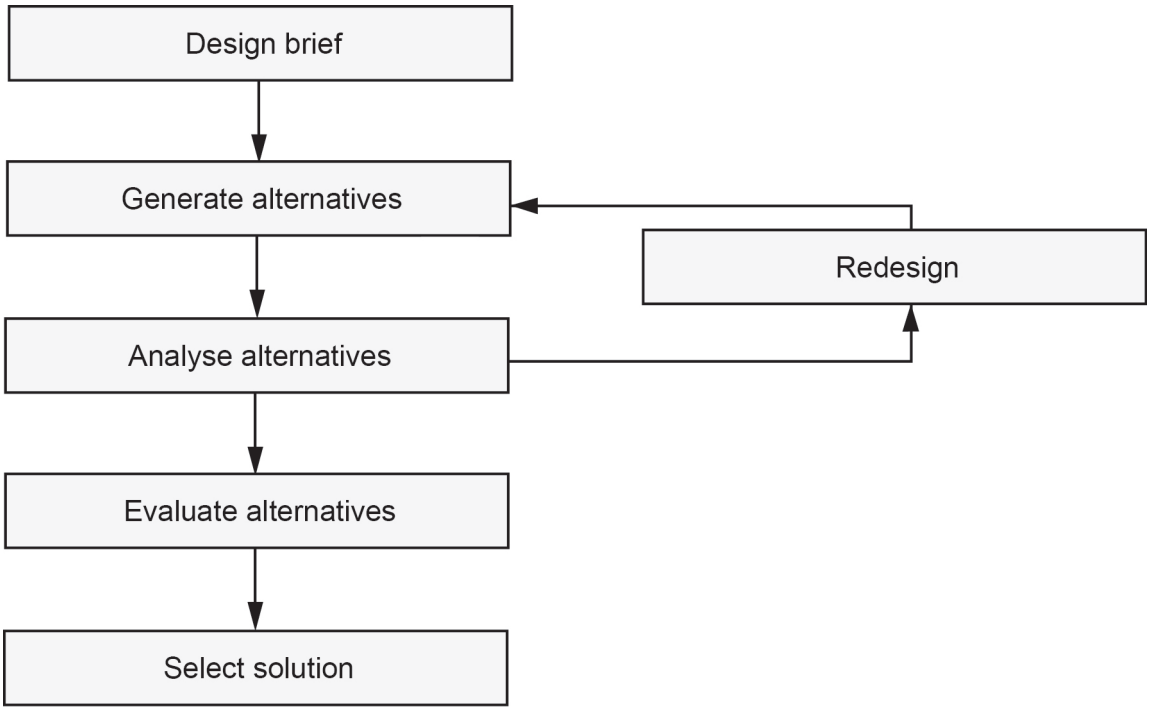
Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time: 50 minutes.

Question 11 **(15 marks)**

The following flowchart diagram describes the process required to complete the design for a product to be manufactured.



(a) Provide a short description of what is commonly taken to be the meaning of each of these steps in the design process. (6 marks)

Design brief: _____

_____

_____

Generate alternatives: _____

_____

_____

Analyse alternatives: _____

_____

_____

Redesign: _____

_____

_____

Evaluate alternatives: _____

_____

_____

Select solution: _____

_____

_____

See next page

(b) You have been given the task of designing a new battery powered torch (flashlight) to be used by security guards as they go check on commercial properties during the night.

List and describe **four (4)** requirements that could be used for the design of this torch. (4 marks)

One: _____

_____

Two: _____

_____

Three: _____

_____

Four: _____

_____

(c) Having produced a number of alternative designs for the torch and analysed each against the nominated performance criteria, you are now ready to evaluate the alternatives. Describe the process you would recommend for this evaluation so that the **best** solution is clearly evident. (5 marks)

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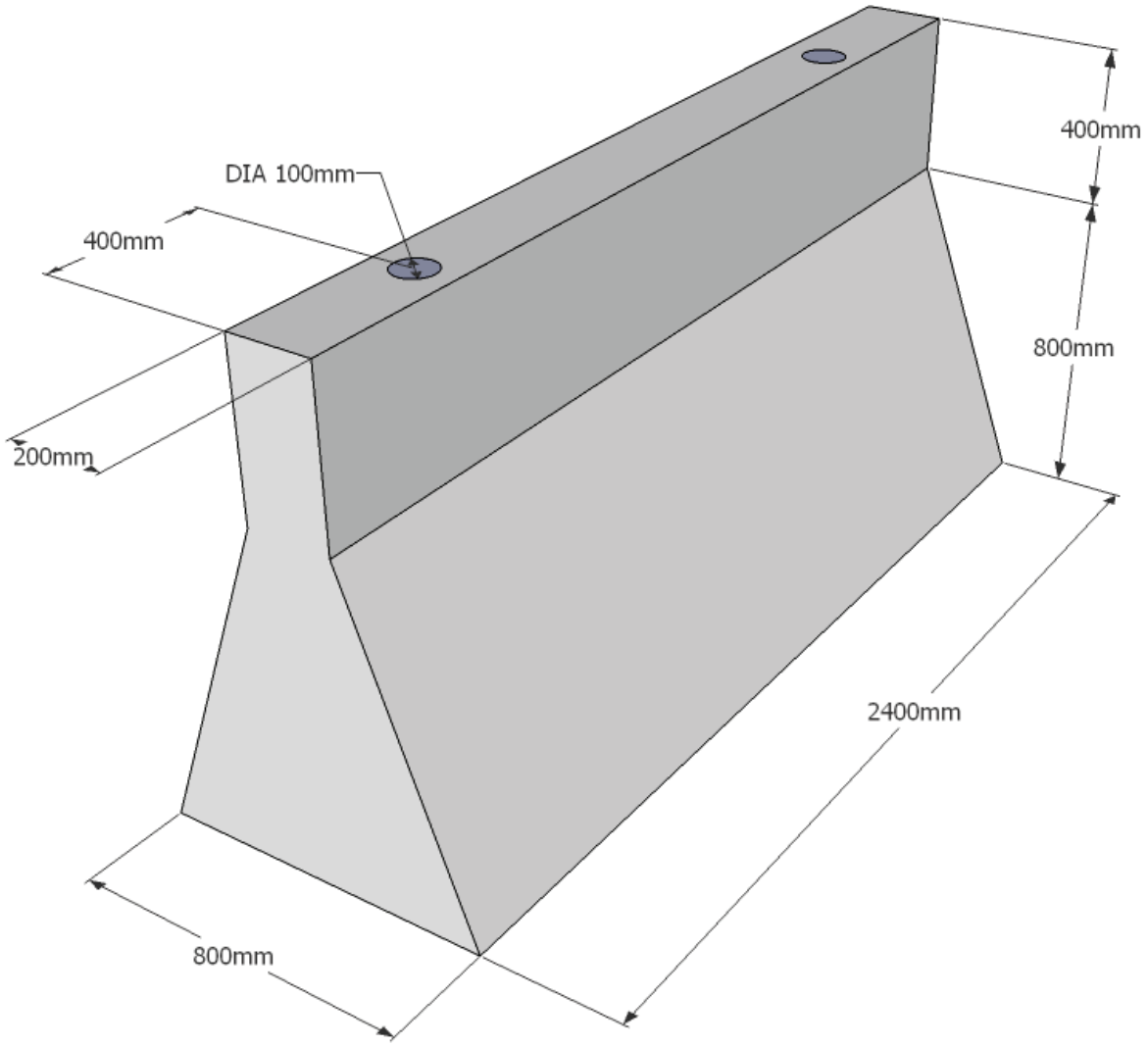
See next page

Question 12 **(15 marks)**

The following diagram shows a 3D view of a traffic barrier module, of the type often seen near roadworks to control the flow of traffic. These traffic barriers are made of a tough impact-resistant plastic and can be filled with water.



The module has a mass of 56 kg when empty. There are two 100 mm diameter holes in the top of the barrier module to allow water to be added. The water can be emptied from a drain valve (not shown in this drawing). Ignore the thickness of walls in all calculations.

See next page

(a) Calculate the total mass of the module when it is filled with water. (6 marks)

(b) On the next page create a top view of the barrier module. Show all dimensions that can be shown on a top view. The grid shown is 200 mm by 200 mm. (5 marks)

See next page

If you wish to have a second attempt at this item, the grid is repeated at the end of the Question/Answer Booklet. Indicate clearly on this page if you have used the second grid and cancel the working on the drawing on this page.

See next page

(c) Provide an explanation as to why it is useful to have a barrier module that can be filled with water. (2 marks)

(d) The water is added to the barrier module from a water tanker truck that has a 100 mm diameter hose that just fits into one of the holes in the top of the module. Explain why a second hole in the top is necessary. (2 marks)

See next page

Question 13 **(15 marks)**

Solar water heaters have been developed, manufactured and used in Australia since the 1950s. They are recognised as a key part of a sustainable home.

A solar water heating system has four basic parts:
1. a collector to absorb thermal energy from sunlight
2. a storage tank to store the collected heat energy in water
3. a circulation system to transfer collected energy from the collector to the tank
4. a booster heater (either electric or gas) to further heat the water if solar radiation is inadequate to ensure sufficient hot water is available on demand.

There are economic and environmental benefits of using a solar water heater. By utilising free energy from the Sun, the solar water heating system provides a financial return via reduced hot water energy bills. It also reduces the environmental impact of producing energy, such as the use of fossil fuel, to heat water. The owner of the solar water heater only uses and pays for the boosting energy when there is a lack of solar radiation. These savings help to pay for the extra cost of the solar water heater over its lifetime. The payback time of solar water heating system can be calculated in either economic or energy terms.

(a) Suppose the solar water heating system has a collector area of 4 m^2 and the average solar power over a clear and sunny day is 500 joules per second per square metre ($J\ s^{-1}\ m^2$).

(i) Show that the total energy received by the solar collector over the day from sunrise (6 am) to sunset (6 pm) is 86.4 megajoules (MJ). (4 marks)

(ii) Convert 86.4 MJ to kilowatt hour (kWh). Show **all** workings.
Hint: power (W) = $\frac{\text{energy (J)}}{\text{time (s)}}$, and 1 J is equal to 1 W s. (2 marks)

See next page

(b) Some electric or gas hot water systems are instantaneous and have no storage. They heat the water as it is required. Why must solar hot water systems have a hot water storage tank? (2 marks)

(c) Suppose a gas-boosted solar water heater and a corresponding sized electric water heater have the following capital costs and yearly operating costs. Assume both systems have the same lifetimes and maintenance costs.

System type	Capital cost	Yearly operating cost
Gas-boosted solar water heater	$4800	$60
Electric water heater	$1200	$360

(i) Calculate the extra capital cost of the solar water heater. Show **all** workings. (1 mark)

(ii) Calculate the annual savings in the operating cost due to the solar water heater. Show **all** workings. (1 mark)

(iii) Calculate the number of years it will take the solar water heater to pay for itself, i.e. when will the savings equal the extra cost? Show **all** workings. (2 marks)

See next page

(d) Consider the following comparison of the operating energy consumption between a solar system and an electric storage water heater over a period of 15 years.

Operating energy (kWh)	
Solar system	Electric system
29 252	118 505

The operating energy is the energy required to heat the water. For the solar system, this is the energy required for boosting.

The life cycle energy includes both the capital and operating energy, and represents the total energy consumed over the lifetime of the water heating system.

The capital energy of the solar system is the energy used to manufacture the solar water heater. This has been estimated to be 3728 kWh.

The energy payback time can be calculated as the capital energy divided by the annual energy saving from the solar system compared with the electric system.

Calculate the energy payback time in years for the solar water heating system. Show **all** workings. (3 marks)

See next page

Question 14 **(15 marks)**

Document 1 'Extract from the National Code of Practice for the Installation of Electric Drives in Vehicles' in the **Document Booklet** should be read in conjunction with this question and used as a primary reference when answering the parts of the question.

(a) What are the front and rear impact acceleration limits specified in the standard for the design of battery restraint systems? (2 marks)

Front: _____

Rear: _____

(b) What is the purpose of battery restraint limits? (1 mark)

_____

_____

_____

_____

(c) A colleague of yours notes that there is no mention in the Code of the reason for the different battery restraint limits. Explain why you think that the limits need to be different. (2 marks)

_____

_____

_____

_____

(d) If lithium batteries are used in a vehicle modification, does the battery box have to be vented? Explain your answer. (2 marks)

Ventilated box (Yes/No): _____

Explanation: _____

(e) You are advised that the DC voltage for the main traction battery pack in a modification meets the HAZV classification in the Guidelines. What is the minimum possible voltage of the pack to warrant this classification? (1 mark)

_____

See next page

(f) What colour must the wiring cable be to comply with the Guidelines? (1 mark)

(g) Referring to Clause 2.10 of the Guidelines, what could happen if it was possible for the driver to remove the ignition key no matter what position it was in? Explain your answer. (2 marks)

Result of action:

Explanation:

(h) An electric drive system is being fitted to a vehicle that normally has four passenger seats. The owner advises you that they do not want to use the two rear seats after the conversion if it means that more batteries can be installed in the vehicle to increase the range. You note that the approved loaded weight for the unmodified vehicle would have been based on four passengers and their luggage.

Assuming that the batteries each weigh 6 kg, calculate how many could be fitted in place of the rear passengers and their luggage allowances. Show **all** workings. (4 marks)

End of Section One

See next page

Section Two: Specialist fields **65% (115 Marks)**

Candidates are required to choose one of the following options, according to which specialist field they studied in 2012.

Tick one of the boxes below to indicate your choice of option.

Specialist field	✓	Question numbers	Pages
Systems and Control	☐	15–28	**19–39**
Mechanical	☐	29–42	**41–57**
Electronic/Electrical	☐	43–56	**59–78**

Now turn to the relevant pages and answer the questions for the specialist field you have selected.

See next page

Section Two: Specialist field—Systems and Control **65% (115 Marks)**

This section has **two (2)** parts.

Part A: Multiple-choice Answer **all** questions

Part B: Extended answer Answer **all** questions

Suggested working time: 120 minutes.

Part A: Multiple-choice **10% (10 Marks)**

This part has **ten (10)** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided.

For each question, shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square, then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time: 10 minutes.

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15. A logic gate with inputs A and B and output $\overline{A+B}$ is commonly called a

    (a) XOR gate.
    (b) NOR gate.
    (c) NAND gate.
    (d) NOT gate.

16. If a typical microprocessor controller is required to drive a 50 mA load from one of its output pins, then it is

    (a) only possible if none of the other outputs on the device are in use.
    (b) always possible regardless of the number of other outputs in use.
    (c) not possible to source or sink such a load current.
    (d) only possible if the microprocessor supply voltage is doubled.

17. If the power supply to a microprocessor is switched off then back on, and it has **not** been programmed to cater for a power interruption, then the

    (a) program resumes at the last instruction being executed before the power was switched off.
    (b) processor restarts the program at the first instruction.
    (c) microprocessor must be reprogrammed because its ROM has been erased.
    (d) result is unpredictable.

See next page

18. In a rack and pinion gear system, if the pinion gear has a circumference of 12 cm and the length of the rack is 288 cm, how far will the rack move if the pinion is rotated 5 times?

(a) 2.4 cm
(b) 12 cm
(c) 24 cm
(d) 60 cm

19. In a typical vehicle power steering system, the driver turns the steering wheel which in turn varies the hydraulic pressure applied to the drive of the front wheel rack and pinion steering linkage. The system is an example of a closed loop control system

(a) only when the driver is considered to be part of the control loop.
(b) only when the driver is not part of the control loop.
(c) irrespective of whether the driver is part of the loop.
(d) only when the vehicle is in motion.

20. If an AC voltage is applied to a diode, the diode will block

(a) the positive component of the signal.
(b) the positive or negative component of the signal, depending on how the diode is wired.
(c) the negative component of the signal.
(d) neither the positive or negative components of the signal, as its purpose is to smooth the input signal.

21. Capacitors are typically connected between control system inputs and ground to

(a) remove unwanted high frequency ‘noise’ voltages.
(b) limit the voltage on the input pins.
(c) rectify the incoming signal.
(d) disable unused inputs.

22. A Proportional Control System would be used in which of the following applications in a typical house?

(i) turning on a fan
(ii) adjusting the temperature of an air conditioner
(iii) setting the timer in a microwave oven
(iv) dimming a light

(a) (i), (ii), (iv)
(b) (ii) and (iv)
(c) (ii), (iii) and (iv)
(d) (ii)

See next page

23. The accuracy of the output from an ADC is primarily determined by the

(a) number of bits used in the conversion.
(b) supply voltage.
(c) magnitude and frequency of the input signal.
(d) output load.

24. In a Pulse Width Modulation System, which of the following vary with changes to the input signal?

(i) the amplitude of the output pulses
(ii) the frequency of the output pulses
(iii) the width of the output pulses
(iv) the energy of the output pulses

(a) (i), (ii), (iii) and (iv)
(b) only (iii) and (iv)
(c) only (iii)
(d) only (iv)

See next page

Part B: Extended answer **55% (105 Marks)**

This part has **four (4)** questions. Answer **all** questions. Write your answers in the spaces provided.

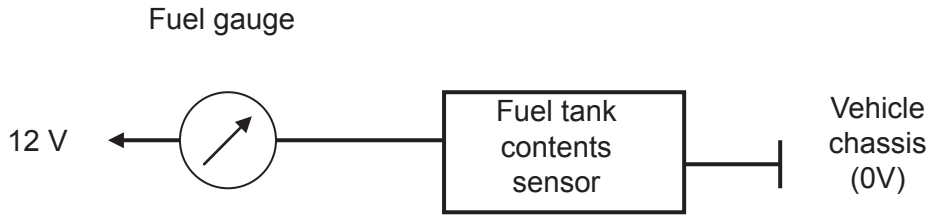
Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question that you are continuing to answer at the top of the page.

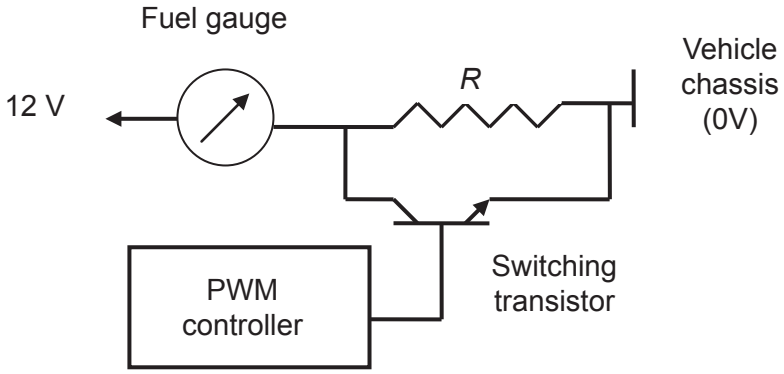
Suggested working time: 110 minutes.

Question 25 **(25 marks)**

You are asked to assist with a project to convert a motor vehicle to electric power drive. The vehicle is fitted with an analogue fuel gauge that is to be reused as an indicator showing the state of charge of the batteries. In the original vehicle, this meter was connected to a variable resistance sensor in the fuel tank. The resistance of the sensor varied from 0 Ω when the tank was empty to 50 Ω when it was full. The equivalent circuit diagram is



You are asked to develop a microprocessor system that will pulse width modulate a switching transistor to vary the resistance and hence the average current flowing through the fuel gauge. The circuit diagram is



See next page

(a) Describe how a Pulse Width Modulation (PWM) controller varies the speed of a typical DC electric motor. (3 marks)

(b) What is the value of the resistor (*R*) required to replicate the performance of the fuel tank sensor? You may assume that the switching transistor has zero resistance when turned on. Explain your answer. (3 marks)

See next page

Question 25 (continued)

(c) If you opt to use a standard 56 Ω resistor (*R*) in your design, what is the PWM mark to space ratio for the fuel gauge to read 'empty'? Explain your answer.

Assume the mark condition is a logical one, or high, output from the microprocessor.

(3 marks)

Mark to space ratio: _____

Explanation: _____

(d) What is the PWM mark to space ratio for the fuel gauge to read 'half full'?

Use the same assumptions as in Part (c) above, and also assume that the resistance of the original fuel tank sensor varied linearly with the volume of fuel. Show **all** workings.

(4 marks)

See next page

(e) Assuming that the state of charge has been input into the microprocessor and stored as a variable between 0 and 100, create a flow chart that will convert the state of charge value into the required PWM output format. (8 marks)

Hint: Assume all mark/space pairs add up to 100 divisions. For example, half charge is 50:50.

See next page

Question 25 (continued)

(f) Describe an alternative hardware solution using a servo-motor and any other components you feel are necessary, that could be used in place of the PWM solution.

(2 marks)

(g) Would you use your alternative solution in preference to the PWM solution? Explain your answer. (2 marks)

Use alternative solution? (Yes/No): _____

Explanation: _____

See next page

Question 26 **(25 marks)**

Document 2 in the **Document Booklet** 'The NMB-MAT Stepper Motor' should be read in conjunction with this question when answering the parts of the question.

(a) List **three (3)** advantages that a belt drive has over a chain drive. (3 marks)

One: _____

_____

_____

Two: _____

_____

_____

Three: _____

_____

_____

(b) Describe **one (1)** advantage that a chain drive has over a belt drive. (1 mark)

_____

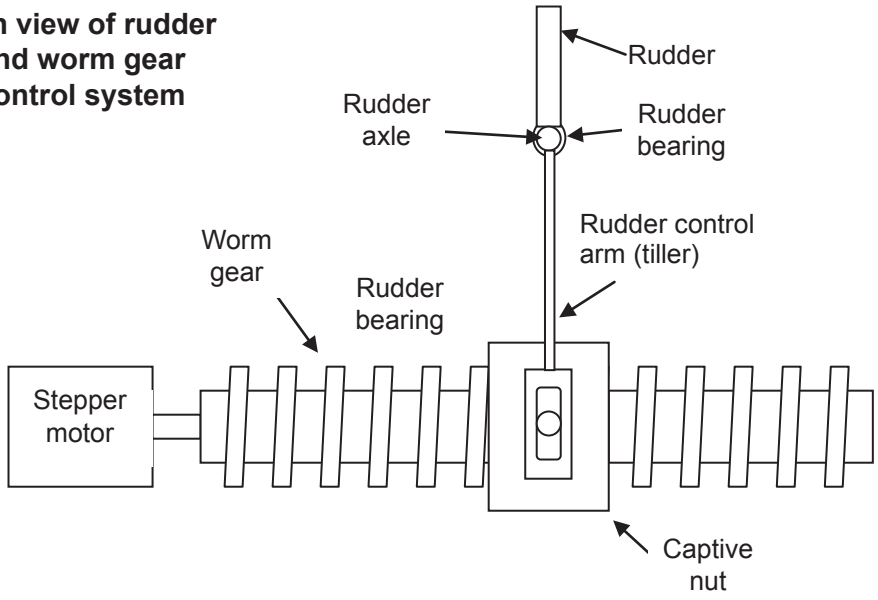
_____

_____

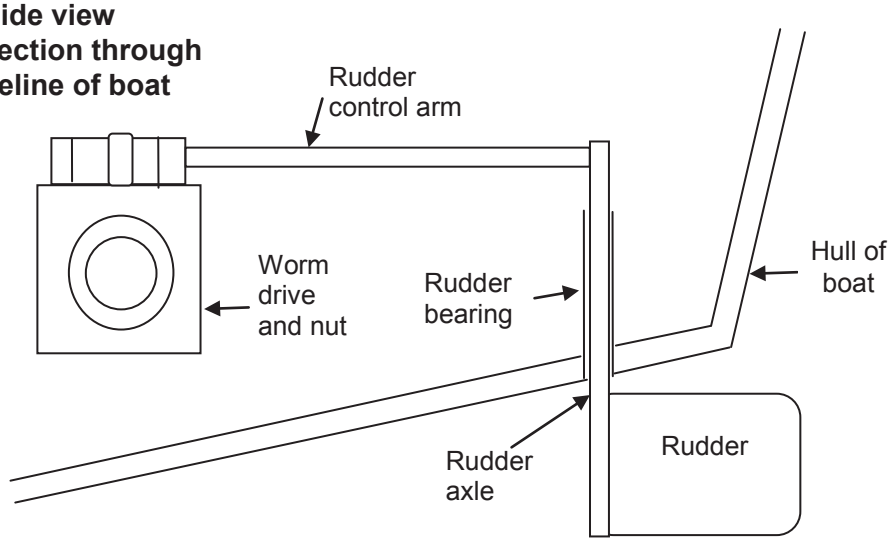
Question 26 (continued)

(c) A worm gear driven by a stepper motor is used in a steering control system for a model boat. The captive nut is directly connected to the steering arm of the rudder.

Plan view of rudder and worm gear control system



Side view cross section through centreline of boat



See next page

(i) The pitch of the thread is 5 mm and the length of the shaft is 100 mm. How far will the drive's captive nut move if the shaft is rotated 180°? Show **all** your workings. (2 marks)

(ii) If the stepper motor was stepped 20 times to achieve the rotation in (i), what are the degrees/step for the stepper motor? (2 marks)

(iii) The torque on the rudder shaft when the boat is travelling at maximum speed and at maximum rate of turn is 1200×10^{-4} N m. If a PM55L-048 Uni-Const Ferrite Plastic Magnet (MSPL) motor is used in the application, what is the maximum frequency (pulses per second) that the stepper motor could be expected to handle?

The specifications for the motor are in the **Document Booklet**. (1 mark)

(iv) If an alternative motor was used that was torque limited in this application to a maximum frequency of 250 pulses per second and the shaft rotates 10° each step, how long would it take it take to move the rudder from being centred to full deflection? Assume that the motor is torque limited for the entire period. Show **all** workings. (7 marks)

See next page

Question 26 (continued)

(v) Describe **two (2)** possible modifications that could be made to reduce the torque load on the motor. Indicate clearly the principle involved in each modification and what the impact would be on the performance of the steering system of each modification. (6 marks)

One: _____

Two: _____

(d) The relative humidity (RH) in a marine environment can approach 100%. Is the PM55L-048 motor suitable for this application? Explain your answer. (3 marks)

Suitable (Yes/No): _____

Explanation: _____

See next page

Question 27 **(30 marks)**

You are asked to build a system to measure the current drain from the batteries in an electrically-powered vehicle. The peak current drain is 1000 A DC. You are given a current sensor that provides a linear voltage output between 0 V (0 A) to 5 V (1000 A). The output of the sensor is to be directly connected to an ADC (Analogue to Digital Converter) input of a microprocessor.

You are given the choice of two different microprocessors to use. One device has an 8 bit ADC and the other a 12 bit ADC but costs twice as much. The minimum resolution of the 8 bit ADC is 19 mV and the 12 bit ADC is 1.2 mV. The required resolution is ± 0.5 A.

(a) Each ADC outputs 0 when the input voltage is 0 V. Show that the maximum number output by the ADC (associated with the maximum current reading) has to be at least 2000 (decimal) to achieve the specified current resolution. (2 marks)

(b) Using the maximum output number in Part (a), show that the resolution required from the ADC is approximately 2.5 mV. Show **all** workings. (3 marks)

See next page

Question 27 (continued)

(c) On the basis of your answer to Part (b), which microprocessor would you use to achieve the resolution required? Explain your answer. (2 marks)

Chosen microprocessor: _____

Explanation: _____

(d) A system is to be fitted with a microprocessor based controller that monitors the power being used and shuts it down if pre-set limits are exceeded. The following design requirements have been specified for the monitor:

- The microprocessor is required to drive an LCD display via its serial port, a LED over-current warning indicator and a relay that is used to turn the system on.
- The relay is to be turned on once the microprocessor has been initialised.
- The current is to be sensed once a second and the LCD updated with the new value.
- Should the current reading exceed 1000 A, the LED is to be turned ON.
- Should the current exceed 1200 A for more than a minute, the relay is to be turned off.

(i) Construct a flow chart that incorporates these requirements. (9 marks)

See next page

(d) (ii) Will the monitor cause the system to fail safely under all conditions if the power supply circuit to the microprocessor fails? Assume that the system is safe when it is powered down. Explain your answer. (2 marks)

Yes/No: _____

Explanation: _____

_____

_____

_____

_____

(iii) Will the monitor cause the system to fail safely under all conditions when the power supply to the microprocessor device is normal?

Identify **two (2)** fault conditions that support your answer and explain what happens in each of these conditions. Assume that the system is safe when it is powered down. (5 marks)

Yes / No: _____

Fault condition one: _____

Explanation: _____

_____

_____

_____

_____

Fault condition two: _____

Explanation: _____

_____

_____

_____

_____

See next page

Question 27 (continued)

(e) How you would interface the relay to the microprocessor? Include a circuit diagram in your answer showing each of the components involved. Describe the purpose of all components except the microprocessor and relays. (5 marks)

(f) The over-current warning LED is connected to the microprocessor output pin via a dropping resistor. The voltage on the output pin is 4.5 V in the high (LED On) state. The voltage drop across the LED when it is conducting is 1.2 V.

Calculate the value of the dropping resistor such that the current flowing into the microprocessor is limited to 10 mA. Show **all** workings. (2 marks)

See next page

Question 28 **(25 marks)**

(a) Show how to construct the following gates using just NAND gates by drawing the correctly connected components.

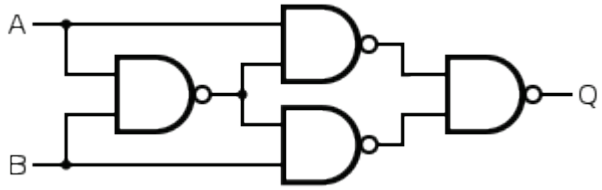
(i) **NOT gate**
Use A to describe the input and 'Q' the output, and show clearly what any unused inputs are connected to (logic 1 or 0) to produce the desired result.
(2 marks)

(ii) **OR gate**
Both A and Not A, and B and Not B are available to be used as inputs as you see fit, and Q is to be used to describe the output. Show clearly what any unused inputs are connected to (logic 1 or 0) to produce the desired result. (2 marks)

See next page

Question 28 (continued)

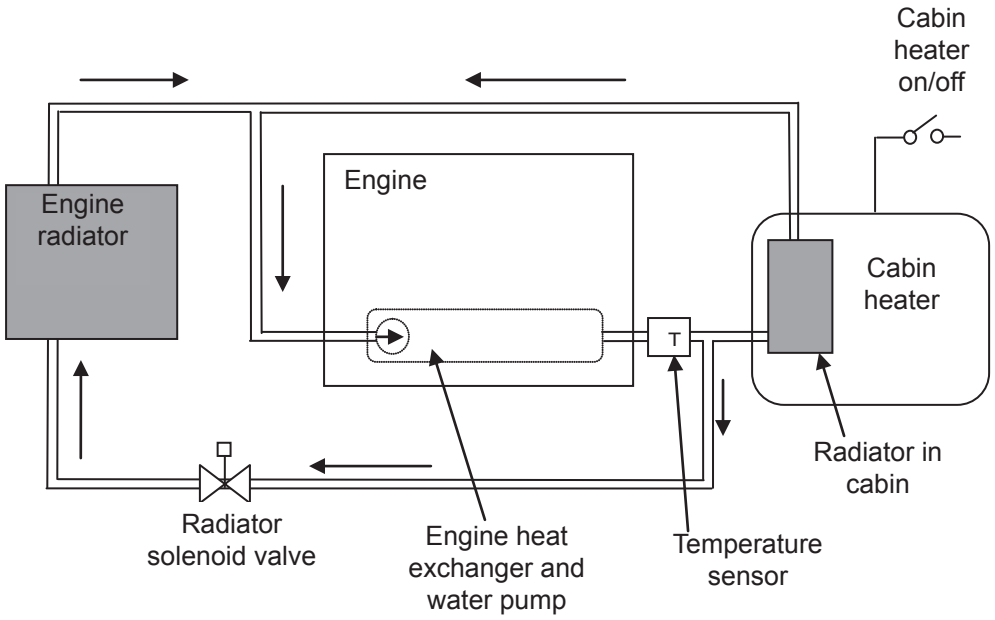
(b) Complete the truth table for the following circuit. What logic building block does it perform? (3 marks)



Input A	Input B	Output Q

Logic block function: _____

(c) You are asked to design a control system that will use the heat from an engine water cooling jacket to provide cabin heating in a vehicle when the driver turns on the heater. A diagram of the proposed system is as follows.



The heat from the cooling jacket water is dissipated through a radiator mounted in the front of the vehicle when the cabin heater is **not** in use and the cooling water temperature varies with the ambient temperature and the power produced by the engine but usually does not exceed 50°C. The water temperature needed for adequate cabin heating is 80°C. The temperature of the water can be raised by switching off the radiator solenoid but leaving it off will cause the water to boil.

The radiator solenoid is to be turned on (output Q = True) whenever:

- the engine is running (Input A = True) and the cabin heater is off (Input B = False)

or

- the cabin heater is on (Input B = True) and the water temperature has exceeded 80°C (Input C = True).

(i) Construct a logic diagram that shows how these signals can be connected to logic gates to achieve the desired result. Label each signal input according the conventions above and each logic gate with its type. (5 marks)

Note: Use only the logic elements described in the **Data Book**.

See next page

Question 28 (continued)

(ii) Construct the truth table for the control of the radiator solenoid. (4 marks)

A	B	C	Q

(d) In order to reduce the load on the engine cooling system as described in Part (c), you are also requested to provide an interlock so that the heater solenoid is only able to be turned on by the driver when:

- the ambient air temperature outside the vehicle exceeds 40°C; and
- the heater control has been selected and the engine is running.

Why is it **not** necessary to include the engine running as one of the inputs to the logic circuit when the heater is operated? Explain your answer. (3 marks)

Why it is not necessary: _____

Explanation: _____

_____

_____

_____

(e) When the control system for the radiator solenoid is built and tested, it is noted that the solenoid valve is switching on and off every couple of seconds when the cabin heater is turned on. This could cause premature failure of the solenoid.

(i) Explain why this is happening. (2 marks)

(ii) Describe a possible solution to the problem and explain briefly how it would work. (2 marks)

Solution:

How it works:

(iii) Would you use a programmable controller or retain a hardwired design approach? Circle your choice, and explain your answer. (2 marks)

Programmable controller Hardwired design

Explanation:

End of Section Two: Systems and Control

See next page

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See next page

Section Two: Specialist field—Mechanical **65% (115 Marks)**

This section has **two (2)** parts.

Part A: Multiple-choice Answer **all** questions

Part B: Extended answer Answer **all** questions

Suggested working time: 120 minutes.

Part A: Multiple-choice **10% (10 Marks)**

This part has **ten (10)** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided.

For each question, shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square, then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time: 10 minutes.

---

29. A pin jointed truss carries its applied loading by a combination of

    (a) bending moments.
    (b) shear forces.
    (c) axial forces.
    (d) gravity forces.

30. If an object is moving in a straight line at constant velocity, it can be described as being in a state of

    (a) acceleration.
    (b) equilibrium.
    (c) instability.
    (d) zero gravity.

31. Compared with structural steel, copper can be described as being

    (a) stiffer.
    (b) less dense.
    (c) stronger.
    (d) more ductile.

32. In a tensile test of a steel specimen, the amount of energy absorbed by the specimen during the test is found from the

    (a) area under the load-extension graph.
    (b) area under the stress-strain graph.
    (c) total force multiplied by the total extension.
    (d) maximum stress divided by the maximum strain.

See next page

33. A uniformly distributed load placed on a beam is best described as a force that

(a) is applied at regular intervals along the beam.
(b) results only from the self weight of the beam.
(c) is applied uniformly along a part of the beam.
(d) is applied at the mid and quarter points of the span of the beam.

34. The SI unit used to describe energy is the joule. An alternative is
(a) newton-metre.
(b) newton per metre.
(c) watt per metre.
(d) watt.

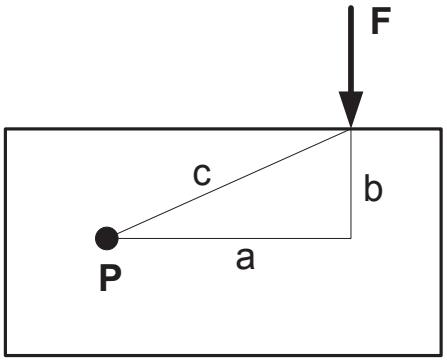
35. If the factor of safety for the design of steel bolts is 1.5, and it is known that a 10 mm diameter bolt will fail at a load of 100 kN, you would expect the diameter of a bolt to safely carry 100 kN will be at least

(a) 15.2 mm.
(b) 14.1 mm.
(c) 12.2 mm.
(d) 11.4 mm.

36. The units of stress for a member of a structure with a tensile force in it are

(a) kg m^{-2}.
(b) kg m^2 s^{-2}.
(c) kg^2 m s.
(d) kg m^{-1} s^{-2}.

37. The following diagram shows a force (F) acting on a rectangular object.



The moment of the force F about a point P is best described by

(a) F × a.
(b) F × b.
(c) F × c.
(d) F × (a+b).

See next page

38. If a ball with mass of 0.1 kg is thrown upward and reaches a height of 20 m above ground before falling back to the ground, its potential energy when at its highest point is closest to

(a) 19.6 J.
(b) 30.4 J.
(c) 50.0 J.
(d) 69.6 J.

See next page

Part B: Extended answer **55% (105 Marks)**

This part has **four (4)** questions. Answer **all** questions. Write your answers in the spaces provided.

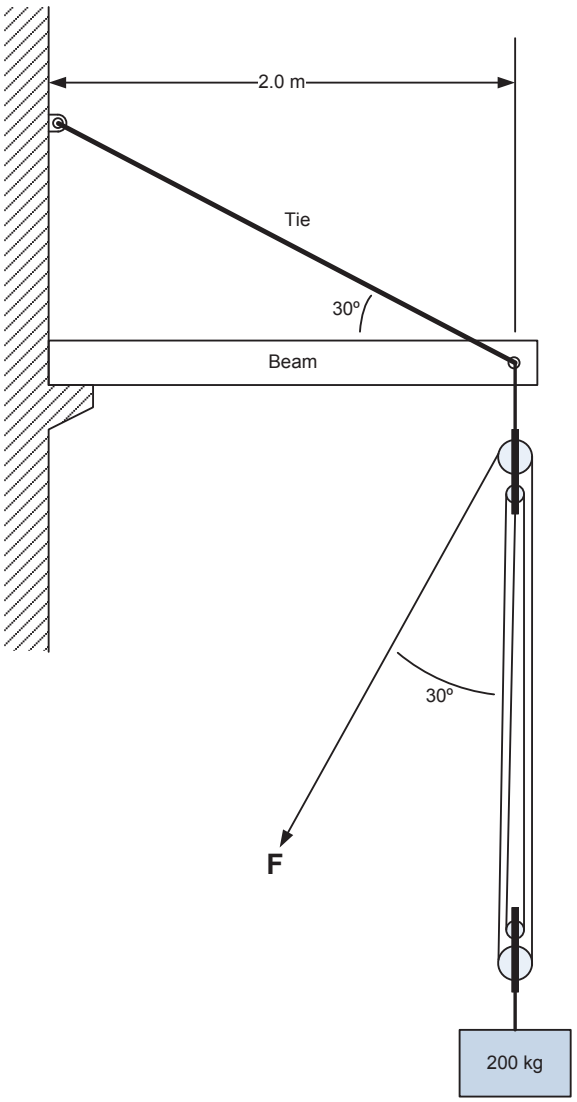
Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question that you are continuing to answer at the top of the page.

Suggested working time: 110 minutes.

Question 39 **(25 marks)**

The diagram below shows a rope and pulley system for unloading boxes from a truck and placing them on the ground for unpacking. The top pulley-block is attached to the end of a beam that is supported at one end on the wall of the factory unit and by a tie rod at the other end.



See next page

The operator pulls the rope with a force F and at an angle of 30° to the vertical to lift a box off the back of the truck. The truck then moves forward so the operator can lower the box to the ground.

The beam weighs 100 kg and you can ignore the weight of the tie and the rope-pulley system.

(a) If the mass of the box is 200 kg, show that the force (F) required to lift it is approximately 490 N. Show **all** workings. (2 marks)

(b) When the load of 200 kg is being lifted, show that the forces caused by the pulley system acting on the end of the beam where the pulley system is attached are:

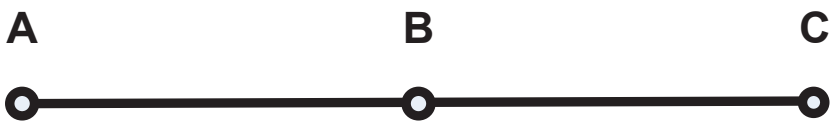
- Vertical force - close to 2384 N
- Horizontal force - close to 245 N.

Show **all** workings. (8 marks)

See next page

Question 39 (continued)

(c) On the diagram below of the beam, draw a schematic representation of the forces resulting from all the applied loads and reactions. Point A is the left-hand end of the beam, C is the right hand end, and B is the mid-point of the beam. Show each force as an arrow, clearly indicating its direction, and label each force with its known value or a blank if its value is currently unknown. (5 marks)



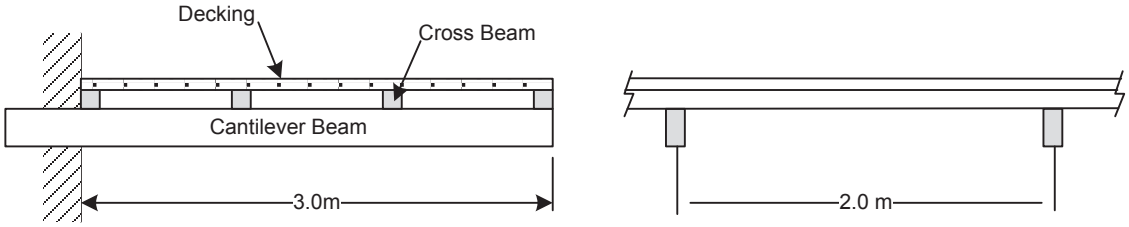
(d) Show that the force in the tie rod is close to 5748 N. (4 marks)

(e) Calculate the magnitude of the vertical and horizontal components of the reaction force at the left-hand end of the beam, i.e. at Point A. Show **all** workings. (6 marks)

See next page

Question 40 **(25 marks)**

The diagram below shows a cross-section and a partial elevation of a cantilevered balcony. The balcony is intended to support the weight of a number of people standing on it. The main beams are cantilevered from the wall and spaced at 2.0 m intervals. Four cross beams support the decking, which is 50 mm thick.



Cross-section **Elevation**

The material and loading properties are:

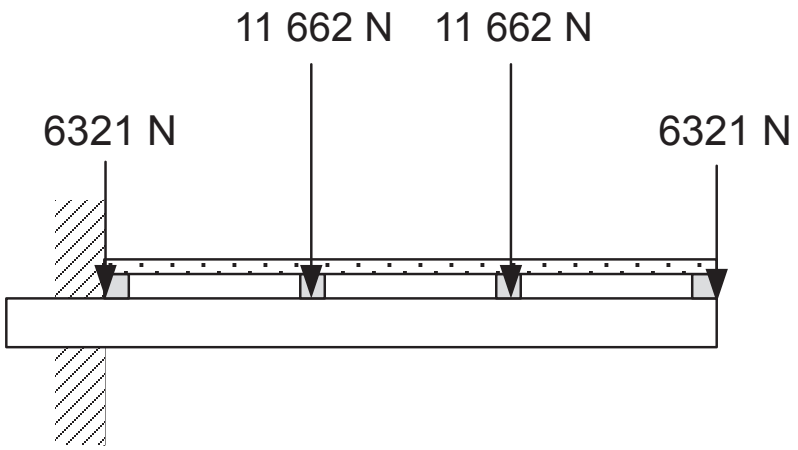
Component	Weight/Load
Cantilever beam	200 kg m^{-1}
Cross beam	50 kg m^{-1}
Decking	900 kg m^{-3}
People	500 kg m^{-2}

You can assume that each cantilevered beam carries the loads from a 2.0 m length of balcony. Also, each cross beam carries a share of the loads imposed from the decking, and the people standing on the balcony, from that part of the decking equidistant from each adjacent cross beam.

(a) Show that the load imposed on the balcony by the people and the weight of the decking is about 5341 N m^{-2}. (3 marks)

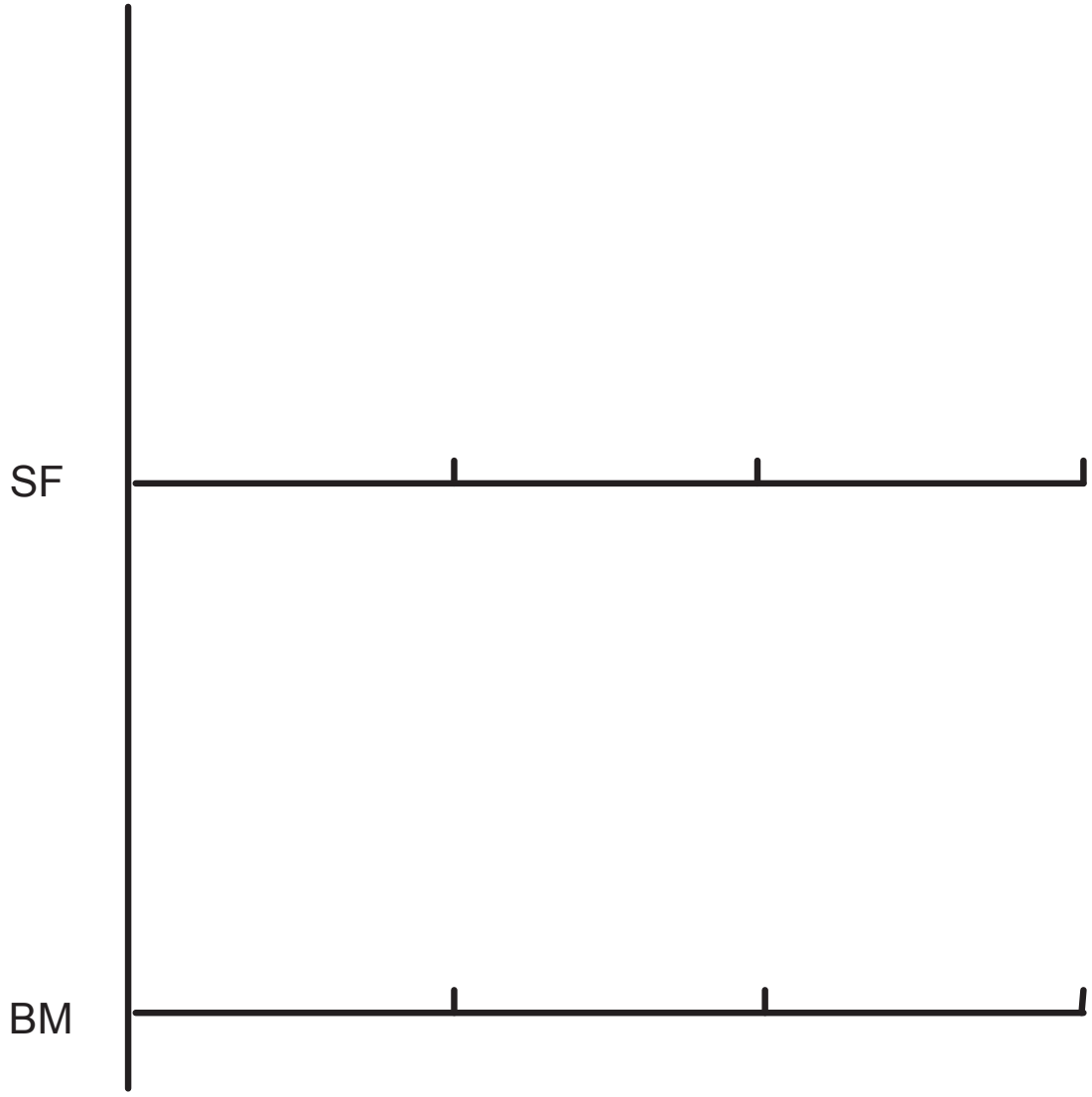
See next page

(b) Show that the loads imposed by the four cross beams that support the decking and the people on the balcony on the cantilever beam are approximately as follows. (5 marks)



Question 40 (continued)

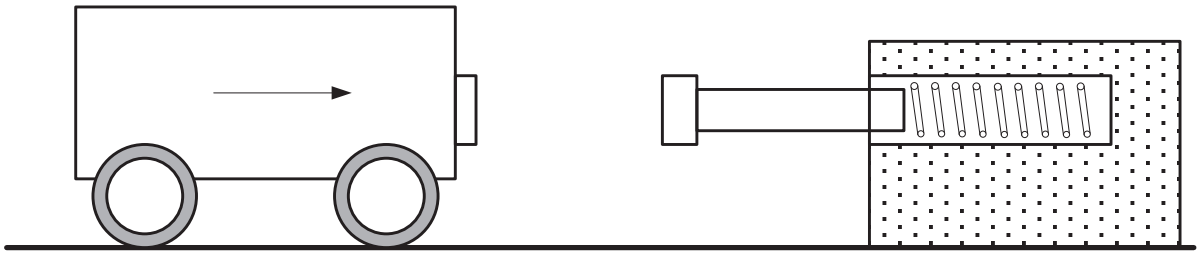
(c) Sketch the shear force and bending moment diagrams for the cantilever beam on the following axes. Calculate the key numeric values to fully define the shape of the diagrams and show these values on the diagrams. (17 marks)



See next page

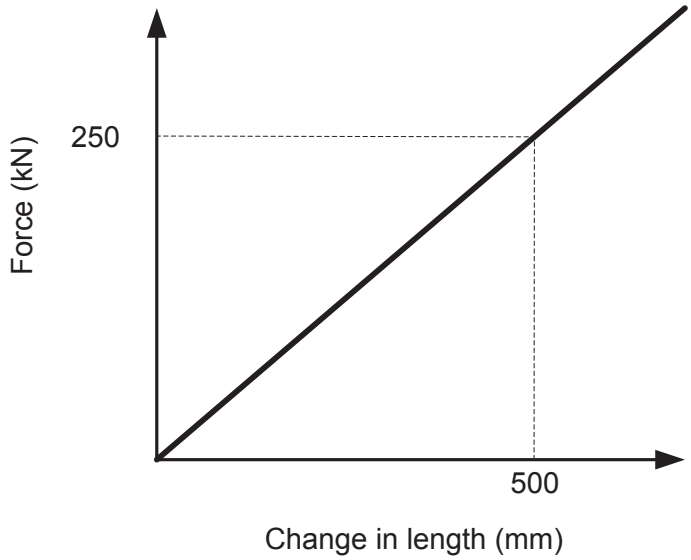
Question 41 **(25 marks)**

The diagram below shows a schematic representation of a railway wagon on a track approaching an energy absorbing buffer stop.



The railway wagon weighs 5000 kg when fully loaded and is potentially moving at up to 20 km h^{-1}. If the brakes on the wagon fail, the buffer stop is intended to bring the wagon to rest without any major damage.

The buffer stop is made up of a compressible ram with a very large spring contained in a large block of concrete. The ram has a linearly elastic response to an imposed force. The characteristics of the ram are as shown in the graph below:



The change in length (horizontal axis) is a measure of how much the ram moves and force (vertical axis) is the force required to make the movement. The slope of this graph is called the stiffness of the ram. You can assume that the buffer stop is heavy enough not to move when struck by the wagon.

See next page

Question 41 (continued)

(a) Explain the difference between potential and kinetic energy, and describe the changes in these energy types you would expect to occur when the wagon hits the buffer stop. (5 marks)

Potential energy: _____

_____

_____

Kinetic energy: _____

_____

_____

Changes: _____

_____

_____

(b) Show that the kinetic energy contained in the wagon when it is moving at 20 km h^{-1} is close to 77 160 N m. (3 marks)

_____

_____

_____

_____

_____

_____

_____

(c) When the wagon hits the ram, the spring contracts and the wagon gradually comes to a stop. Show that the ram will contract about 0.55 m before the wagon comes to a stop. (6 marks)

(d) Show that the average de-acceleration imposed on the wagon is about 27.8 m s^{-2} while it is coming to rest. (4 marks)

(e) Calculate the time taken for the wagon to come to rest after it first contacts the buffer ram. (4 marks)

See next page

Question 41 (continued)

(f) Explain where all the kinetic energy has gone once the wagon has come to rest.

(3 marks)

See next page

Question 42 **(30 marks)**

This question should be answered with reference to Document 3 'Stainless Steel' in the **Document Booklet.**

Stainless steel is a particular type of steel. Answer the following questions relating to the properties and uses of stainless steel.

(a) Describe **two (2)** properties of stainless steel that make it suitable for use in external environments. (2 marks)

One: _____

_____

Two: _____

_____

(b) Stainless steel is an alloy of steel with which additional element? What is the approximate percentage of that element by mass? (2 marks)

Element: _____

Percentage by mass: _____

(c) When was it reported in the press that stainless steel was invented, and for what use? (2 marks)

When: _____

Use: _____

(d) Complete the following sentences. (3 marks)

To be protective, the corrosion layer must be

_____

Most normal ironwork corrodes because it develops a

_____

It was known as early as 1821 that iron-chromium alloys were corrosion resistant, but they were not useful because

_____

See next page

Question 42 (continued)

(e) In harsh environments what percentage of chromium is recommended for stainless steel? (1 mark)

_____

(f) Chromium forms a passivation layer on the surface of stainless steel. What is this layer composed of and how does it provide protection if the surface is scratched? (2 marks)

Layer is: _____

Protection: _____

(g) Name **five (5)** common applications for stainless steel. (5 marks)

One: _____

Two: _____

Three: _____

Four: _____

Five: _____

(h) Name one notable Australian application of stainless steel and how much was required to build it. (2 marks)

_____

(i) Describe the steps in the process that is used to prepare stainless steel before it is ready for sale. (5 marks)

One: _____

Two: _____

Three: _____

Four: _____

Five: _____

See next page

(j) For the following manufactured components, indicate whether you would recommend that they be made from stainless steel and give short justifications for your answers. You need to consider that stainless steel is likely to be much more expensive to use than normal grades of steel. (6 marks)

Component	Use stainless steel? (yes/no)	Reason
Handrails on external stairways	_____	_____ _____ _____ _____ _____
Piping in desalination plants	_____	_____ _____ _____ _____ _____
Boxes for desktop computers	_____	_____ _____ _____ _____ _____

End of Section Two: Mechanical

See next page

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See next page

Section Two: Specialist field—Electronic/Electrical **65% (115 Marks)**

This section has **two (2)** parts.

Part A: Multiple-choice Answer **all** questions

Part B: Extended answer Answer **all** questions

Suggested working time: 120 minutes.

Part A: Multiple-choice **10% (10 Marks)**

This part has **ten (10)** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. For each question, shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time: 10 minutes.

---

43. When an additional resistor is connected across an existing parallel resistive circuit, the total resistance

    (a) decreases.
    (b) increases.
    (c) remains the same.
    (d) is impossible to determine without knowing the actual resistance values.

44. If 0.47 µF, 0.22 µF and 0.1 µF capacitors are connected in series, the overall capacitance value is approximately

    (a) 0.06 µF.
    (b) 0.79 µF.
    (c) 16.67 µF.
    (d) 0.013 µF.

45. On the schematic symbol of a NPN transistor, the arrow points

    (a) inward on the base lead.
    (b) outward on the collector lead.
    (c) inward on the emitter lead.
    (d) outward on the emitter lead.

See next page

46. Assuming that the cost of electricity is 20 cents per kWh, approximately how long can you operate a 200 W television for $1?

(a) 5 hours
(b) 10 hours
(c) 25 hours
(d) 40 hours

47. An instrument used for measuring potential difference is called

(a) an ammeter.
(b) an ohmmeter.
(c) a potentiometer.
(d) a voltmeter.

48. To measure a circuit's source voltage, the voltmeter must

(a) have the black lead toward the positive side of the source.
(b) be placed in series in the circuit.
(c) be placed across the source.
(d) only be used when the source is switched off.

49. In a series resistive circuit, the smallest amount of power is dissipated by the

(a) first resistor.
(b) last resistor.
(c) resistor with the highest resistance.
(d) resistor with the lowest resistance.

50. A particular capacitor stores 60 μC of charge when 12 V are applied across its plates. What is its capacitance value?

(a) 0.2 μF
(b) 5 μF
(c) 60 μF
(d) 720 μF

51. If the source voltage of 120 V is applied to the primary of an ideal transformer with a turns ratio of 5:1, what is the voltage across the secondary load?

(a) 24 V
(b) 60 V
(c) 120 V
(d) 600 V

See next page

52. A transistor has a collector current I_C of 10 mA. How much is the base current I_B if the transistor has a β of 200?

(a) 50 μA
(b) 20 mA
(c) 0.5 A
(d) 2 A

See next page

Part B: Extended answer **55% (105 Marks)**

This part has **four (4)** questions. Answer **all** questions. Write your answers in the spaces provided.

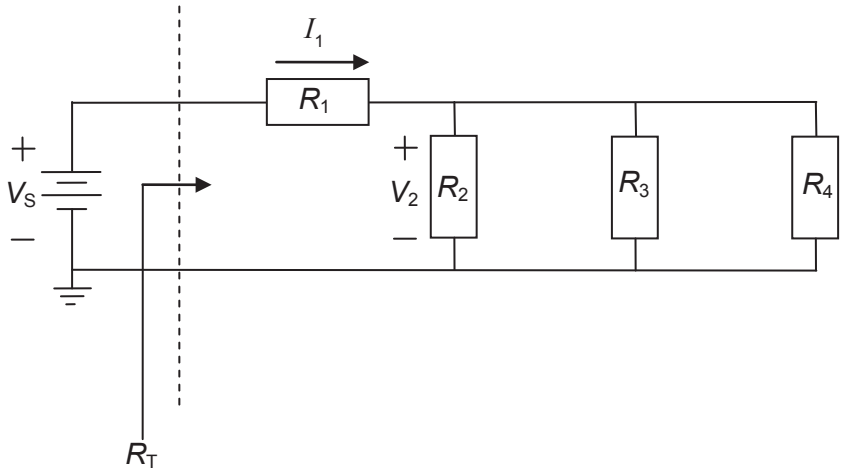
Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question that you are continuing to answer at the top of the page.

Suggested working time: 110 minutes.

Question 53 **(25 marks)**

A DC voltage source of unknown voltage value V_S is applied across a resistor network, as shown in the circuit diagram below, where R_1 = 1 kΩ, R_2 = 2 kΩ, R_3 = 1 kΩ, and R_4 = 1 kΩ.



(a) Determine the value of the total resistance R_T, which is the equivalent resistance value seen by the voltage source. Show **all** workings. (3 marks)

See next page

(b) Given that the source voltage is set to a value such that the resistor R_4 is dissipating 100 mW of power, calculate the values for the voltage V_2, the current I_1 and the source voltage V_S. Show **all** workings.

(i) Voltage V_2 (2 marks)

(ii) Current I_1 (4 marks)

(iii) Source voltage V_S (4 marks)

See next page

Question 53 (continued)

(c) Consider the following two separate scenarios:

(i) If the resistor R_1 was replaced by another resistor of lesser resistance value (while all other circuit elements remained unchanged), how would this affect the total resistance R_T and the current I_1?

Tick the appropriate boxes below and provide a reason for each.

(4 marks)

The total resistance R_T would:

- increase ☐
- decrease ☐
- remain unchanged. ☐

Reason: _____

_____

The current I_1 would:

- increase ☐
- decrease ☐
- remain unchanged. ☐

Reason: _____

_____

(c) (ii) If the source voltage was increased in value (while all other circuit elements remained unchanged), how would this affect the total resistance R_T and the current I_1?

Tick the appropriate boxes below. There is no need to show your workings.

(4 marks)

The total resistance R_T would:

- increase ☐
- decrease ☐
- remain unchanged. ☐

Reason: _____

_____

The current I_1 would:

- increase ☐
- decrease ☐
- remain unchanged. ☐

Reason: _____

_____

Question 53 (continued)

(d) The current, voltage and resistance values can be measured with appropriate instruments.

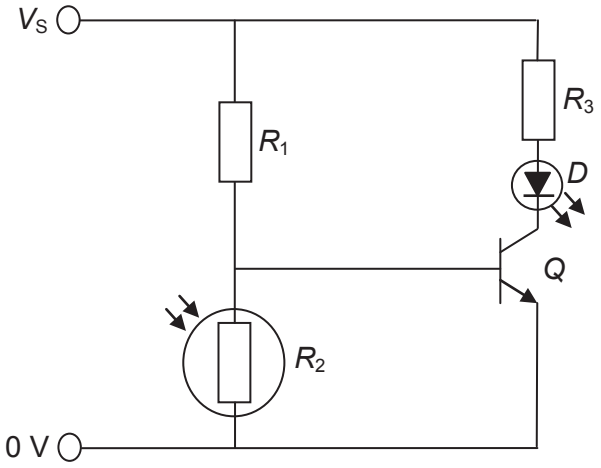
(i) Draw a circuit diagram below to illustrate clearly how an ammeter should be connected to the circuit in order to measure the current I_1 correctly. (2 marks)

(ii) Draw a circuit diagram below to illustrate clearly how an ohmmeter should be connected to the circuit in order to measure the total resistance R_T correctly. (2 marks)

See next page

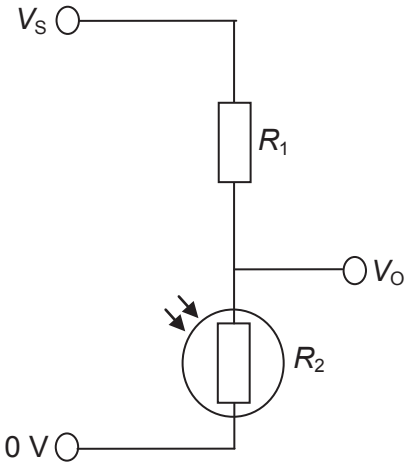
Question 54 **(25 marks)**

The figure below shows a basic 'dark sensor' circuit that uses a transistor to switch on the light emitting diode (LED) when there is a lack of incident light on the light dependent resistor (LDR). Conversely, the LED is deactivated by the transistor when there is sufficient incident light on the LDR.



'Dark sensor' circuit

(a) The left part of the above 'dark sensor' circuit is a voltage divider module, as shown in the figure below. Suppose V_S = 6 V, R_1 = 10 kΩ and the resistance of the LDR, R_2, ranges from 100 Ω in very bright light to 200 kΩ in darkness. Note that an LDR is a resistor whose resistance increases with decreasing intensity of incident light. Therefore, in the voltage divider module, the output voltage Vo varies as R_2 changes.



See next page

Question 54 (continued)

(a) (i) By using the voltage division principle, write a mathematical expression for V_O in terms of R_1, R_2, and V_S. (2 marks)

(ii) Show that V_O swings from 59.4 mV to 5.71 V. (2 marks)

(iii) Calculate the value for R_2 such that V_O = 0.7 V. Show **all** workings. (2 marks)

(iv) Suppose a 4-band colour coded resistor of 10 kΩ with 5% tolerance is used to implement R_1. What colours would this resistor display? State the colours for each of the bands. (4 marks)

Band one: _____

Band two: _____

Band three: _____

Band four: _____

See next page

(b) Suppose the above 'dark sensor' circuit has the following parameters.

Parameters	
Source voltage, V_S	6 V
Resistor R_3	220 Ω
LED on-voltage $V_{LED,on}$	2 V
Transistor on-voltage $V_{BE,on}$	0.7 V
Transistor saturation voltage $V_{CE,sat}$	0 V
Transistor current gain β	100

Determine the amount of current that flows through the LED when

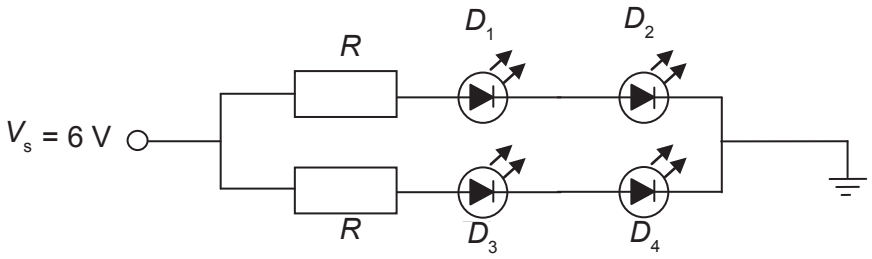
(i) the resistance value of the LDR reaches a high enough value to turn on and operate the transistor at its saturation region. Show **all** workings. (4 marks)

(ii) the transistor is operating in the cut-off region. Show **all** workings. (2 marks)

See next page

Question 54 (continued)

(c) Instead of one LED, suppose the above 'dark sensor' circuit is now required to drive a cluster of 4 LEDs in a 2-by-2 array. The figure below shows such a light module in isolation from the rest of the circuit. This module is designed so that each LED operates at a forward voltage of 2.2 V and a current of 16 mA.



(i) Determine the required value for resistor *R*. Show **all** workings. (4 marks)

(ii) Show that each resistor is dissipating 25.6 mW and each LED is dissipating 35.2 mW of power. (2 marks)

See next page

(iii) If the LED D_1 was faulty and behaved like an open circuit, how would this affect D_3?

Tick the appropriate box below and explain your answer. (3 marks)

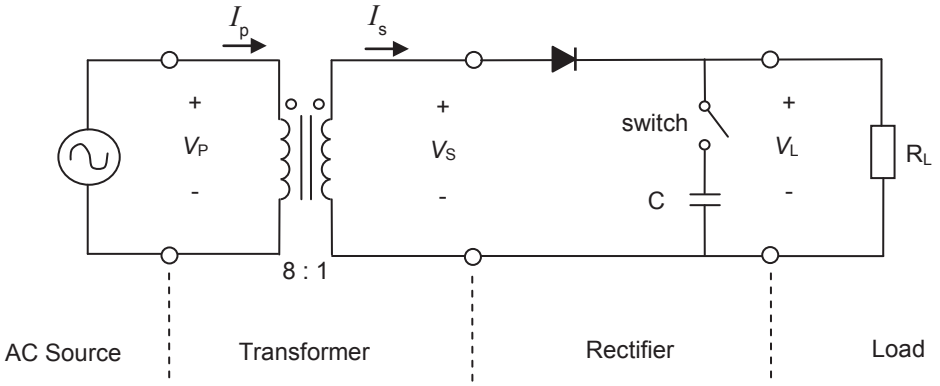
The LED D_3 would be:

- the same in brightness ☐
- brighter ☐
- dimmer ☐
- off. ☐

Explanation:

Question 55 **(25 marks)**

Consider the following circuit, which has a transformer and a rectifier connected between an AC source and a load. Assume the switch is initially open.



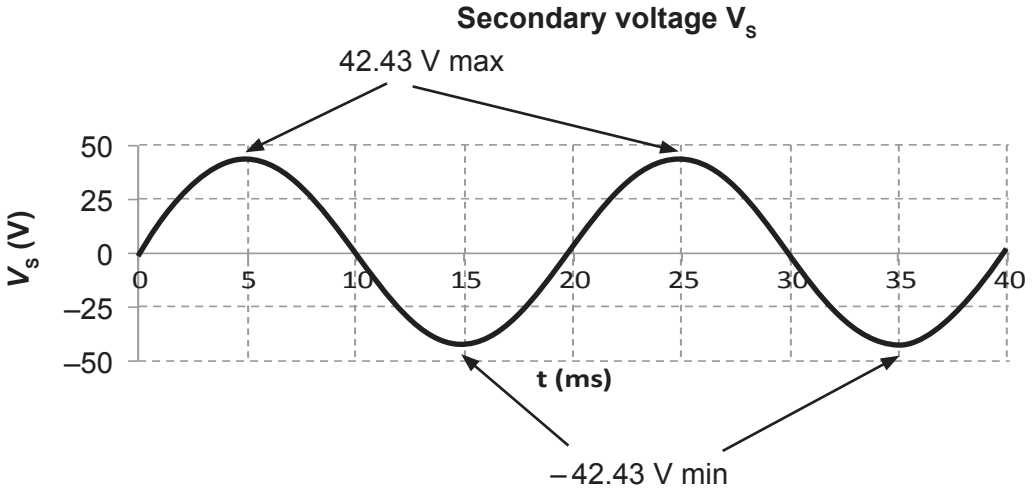
(a) Suppose an ideal transformer is used. Calculate

(i) the secondary voltage V_S of the transformer in the case when the primary voltage V_P = 240 VAC. Show **all** workings. (2 marks)

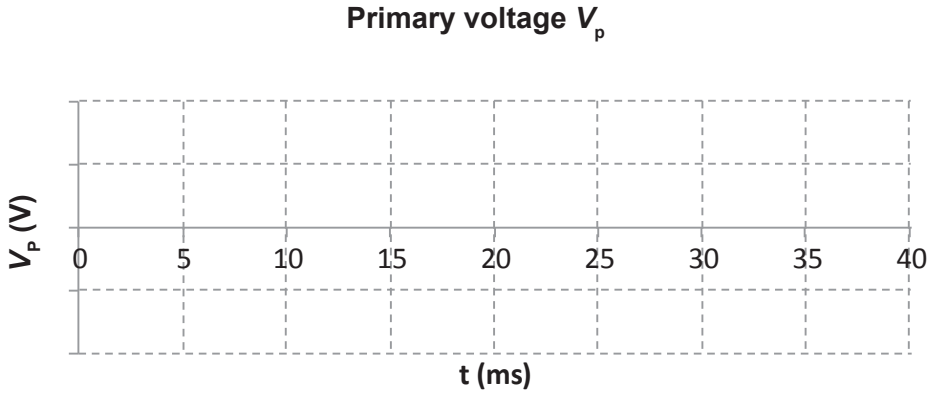
(ii) the primary current I_P of the transformer in the case when the secondary current I_S = 0.3 A AC. Show **all** workings. (2 marks)

See next page

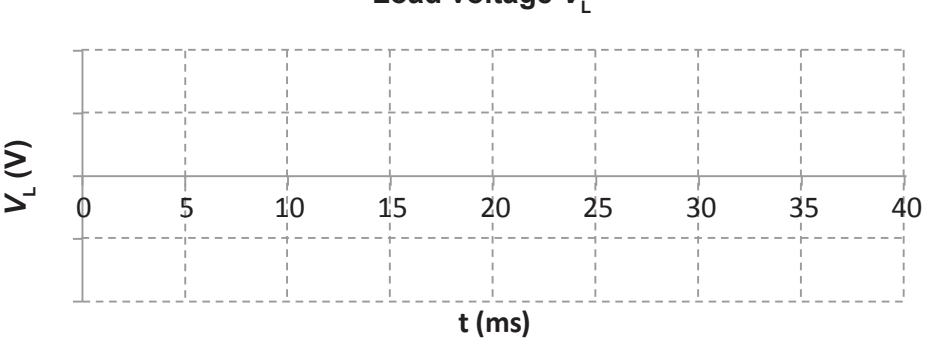
(b) Suppose the diode used in the rectifier has a forward voltage of 0.6 V, the resistor R_L = 100 Ω, the switch is open and the waveform of the secondary voltage V_S is as shown below.



(i) Sketch the waveform clearly and label its maximum and minimum voltage values for the primary voltage V_P. (3 marks)



(ii) Sketch the waveform clearly and label its maximum and minimum voltage values for the load voltage V_L. Assume no reverse breakdown of the diode. (3 marks)

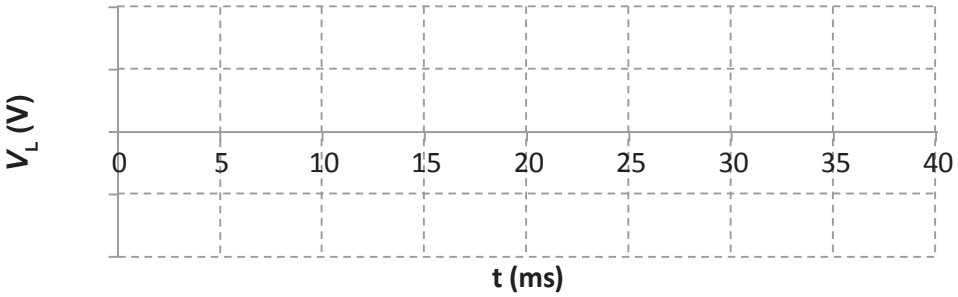


See next page

Question 55 (continued)

(iii) Sketch the waveform clearly and label its maximum and minimum voltage values for the load voltage V_L when the diode is connected in reverse by mistake, i.e. when the diode's anode and cathode are swapped around. (3 marks)

Load voltage V_L when diode is connected in reverse



(iv) Calculate the frequency of V_P. Show **all** workings. (2 marks)

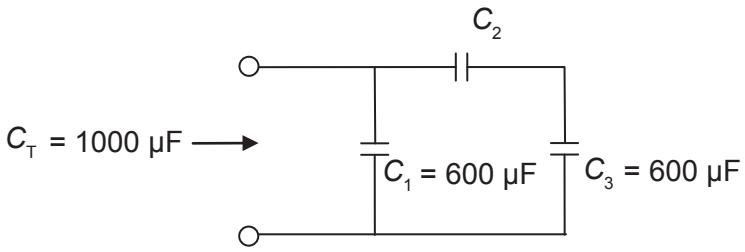
(v) Calculate the maximum current that can flow through the load. Assume the diode is now in the original (correct) connection. Show **all** workings. (2 marks)

See next page

(c) Suppose the switch is closed and the capacitor of 1000 μF now becomes part of the circuit.

(i) Explain what primary effect this capacitor has on the load voltage waveform. (2 marks)

(ii) With reference to the capacitor network shown below, calculate the value of capacitor C_2 such that the equivalent overall capacitance is C_T = 1000 μF. Show **all** workings. (4 marks)

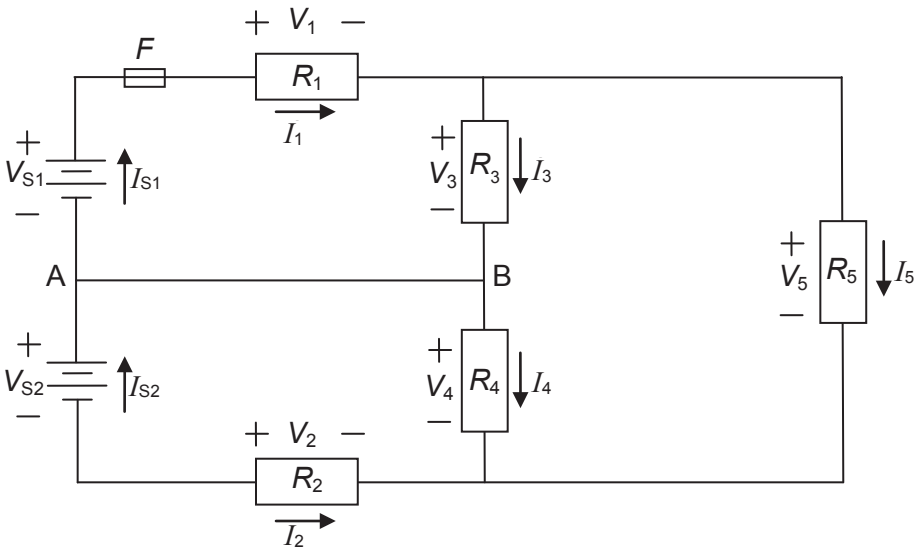


(iii) What is 1000 μF in nanofarad (nF)? (2 marks)

See next page

Question 56 **(30 marks)**

A circuit is constructed as shown below, with five resistors R_1=2 kΩ, R_2=2 kΩ, R_3=6 kΩ, R_4=6 kΩ, and R_5=4 kΩ, a fuse F, and two batteries V_{S1}=12 V and V_{S2}=16 V. Unless stated otherwise, the fuse is behaving like a short circuit with zero resistance (zero voltage drop). An ideal ammeter is used to obtain readings of I_{S1}=3.75 mA and I_{S2}=4.25 mA. The diagram below also specifies the direction of the current and the voltage polarity of each circuit element.



(a) Use the Kirchhoff's current law to determine the value for the current I_{AB}, which is the current that flows from Node A to Node B. Show **all** workings. (2 marks)

See next page

(b) Knowing that the power dissipated by the resistor R_5 is 36 mW, calculate all the resistor currents. Provide your answers in the following table. Take note of all the current directions as given in the above figure. Show **all** workings. (10 marks)

I_1 =
I_2 =
I_3 =
I_4 =
I_5 =

(c) Calculate all the resistor voltages. Provide your answers in the following table. Take note of all the voltage polarity directions as given in the figure. Show **all** workings. (10 marks)

V_1 =
V_2 =
V_3 =
V_4 =
V_5 =

See next page

Question 56 (continued)

(d) Calculate the total power supplied by the two batteries. Show **all** workings. (2 marks)

(e) Suppose the fuse F is blown.

(i) Show that the equivalent resistance value as seen by the battery V_{S2} with the fuse *F* blown is 5.75 kΩ. (4 marks)

(ii) Calculate the new value for the current I_{S2} when the fuse F is blown. Show **all** workings. (2 marks)

End of Section Two: Electronic/Electrical

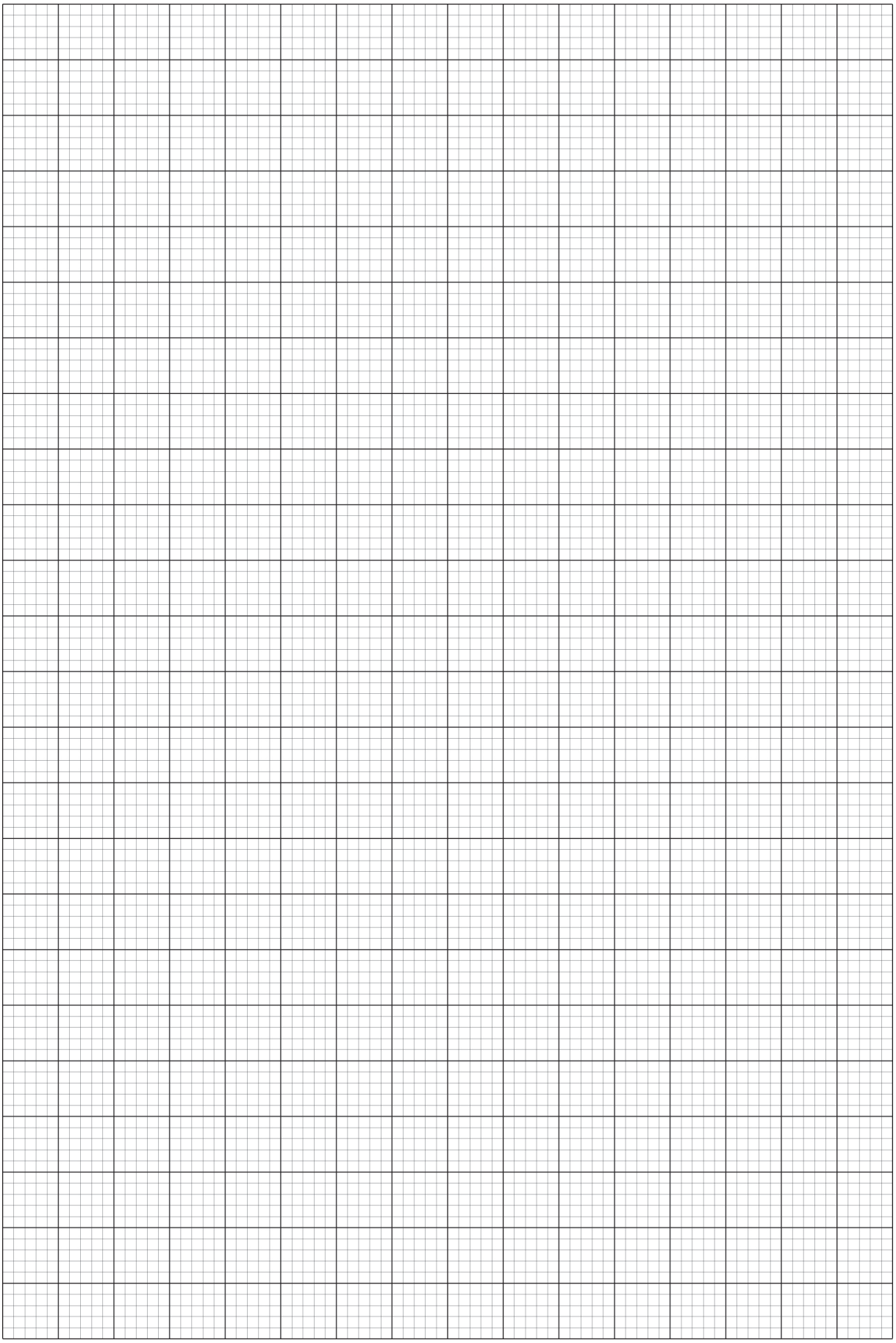
End of questions

Additional working space

Additional working space

Additional working space

Additional working space



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ACKNOWLEDGEMENTS

Question 13 Text adapted from: Berrill, T., & Blair, A. (2007). *Solar water heater training course: Installer and user manual*. Melbourne: Australian Business Council for Sustainable Energy. Retrieved March, 2012, from www.cleanenergycouncil.org.au/resourcecentre/Consumer-Info/SWHguide.html.

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