VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education 2015

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER | | | | | | | | | Letter |

VCE VET INTEGRATED TECHNOLOGIES

Written examination

Monday 9 November 2015

Reading time: 9.00 am to 9.15 am (15 minutes)
Writing time: 9.15 am to 10.45 am (1 hour 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	10	10	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 correction fluid/tape.

Materials supplied
- Question and answer book of 26 pages, including a formula sheet on page 26.
- 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 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.

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** or that **best answers** 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.

Question 1

Wave-powered electricity generators are being used in coastal areas of some countries.

The electricity generated is produced by

A. a chemical reaction with salt water.

B. the piezo-electric effect.

C. photovoltaic action.

D. electromagnetism.

Question 2

Residual Current Devices (RCDs) are installed in general purpose power and lighting circuits in residential housing to

A. monitor the active and neutral currents when more than 30 mA flow in the earth.

B. isolate the circuit when more than 30 mA of active or neutral currents flow in the earth.

C. isolate the circuit when a current imbalance of more than 30 mA between the active and neutral wires is detected.

D. protect the house wiring from excess current when more than 30 mA of active and neutral currents flow in the earth.

Question 3

500 kV_{AC} extra high voltage (EHV) transmission lines are used to supply energy from coal-fired power stations in the Latrobe Valley to distribution companies throughout Victoria.

EHV transmission is used to

A. reduce the power loss on the lines.

B. reduce the number of inverters required.

C. reduce the resistance on the lines due to the extra high voltage.

D. keep the insulators on the transmission towers clean due to the corona produced by the extra high voltage.

Question 4

The three-phase 500 MW generator at Loy Yang A produces 21 kV_{AC} yet the energy is transmitted at 500 kV_{AC}.

What device is used to increase the voltage from 21 kV to 500 kV?

A. a rectifier

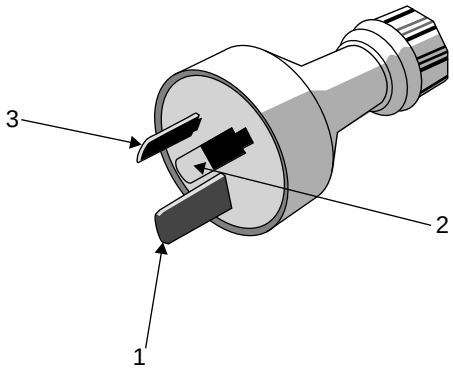
B. an inverter

C. a transformer

D. a supercapacitor

Question 5

A 3-pin 230 V_{AC} mains plug is shown below.



Which one of the following is the correct pin-out for a 3-pin plug?

	Pin 1	Pin 2	Pin 3
A.	active	neutral	earth
B.	earth	active	neutral
C.	neutral	earth	active
D.	earth	neutral	active

Question 6

What is the capacitance value of the capacitor shown above?

A. 271 nF
B. 271 pF
C. 270 nF
D. 270 pF

Question 7

The Australian standard neutral wire colour in a 230 V_{AC} extension lead is

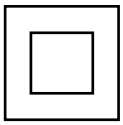
A. blue.

B. black.

C. brown.

D. green with a yellow stripe.

Question 8



The symbol above indicates that an electrical device

A. does not require testing and tagging.

B. does not require an earth connection for safe operation.

C. requires an insulation-resistance (IR) test before it is used.

D. is from overseas and does not comply with Australian standards.

Question 9

An IR tester may be used to

A. check for short or open circuits in a cabling system.

B. check the polarity of a 3-core flexible extension lead.

C. measure mains voltage drops from the switchboard to a power point.

D. carry out a non-destructive 500 V insulation test on a portable appliance.

Question 10

An electrician is carrying out an IR test on a recently completed wiring installation. With no mains voltage and no appliances connected, an IR test between the active wire and the earth wire on a sub-circuit is performed.

An acceptable IR test (500 V) result is

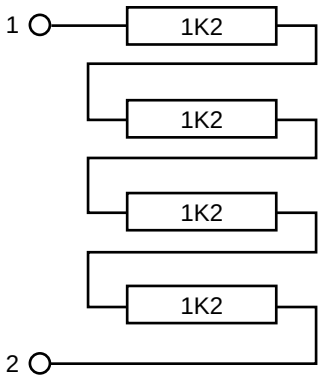
A. 0 Ω

B. 2 Ω

C. 5 kΩ

D. 5 MΩ

Question 11



The total resistance between terminals 1 and 2 in the resistor connections above is

A. 4800 Ω

B. 1200 Ω

C. 300 Ω

D. 4.8 Ω

Question 12

Which one of the following is true?

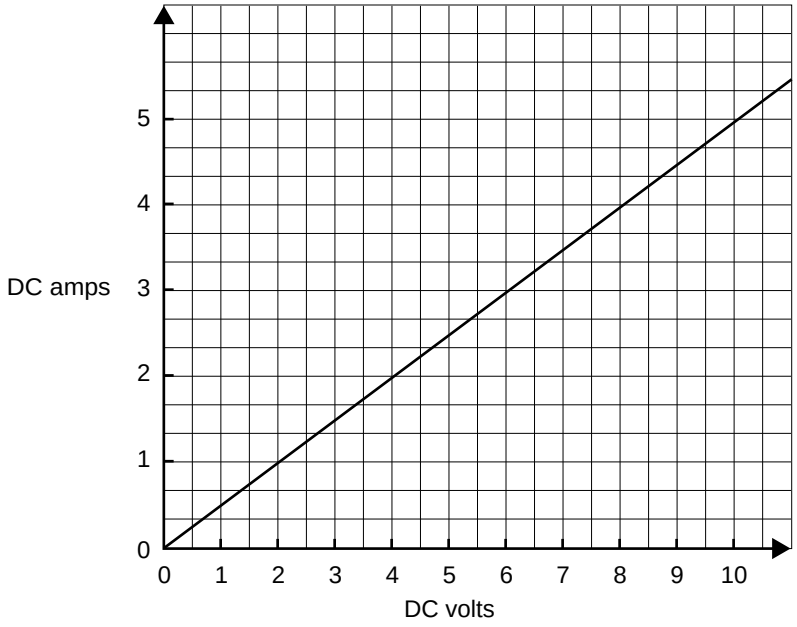
A. Semiconductors are used only in the electronics industry.

B. Copper is a better conductor than aluminium.

C. The earth we stand on is an insulator.

D. Pure water is a conductor.

Question 13



The graph above represents the relationship between voltage and current in a circuit.
What is the resistance of the circuit?

A. 0.5 Ω

B. 2 Ω

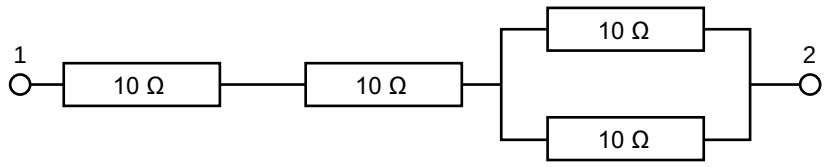
C. 18 Ω

D. 50 Ω

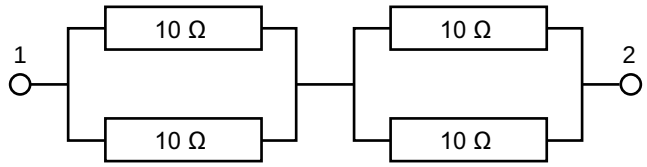
Question 14

Which one of the following networks has a total resistance of 25 Ω between terminals 1 and 2?

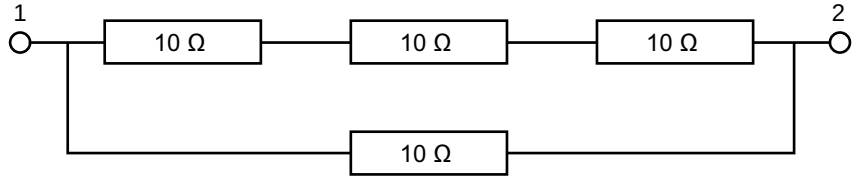
A.



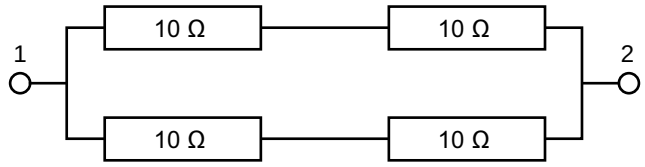
B.



C.

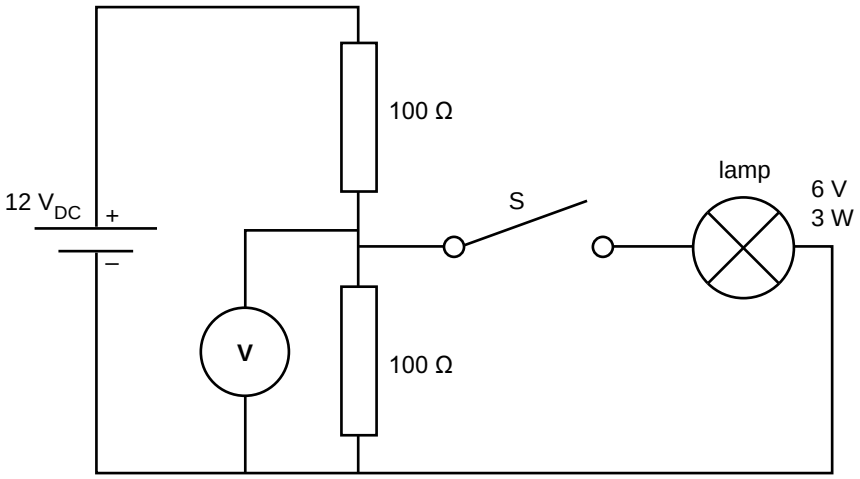


D.



Question 15

The circuit below shows a voltage divider network used to drive a lamp.



When switch S is closed, the lamp

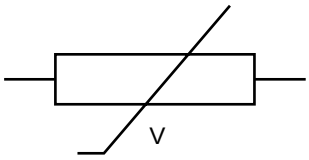
A. glows dimly and the voltmeter reading is 6 V_{DC}.

B. glows brightly and the voltmeter reading is 6 V_{DC}.

C. glows dimly and the voltmeter reading is less than 3 V_{DC}.

D. glows brightly and the voltmeter reading is less than 3 V_{DC}.

Question 16



The symbol above represents a

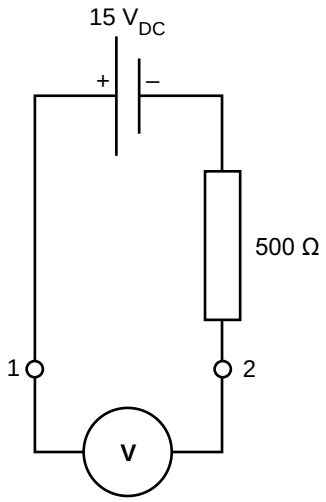
A. varistor, used to protect equipment from overvoltage.

B. potentiometer, used to adjust the gain of an amplifier.

C. voltage-dependent resistor, used in power supplies to adjust the output voltage.

D. positive temperature coefficient resistor, used to stabilise a circuit with changes in temperature.

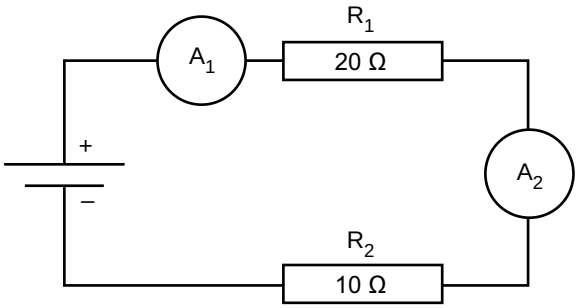
Question 17



The voltage shown on the voltmeter in the circuit above is

A. 0 V_{DC}
B. 7.5 V_{DC}
C. 15 V_{DC}
D. 30 mA

Question 18

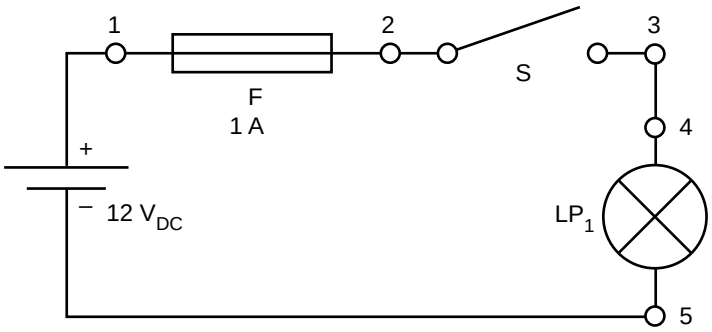


With reference to the circuit above, which one of the following statements is correct?

A. The supply current is the sum of the currents through R_1 and R_2.
B. The current shown on ammeter A_1 is double the current shown on ammeter A_2.
C. The current shown on ammeter A_1 is equal to the current shown on ammeter A_2.
D. The current shown on ammeter A_2 is double the current shown on ammeter A_1.

Question 19

Refer to the circuit below.



With switch S closed, the lamp in the circuit fails to light. While replacing the lamp, you accidentally short circuit the lamp socket (with S closed). With the new lamp installed, you measure the voltages between given points around the circuit.

Which of the following shows the expected result with switch S closed?

	1–2	2–3	3–4	4–5	1–5	Lamp status
A.	0 V_{DC}	0 V_{DC}	12 V_{DC}	12 V_{DC}	12 V_{DC}	on
B.	12 V_{DC}	0 V_{DC}	0 V_{DC}	0 V_{DC}	12 V_{DC}	off
C.	0 V_{DC}	12 V_{DC}	0 V_{DC}	0 V_{DC}	12 V_{DC}	off
D.	0 V_{DC}	12 V_{DC}	0 V_{DC}	12 V_{DC}	12 V_{DC}	on

Question 20

The most effective type of control measure for a hazard is

A. insulation.

B. elimination.

C. substitution.

D. personal protective equipment (PPE).

END OF SECTION A

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided.
Formulas must be relevant to the calculations. Calculations must be shown.
All units must be specified in correct engineering notations in the answers.

Question 1 (3 marks)
A through-hole Printed Circuit Board (PCB) needs to have components added in preparation for soldering. Table 1 below lists the tools and personal protective equipment (PPE) items that are available for this task.

Table 1

drill table vice	gas lighter	large file	G clamp	long-nose pliers
multigrips	safety glasses	earmuffs	dust mask	adjustable wrench
side-cutting pliers	cordless drill	4 mm drill bit	claw hammer	Phillips head screwdriver

In the space provided below, select the three **most relevant** items from Table 1 and state why each was selected to complete the task.

	Item	**Why it was selected**
1.		
2.		
3.		

Question 2 (8 marks)
In electrotechnology, measurements are generally described in engineering notations, such as microfarads (e.g. 47 μF) and megahertz (e.g. 5 MHz).

Complete the table below by converting the values given into engineering notations.

Value	**Engineering notation**	**Value**	**Engineering notation**
100 000 V		0.0001 A	
0.00005 F		$64\,000 \times 10^{6}$ B	
600 000 Hz		$0.15 \times 10^{4}\ \Omega$	
19 000 W		$2.44 \times 10^{-8}\ \Omega$/m	

Question 3 (10 marks)

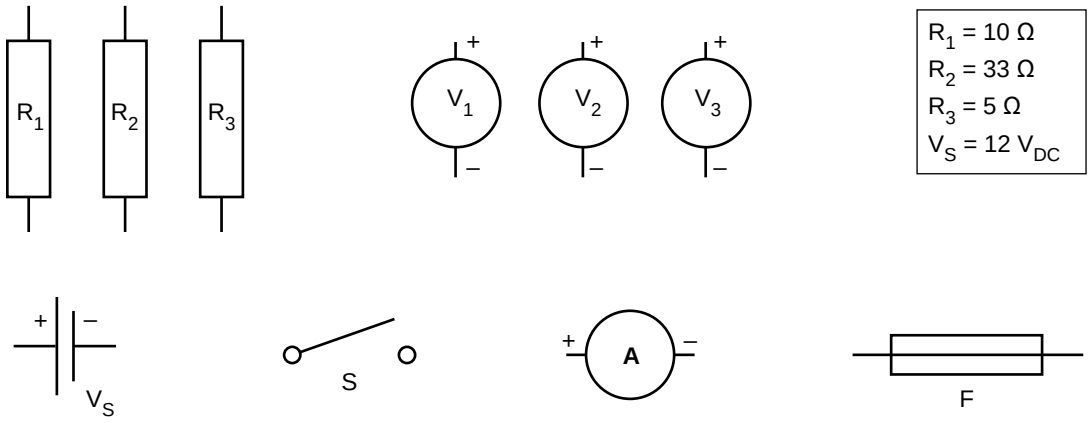


Figure 1

a. Using **all** of the components shown in Figure 1 above, draw a circuit diagram, configured as follows, in the space below:

- R_1, R_2 and R_3 are in series and connected to a 12 V_{DC} battery.
- Voltmeters V_1, V_2 and V_3 measure the voltage across R_1, R_2 and R_3 respectively.
- The ammeter should measure the circuit's current.
- Switch S and fuse F are to be included in the circuit.
- Correct meter polarity should be observed for both the ammeter and the voltmeters. 6 marks

b. With your circuit connected as described in **part a.**, what power rating for resistor R_2 is required to prevent it from overheating? Show your working. 2 marks

_____

_____

_____

c. From the list below, circle the minimum size fuse required to protect the circuit. 1 mark

200 mA 300 mA 1 A 2 A

d. Resistor R_3 is a 5 Ω 5% tolerance resistor.

Enter the colour for each band in the spaces below. 1 mark

Band 1	Band 2	Band 3	Band 4

Question 4 (10 marks)

Refer to the circuit diagram in Figure 2. Assume switch S is closed.

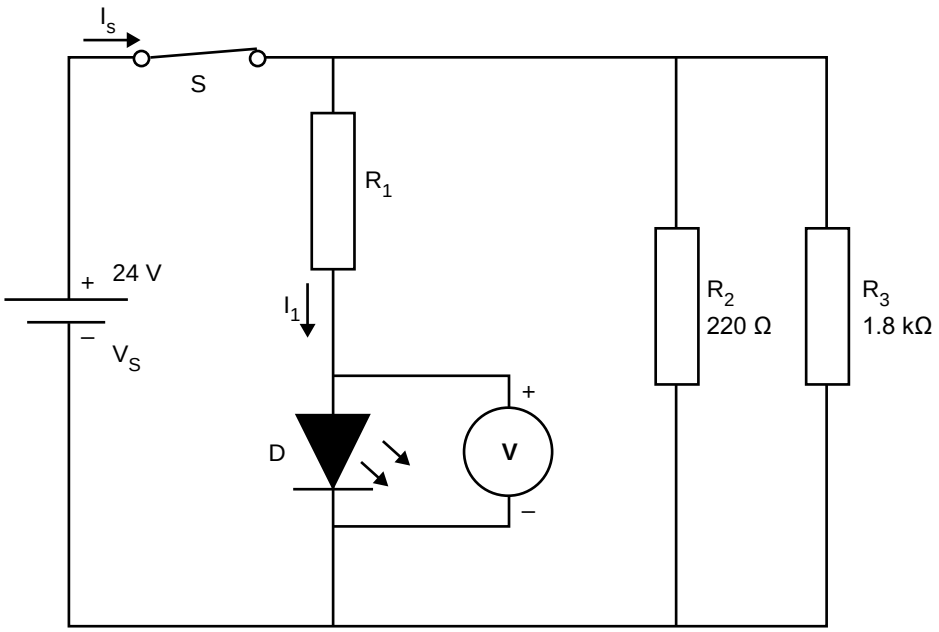


Figure 2

a. The light-emitting diode (LED) D is lit and the voltmeter reading is 3.7 V_{DC}.

If the nominal current for this type of LED is 20 mA (I_1), find the resistance of R_1. Show your working. 3 marks

b. Determine the current through R_3. Show your working. 2 marks

c. What is the value of the current I_s? Show your working. 3 marks

d. What is the total power used by the circuit? Show your working. 2 marks

Question 5 (10 marks)
Refer to the circuit diagram in Figure 3.

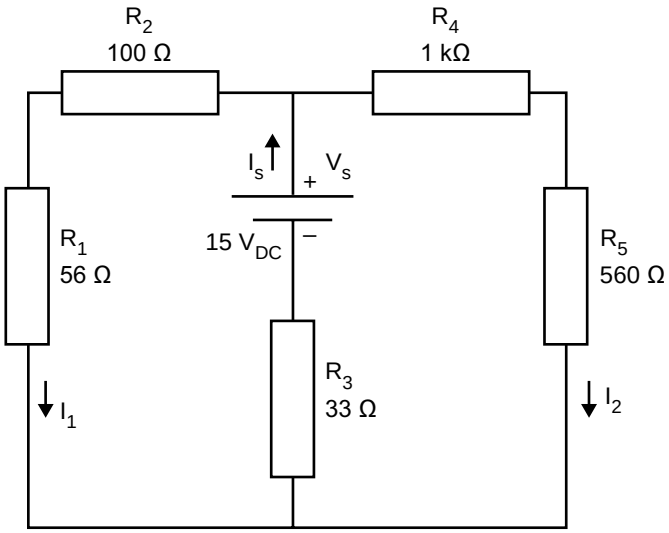


Figure 3

a. Find the total resistance in the circuit. Show your working. 4 marks

b. Find the current I_s. Show your working. 2 marks

c. Find the current I_1. Show your working. 2 marks

d. Find the voltage drop across R_3. Show your working. 2 marks

Question 6 (4 marks)

In the electrotechnology industry, different cabling systems are used for different purposes. Cables are selected to meet the requirements of each system.

a. Top-quality audio leads use many thin braided copper wires together with silicon insulation and gold-plated plugs and sockets.

i. Why are braided wires with silicon insulation used? 1 mark

ii. Why are gold-plated plugs and sockets used? 1 mark

b. Data and audio cables are often exposed to 'noise'.

i. What is noise and how might it be caused? 1 mark

ii. How can the effect of noise be reduced in the cabling system? 1 mark

Question 7 (8 marks)

a. Table 2 below lists the resistivity of a number of materials.

In Table 2, rank the materials from lowest resistivity to highest resistivity, using the numbers 1 to 8, with 1 being the lowest and 8 being the highest. 2 marks

Table 2

Materials	Resistivity (ρ) at 20 °C (Ω.m)	Rank from lowest resistivity to highest resistivity
aluminium	2.82×10^{-8}	
copper	1.7×10^{-8}	
gold	2.44×10^{-8}	
iron	1.0×10^{-7}	
tungsten	5.6×10^{-8}	
nichrome	1.10×10^{-6}	
mercury	9.8×10^{-7}	
silver	1.59×10^{-8}	

b. List **two** factors that affect the resistance of a cable. 2 marks

c. A 1.8 Ω resistor needs to be made from 0.5 mm diameter nichrome wire.

Referring to Table 2 for the resistivity of nichrome, what length of nichrome wire is required to make the resistor? Show your working. 4 marks

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Question 8 (11 marks)

Figure 4 shows a control circuit and a power circuit for a 230 V_{AC} pump motor.

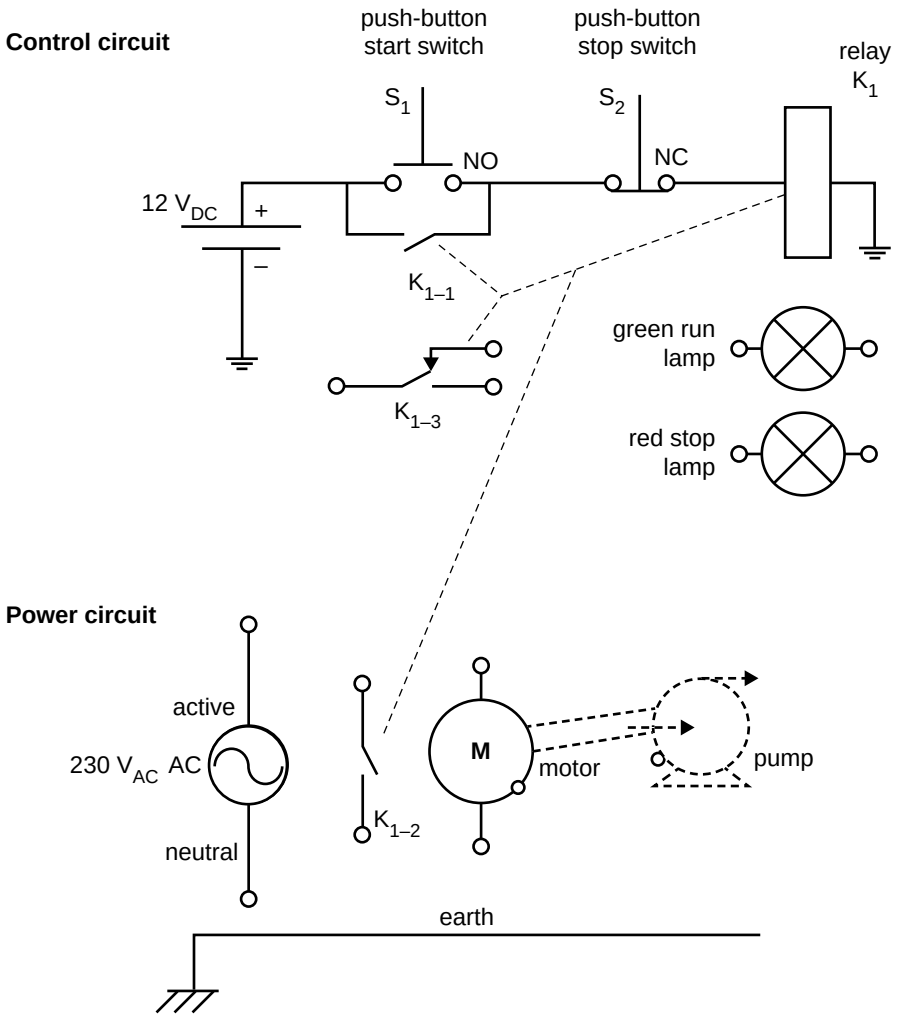


Figure 4

a. The control circuit consists of a normally open (NO) push-button start switch, S_1, a normally closed (NC) push-button stop switch, S_2, and a 12 V_{DC} relay, K_1, with three sets of contacts.

i. Explain how relay K_1 will be energised when the start button is pressed. 1 mark

ii. Explain how relay K_1 remains energised after S_1 is released. 1 mark

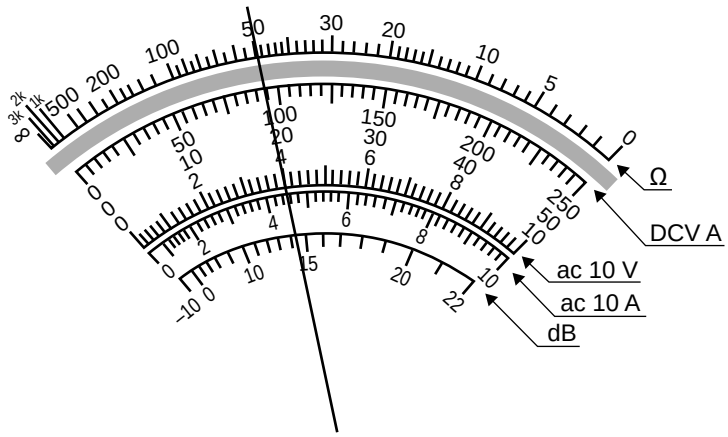
iii. Explain how relay K_1 is de-energised when the stop button is pressed. 1 mark

b. The power circuit consists of a motor-driven pump, relay K_1, NO contacts and a 230 V_{AC} supply.

i. In the power circuit on Figure 4, draw the connections so that when K_1 energises, the pump motor will run. 3 marks

ii. In the control circuit on Figure 4, complete the circuit so that the green lamp is on when the pump motor is on and the red lamp is on when the pump motor is off. 3 marks

iii. With power applied to the circuit, the pump motor fails to start. Removing power and testing the power circuit using an analogue multimeter reveals $K_{1–2}$ contacts to be resistive, as shown in Figure 5.



Ohms multiplier range selection	
ohms × 1 range	
ohms × 10 range	✓
ohms × 100 range	

Figure 5

What is the resistance of the contacts $K_{1–2}$? 2 marks

Question 9 (6 marks)

Figure 6 shows a capacitor and resistor network.

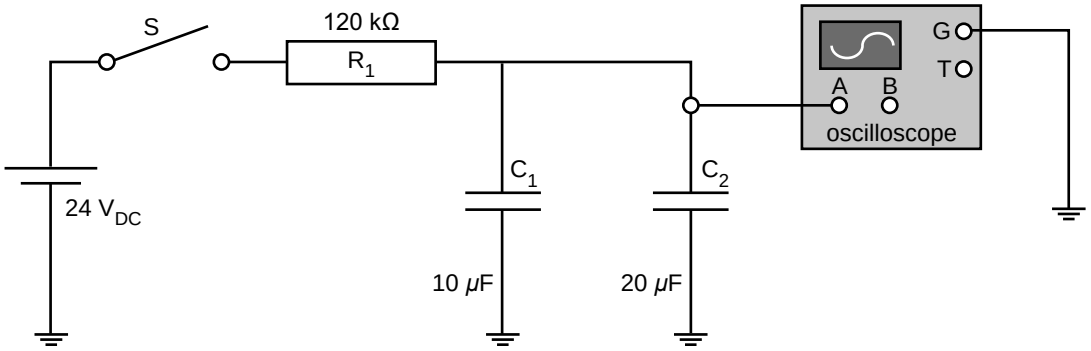
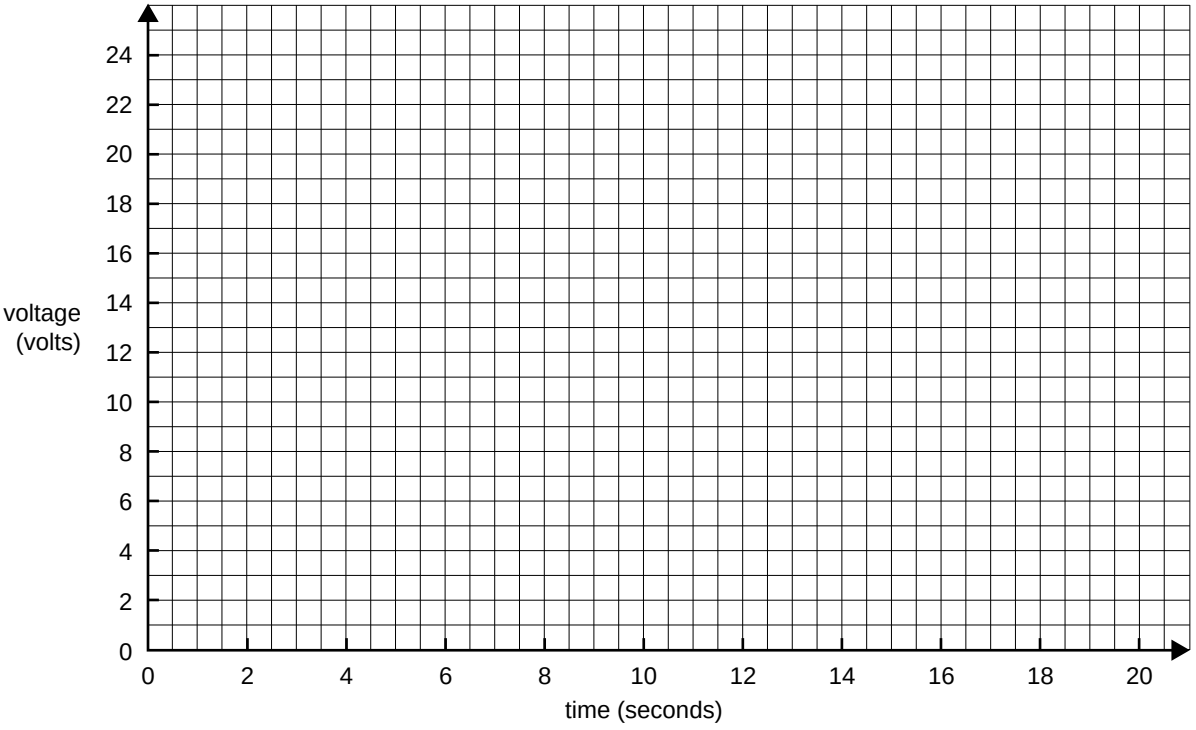


Figure 6

a. What is the total capacitance in the circuit? 1 mark

b. How long will capacitors C_1 and C_2 take to fully charge? Show your working. 3 marks

c. On the graph below, sketch the waveform displayed by the oscilloscope when the switch is closed for a period of 20 seconds. Assume the capacitors are fully discharged before the switch is closed. 2 marks



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Question 10 (10 marks)

A group of students wants to design and build a solar-powered system at their school. The students will be supervised by a local electrical contractor.

The students' goal is to create a 3 kW system that allows them to monitor and log irradiance levels, power output, photovoltaic (PV) voltage and temperature, while offering cost-saving benefits to the school when the system is running.

The students search the internet to find photovoltaic panels and an inverter to complete the task. The specifications of the chosen photovoltaic panels and inverter are shown in Tables 3 and 4 below.

Table 3. PV panel specifications

maximum power	Pmax	225 W
open circuit voltage	V_{DC}	37.3 V
max. power point voltage	V_{mpp}	29.7 V
short circuit current	I_{SC}	8.13 A
max. power point current	I_{mpp}	7.59 A
bypass diode fitted	yes	
Specifications given @ 1000 W/m^2, 25 °C		

Table 4. 3 kW inverter specifications

PV input		**Grid output**	
nominal DC voltage	360 V_{DC}	nominal output power	3 kW
MPPT range	150–550 V	max. output power	3.1 kW
working range	100–550 V	operating voltage	190–270 V_{AC}
max. PV o/p circuit voltage	550 V	operating frequency	47–53 Hz
max. input current @ 360 V	12.4 A	current distortion	< 3%
max. input current	13.8 A	power factor	> 0.99
max. input power	3.3 kW	max. efficiency	> 94%

a. Refer to the PV panel and inverter specifications in Tables 3 and 4.

i. Using the inverter's 'nominal DC voltage' as the minimum voltage requirement and the PV panel's 'max. power point voltage', determine the minimum number of panels required. Show your working. 2 marks

ii. In what configuration would the panels be connected? 1 mark

b. On Figure 7 below, draw and label the wiring diagram showing the number of panels given in **part a.** connected via the isolation switch to the inverter.
The existing devices shown in Figure 7 should be used as part of the design. 3 marks

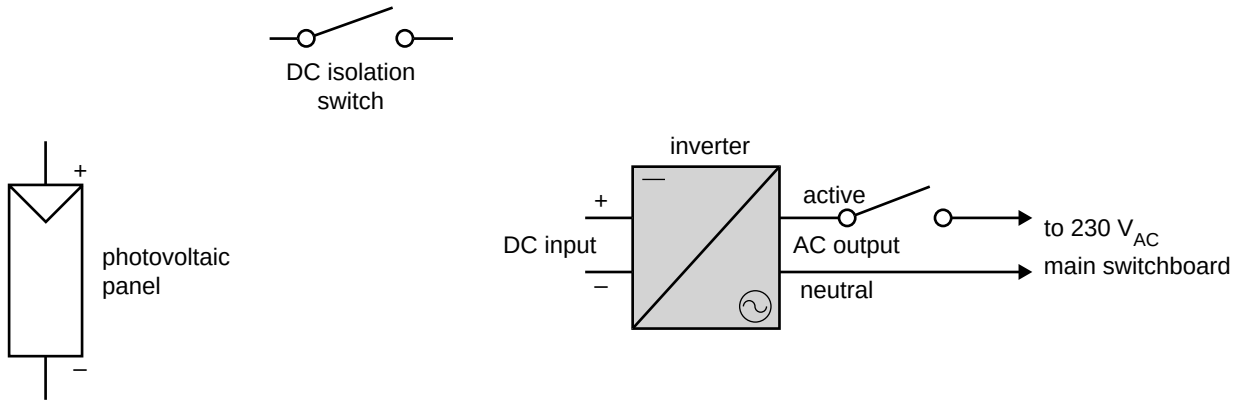


Figure 7

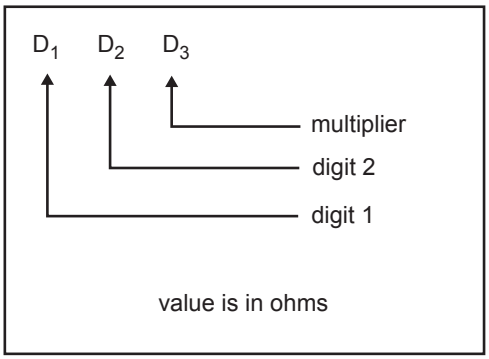
c. Using your result in **part a.**, at the PV panel's maximum power point voltage and current, what will be the maximum power delivered to the inverter? Show your working. 2 marks

d. Using your result in **part c.**, if the efficiency of the inverter is 94%, what is the maximum power the inverter can supply to a load? Show your working. 2 marks

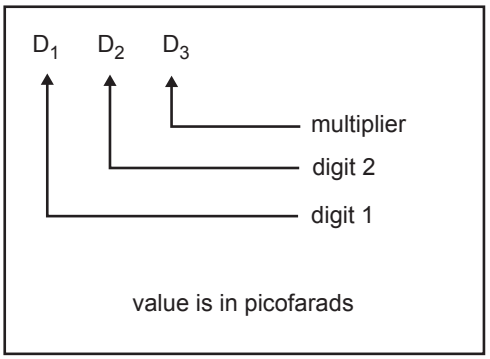
END OF SECTION B
TURN OVER

Formula sheet

resistor code



capacitor code



$$R_T = R_1 + R_2 + R_3$$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$R_T = \frac{R_1 R_2}{R_1 + R_2}$$

$$R = \frac{\rho l}{A}$$

$$V = I \times R$$

$$P = V \times I$$

$$V_X = V_S\left(\frac{R_X}{R_T}\right)$$

$$V_{PK} = \sqrt{2} \times V_{RMS}$$

$$\text{turns ratio} = \frac{N1}{N2}$$

$$\frac{V_{primary}}{V_{secondary}} = \frac{N_{primary}}{N_{secondary}} = \frac{I_{secondary}}{I_{primary}}$$

$$f = \frac{1}{T}$$

$$V_{STEP} = \frac{V_{max}}{2^n - 1}$$

$$\tau = C \times R$$

$$A = \frac{\pi d^2}{4}$$

$$C = \frac{\varepsilon A}{d}$$

$$C_T = C_1 + C_2 + C_3$$

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$Q = V \times C$$

$$W = \frac{1}{2}CV^2$$

$$W = P\,t$$

Resistor colour code

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

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

END OF QUESTION AND ANSWER BOOK