NEW SOUTH WALES
DEPARTMENT
OF EDUCATION
AND TRAINING

TAFE NSW

Family Name .....

Given Name .....

Student Number .....

Centre .....

Signature .....

November 2005

6077AC Electrical Systems Safety

Time allowed - Three hours plus Ten minutes reading time

32 Pages in this Question Booklet

ALL Questions to be attempted

TOTAL MARKS AVAILABLE =100

Section	Possible Mark	Actual Mark
A	15	
B	20	
C	45	
D	20	
TOTAL	100	

Aids to be supplied by college:

- None.

Aids to be supplied by student:

- Australian/New Zealand Wiring rules AS/NZS 3000:2000 (AMDT 3 – July 2003)
- Australian/New Zealand Wiring rules AS/NZS 3008:2000
- NSW Service and Installation Rules
- Students own marginal notes, indexing and formal amendments may be included in the above regulation books.
- Pen, pencil, eraser, rule, calculator.

Instructions to Students:

- **Mobile phones are to be turned off and removed from your person**. You cannot access a mobile phone during this examination.
- All questions to be answered in the space provided on this **examination paper**. Answers to Section A – multi-choice questions, are to be recorded on the Answer Sheet attached to this examination paper.
- You are not to use any other reference books in this examination.
- The whole of this paper is to be handed to the Supervisor upon completion.

Aids permitted where indicated:

Standard Dictionaries	Bilingual Dictionaries	Technical Dictionaries	Programmable Calculators	Non-programmable Calculators
No	No	No	No	Yes

SECTION A – (10 Marks)

INSTRUCTIONS: Select the best answer for the following statements and place an 'X' in the appropriate box on the Answer Sheet attached to the back of this examination paper. Each correct answer is worth one (1) mark.

QUESTION 1. (1 Mark)

All installation work must be tested

(a) as each circuit is installed

(b) after the supply has been connected

(c) by the supply authority

(d) before being permanently connected to the supply

QUESTION 2. (1 Mark)

Tools and equipment used on a job site must be inspected for safe operation:

(a) weekly

(b) monthly

(c) quarterly

(d) yearly

QUESTION 3. (1 Mark)

The first test that should be made on a completely new installation is:

(a) visual inspection test

(b) insulation resistance test

(c) earth resistance on the main earthing conductor

(d) earth resistance of sub-circuit earthing conductors

QUESTION 4. (1 Mark)

Safety at work is the responsibility of:

(a) building owners and employers

(b) work site supervisor

(c) employers and their employees

(d) owner or controller of work site and employers and their employees

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SECTION A – (Cont'd)

QUESTION 5. (1 Mark)

Equipment used in an electrical installation must:

(a) be rated for 230V, 50Hz operation

(b) carry the EMI compliant mark

(c) be safe to use and not cause danger

(d) carry the regulatory compliant mark

QUESTION 6. (1 Mark)

A major hazard with confined spaces is:

(a) difficulty in using tools

(b) unable to stand upright when working

(c) only one person can work at a time

(d) flammable contaminants and oxygen depletion

QUESTION 7. (1 Mark)

Ensuring that an electrical installation, within commercial premises, is safe for use is the responsibility of:

(a) controller of the premises

(b) owner of the premises

(c) site electrician

(d) installing electrical contractor

QUESTION 8. (1 Mark)

A common cause of indirect contact with live electrical components is:

(a) Insulation failure

(b) Electrical overloads

(c) Contact with bare machine terminals

(d) Contact with non-insulated aerial conductors

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SECTION A – (Cont'd)

QUESTION 9. (1 Mark)

The MEN system of earthing is where:

(a) All parts of an installation required to be earthed are connected to the general mass of earth but not to the main neutral link

(b) All parts of an installation required to be earthed are connected to the general mass of earth and in addition are connected to the main neutral link

(c) All parts of an installation required to be earthed are not connected to the general mass of earth but are connected to the main neutral link

(d) All parts of an installation required to be earthed are connected only to the general mass of earth and the main earth link

QUESTION 10. (1 Mark)

The factor to consider when selecting a circuit protection device to ensure the protection device only isolates the faulty circuit is:

(a) Correctly graded discrimination

(b) Category of the device matches to the load factor

(c) Fault current rating matches the prospective fault current

(d) Current rating is correctly determined to protect the cables

QUESTION 11. (1 Mark)

A major factor that directly affects fault-loop impedance in an MEN installation is:

(a) Soil resistivity

(b) The power rating of the load

(c) The length of the final sub-circuit

(d) Environmental factors such as humidity

QUESTION 12. (1 Mark)

Which of the following wiring systems is most suitable for a circuit supplying a fire pump?

(a) TPS cable, unenclosed on a cable tray

(b) MIMS cables on a cable tray

(c) Single insulated, V75 cable in PVC conduit

(d) TPS cable sharing the same conduit as power and light circuits

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SECTION A – (Cont'd)

QUESTION 13. (1 Mark)

A suitable wiring system used as aerial cable without further support is:

(a) TPS cables

(b) Neutral-screened cables

(c) Annealed copper conductors

(d) Flexible insulated conductors

QUESTION 14. (1 Mark)

Before removing a meter connected to a current transformer, it is essential to:

(a) short circuit the CT primary to the secondary at the metering links

(b) open circuit the CT secondary at the metering links

(c) short circuit the CT secondary winding at the metering links

(d) short circuit the CT primary winding at the metering links

QUESTION 15. (1 Mark)

One method for determining the size of consumer mains and sub-mains of an electrical installation is:

(a) Location of points

(b) Safe design and construction

(c) Demand of devices for isolation

(d) Measuring the highest rate of electricity use in any 15 minute period

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SECTION B – (30 Marks)

INSTRUCTIONS: Use AS/NZS 3000:2000 to best answer each question in the space provided showing the AS/NZS 3000:2000 references used to obtain the answer.

QUESTION 1. (2 Marks)

The 2000 Edition of the Wiring Rules establishes (or sets out) the minimum requirements for the design, construction and testing of electrical installations. What is the intent of these requirements?

_____

_____

_____

Reference (_____)

QUESTION 2. (2 Marks)

AS/NZS 3000 suggests several methods for determining the maximum demand of an installation. Which of these is most suited for designing the electrical installation for a shopping complex having a department store, a supermarket and a number of specialty shops?

_____

Reference (_____)

QUESTION 3. (2 Marks)

What are two (2) main reasons for dividing electrical installations into final sub-circuits?

_____

_____

_____

Reference (_____)

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SECTION B – (Cont'd)

QUESTION 4. (2 Marks)

What are the requirements for earthing conductors when carrying fault currents?

_____

_____

_____

Reference (_____)

QUESTION 5. (2 Marks)

What is the maximum internal fault-loop impedance at 230 V, of a single-phase circuit wired in 4 mm^2 TPS cable when supplying a stationary cooking appliance in a domestic installation and protected by a 20 A type C circuit breaker?

_____

Reference (_____)

QUESTION 6. (2 Marks)

What is the purpose of equipotential bonding?

_____

_____

_____

_____

_____

Reference (_____)

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SECTION B – (Cont'd)

QUESTION 7. (2 Marks)

Special precautions are needed for fire hazard prevention when installing fixed electrical equipment, which could attain high surface temperatures, next to other materials. What specific types of equipment are considered high temperature sources?

_____

_____

_____

Reference (_____)

QUESTION 8. (2 Marks)

What are the requirements for protective devices installed for protection against short-circuit currents?

_____

_____

_____

_____

Reference (_____)

QUESTION 9. (2 Marks)

What devices are suitable for providing protection against both overload and short-circuit conditions?

_____

_____

_____

Reference (_____)

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SECTION B – (Cont'd)

QUESTION 10. (2 Marks)

When selecting equipment for an electrical installation, they must satisfy a number of provisions. What are these provisions?

_____

_____

_____

_____

_____

_____

_____

Reference (_____)

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SECTION C – (45 Marks)

INSTRUCTIONS: This section involves calculations. Show all necessary working in the space provided, marks will be awarded accordingly. Answers are to be highlighted or underlined.

The questions in this section relate to a factory installation. A main switchboard supplies a number of switchboards in the factory.

Details of the installation are provided in *Figure 1* **and** *Figure 2*

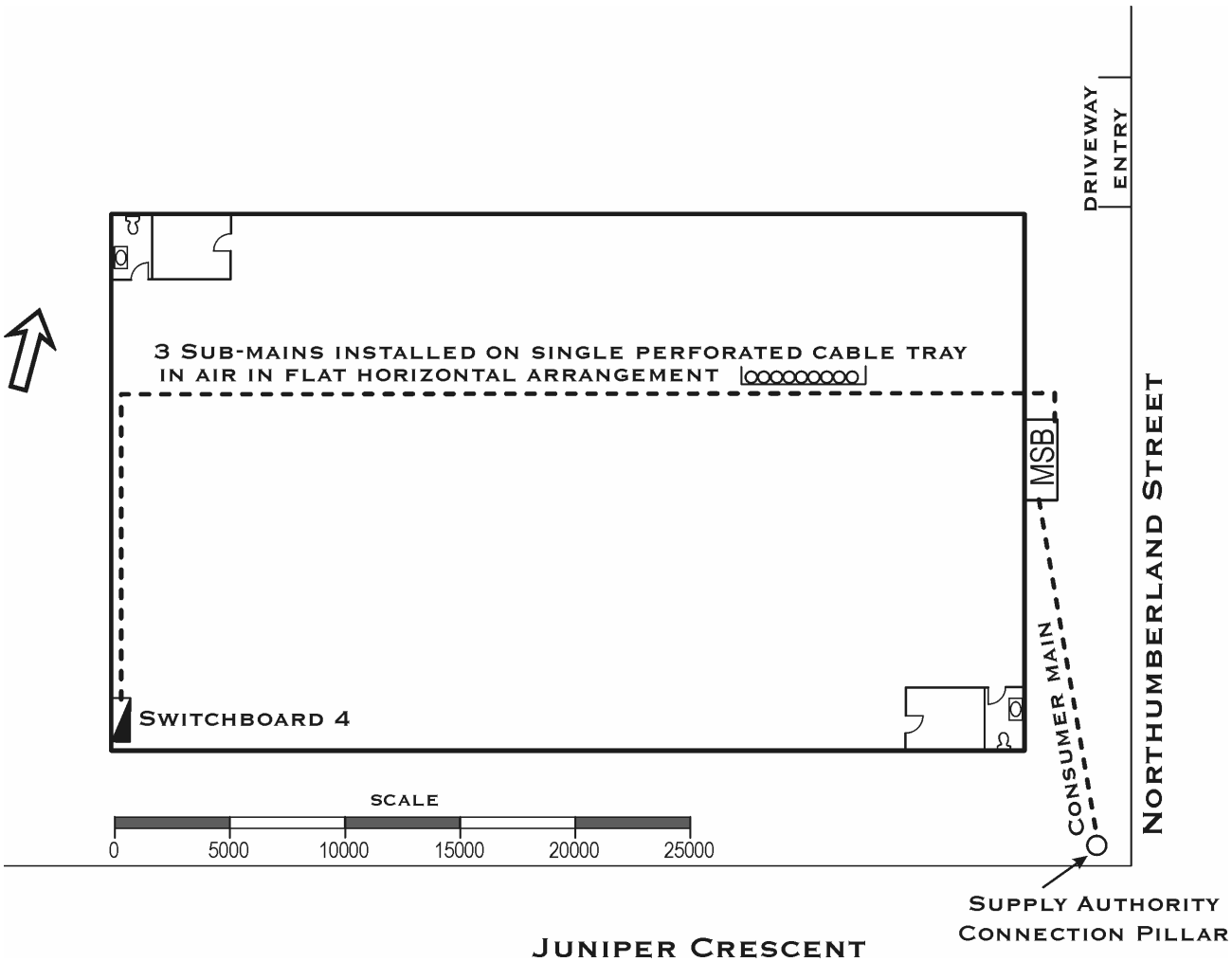

Figure 1

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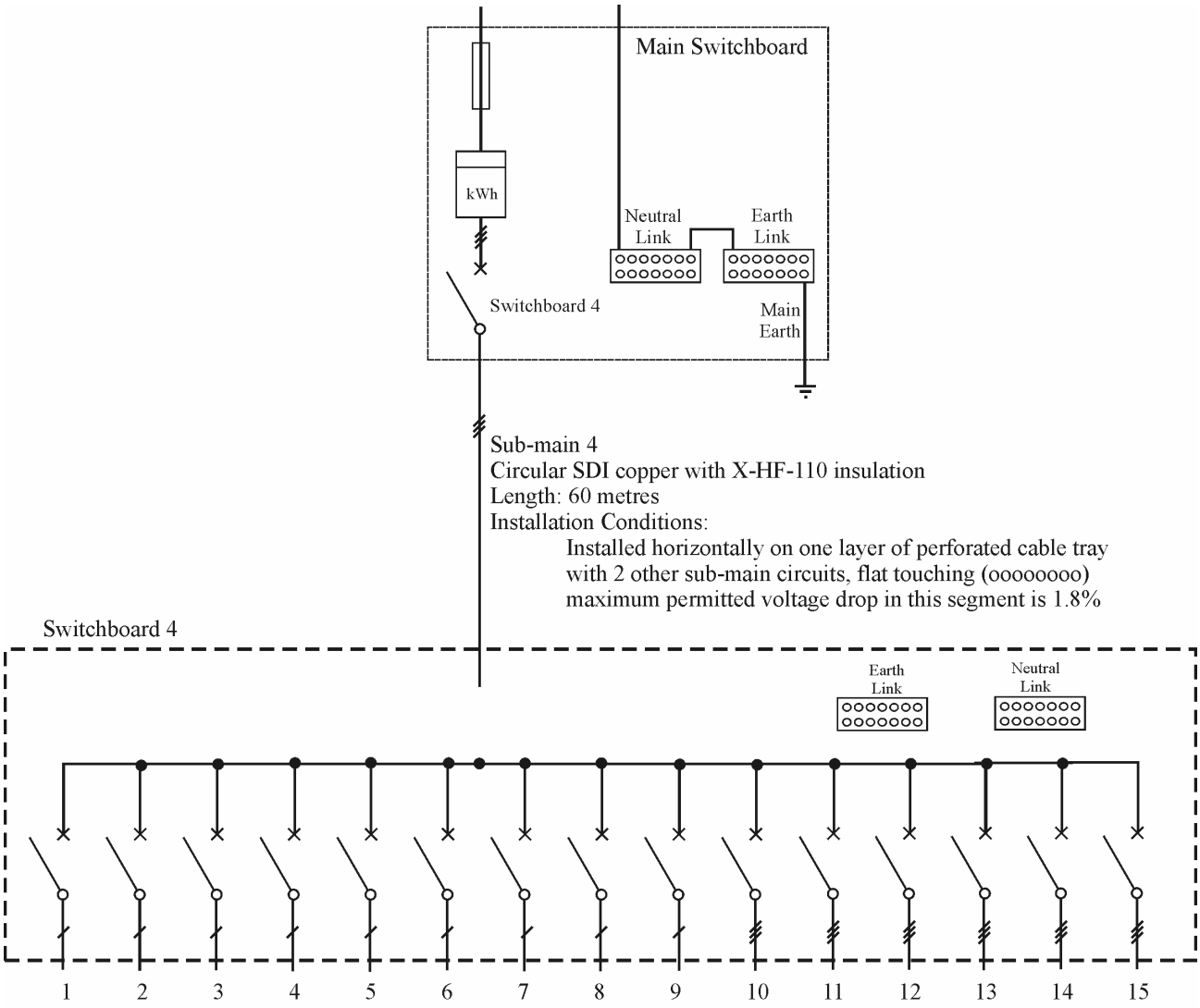
SECTION C – (Cont'd)



Circuit	Description	Quantity	Rating
1	Fluorescent Lighting	18	0.85A each
2	Fluorescent Lighting	16	0.85A each
3	Fluorescent Lighting	16	0.85A each
4	1 phase socket outlets	6	10A each
5	1 phase socket outlets	8	10A each
6	1 phase socket outlets	8	10A each
7	1 phase water heater instantaneous	1	15A
8	1 phase motors	2	7.2A each
9	1 phase motors	2	6.8A each
10	3 phase arc welder	1	15A
11	3 phase arc welder	1	15A
12	3 phase socket outlet	1	32A
13	3 phase socket outlet	1	20A
14	3 phase motor	1	14A
15	3 phase motor	1	12A

Figure 2

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SECTION C – (Cont'd)

Use the information in Table 1 to assist in answering Questions 1 and 6.

Table 1

Conductor size (mm^2)	a.c. resistance at 50 Hz in Ω/km		
	at 75°C	at 90°C	at 110°C
2.5	9.01	9.45	10.0
4	5.61	5.88	6.24
6	3.75	3.93	4.17
10	2.23	2.33	2.48
16	1.40	1.47	1.56
25	0.884	0.927	0.984
35	0.638	0.668	0.710
50	0.471	0.494	0.524
70	0.327	0.342	0.363
95	0.236	0.247	0.262
120	0.188	0.197	0.208
150	0.153	0.160	0.169
185	0.123	0.129	0.136

QUESTION 1. (2 Marks)

The 3-phase 400/230-volt consumer main to the factory consists of R-E-110 SDI cables having circular copper conductors. The active conductors are 150 mm^2. The Supply Authority nominates the fault level at the point of supply as 30 kA. The soil resistivity for the installation is very low. The cables have a route length of 18 metres. Calculate the theoretical fault current (A to E) at the main switchboard.
(Hint: assume the return path has negligible resistance due to the low soil resistivity)

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SECTION C – (Cont'd)

QUESTION 2. (5 Marks)

Calculate the maximum demand of the three-phase sub-main to Switchboard 4. The occupant intends to use rotating electrical machines in this area. The factory does not contain heating or cooling.
Enter required information for each circuit as listed in the following Table.

Load group	Load description	Qty	Calculation	Demand (Red)	Demand (White)	Demand (Blue)
	Circuit 1 — Lighting					
	Circuit 2 — Lighting					
	Circuit 3 — Lighting					
	Circuit 4 — 1 ph Power					
	Circuit 5 — 1 ph Power					
	Circuit 6 — 1 ph Power					
	Circuit 7 — 1 ph HWS					
	Circuit 8 — 1 ph Motors					
	Circuit 9 — 1 ph Motors					
	Circuit 10 — 3 ph Welder					
	Circuit 11 — 3 ph Welder					
	Circuit 12 — 3 ph Power					
	Circuit 13 — 3 ph Power					
	Circuit 14 — 3 ph Motor					
	Circuit 15 — 3 ph Motor					
			Maximum Demand			

Maximum demand of the three-phase sub-main 4 is _____

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SECTION C – (Cont'd)

QUESTION 3. (5 Marks)

The maximum demand of the sub-main 4 was determined to be 180 A and the major portion of the load was balanced 3-phase equipment, resulting in a maximum out-of-balance current of 55 Ampere. What would be the minimum size of the active, neutral and earth conductors for X-HF-110 SDI cables having circular copper conductors when installed on single perforated cable tray together with two similar sub-main cables when each cable is in contact with the next (that is flat touching)?

Standard used: _____

Derating (if applicable)

Table No used: _____

Column: _____

Derating factor: _____

Required current carrying capacity: _____

Active conductor

Table No used: _____

Column: _____

Cross-sectional area: _____

Determine the current carrying capacity of the neutral

_____

_____

_____

Reference (_____)

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SECTION C – (Cont'd)

QUESTION 3. (cont)

Determine the size of the neutral conductor

Table No: _____

Column No: _____

Cross sectional area: _____

Determine the size of the earth conductor

Standard used: _____

Table No: _____

Cross sectional area: _____

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SECTION C – (Cont'd)

QUESTION 4. (4 Marks)

If the maximum demand of sub-main 4 was determined to be 180 A, and the sub-main comprised X-HF-110 SDI cables having 50 mm^2 circular copper active and neutral conductors, would the voltage drop be within the specified limit of 1.8%?

Standard used: _____

Table No: _____

mV/A.m rating: _____

_____

_____

_____

_____

Does this comply with the 1.8% specified limit?

_____

QUESTION 5. (2 Marks)

If the maximum demand of sub-main 4 was determined to be 180 A, select a suitable protective device for sub-main 4.

Description of selected device: _____

Nominal current rating: _____

Category rating of device: _____

Maximum value of fault loop impedance for selected device: _____

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SECTION C – (Cont'd)

QUESTION 6. (2 Marks)

If the maximum demand of sub-main 4 was determined to be 180 A, and the sub-main comprised X-HF-110 SDI cables having 50 mm^2 circular copper active and neutral conductors with a 16 mm^2 earth conductor, calculate the fault current rating (A – E) of the main isolator for switchboard 4 when the fault current at the main switchboard is limited to 20 kA. (Use Table 1 for conductor resistances).

QUESTION 7. (2 Marks)

If the maximum demand of sub-main 4 was determined to be 180 A, and the sub-main comprised X-HF-110 SDI cables having 50 mm^2 circular copper active and neutral conductors with a 16 mm^2 earth conductor, verify that a 200 A type C circuit breaker would adequately protect the circuit with the fault-loop impedance limitations.

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SECTION C – (Cont'd)

The remaining questions in this section relate to a multiple domestic installation comprising ten (10) separate occupancies. A main switchboard for the complex supplies a switchboard in each of the occupancies.

Details of the installation are provided in *Figure 3*, *Figure 4* **and** *Figure 5*

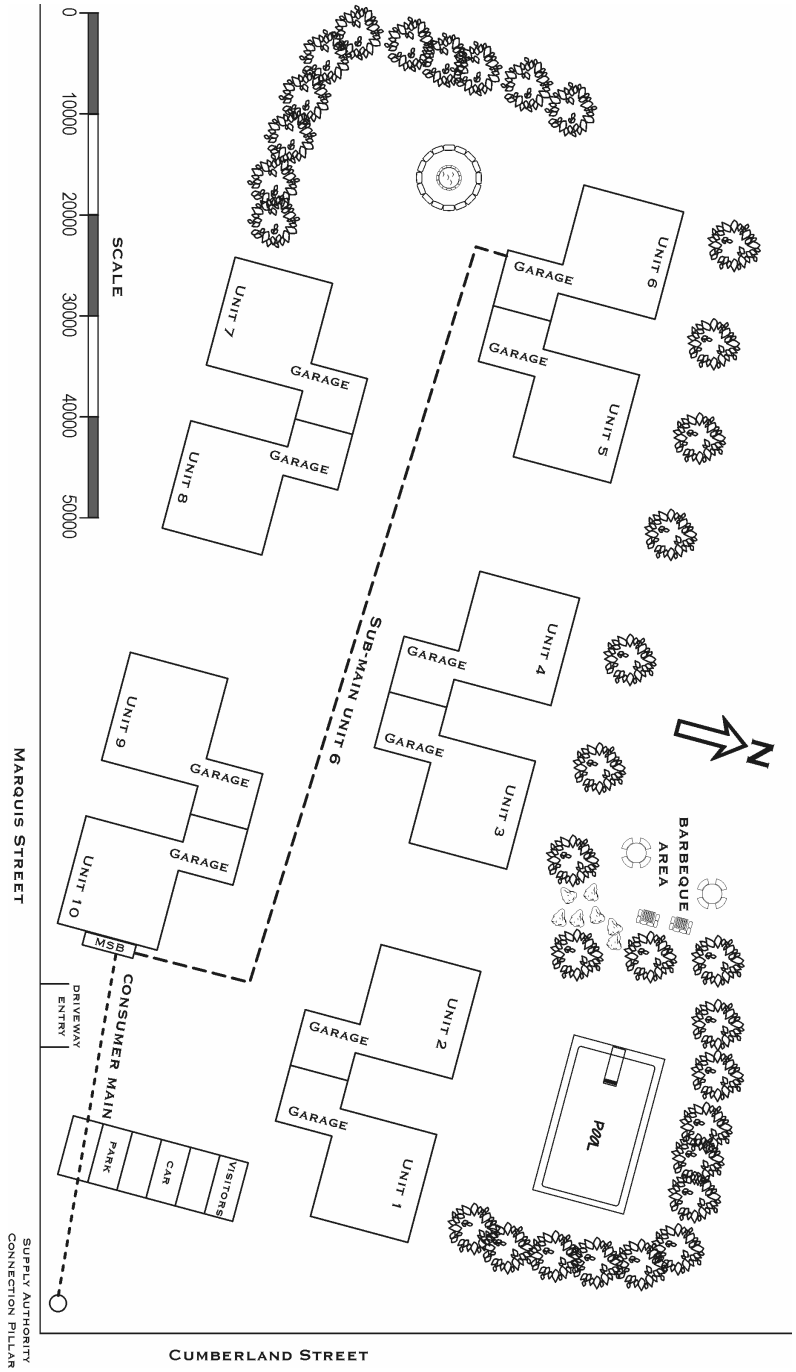

Figure 3

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SECTION C – (Cont'd)

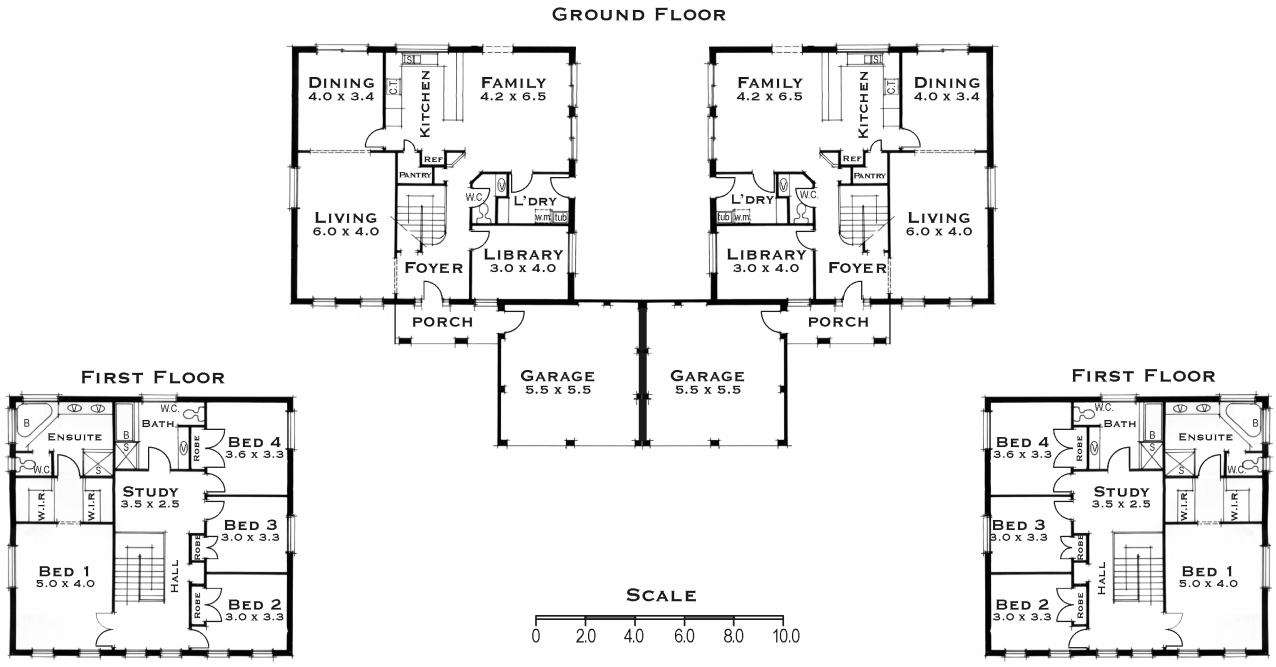

Figure 4

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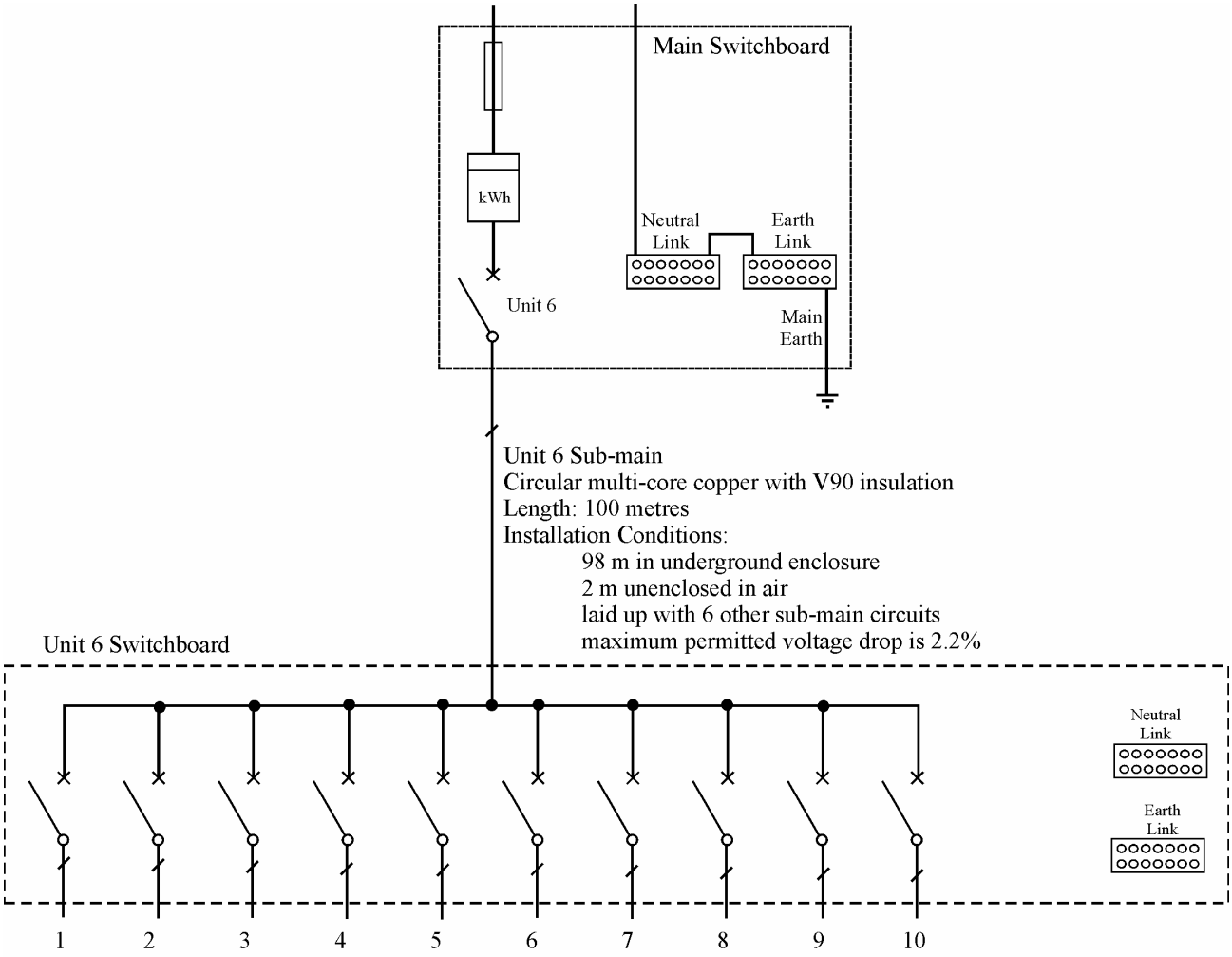
SECTION C – (Cont'd)



Circuit	Description	Quantity	Rating
1	Lighting	18	100 W each (nominal 240V)
2	Lighting	20	100 W each (nominal 240V)
3	1 phase socket outlets	9 double	10A each (nominal 240V)
4	1 phase socket outlets	5 double, 7 single	10A each (nominal 240V)
5	1 phase socket outlets	6 double, 6 single	10A each (nominal 240V)
6	1 phase socket outlet	1	15A (nominal 240V)
7	1 phase air conditioner	1	18A (nominal 240V)
8	1 phase quick recovery HWS	1	20A (nominal 240V)
9	1 phase cook-top	1	8.2kW (nominal 240V)
10	1 phase wall oven	1	5.6kw (nominal 240V)

Figure 5

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SECTION C – (Cont'd)

QUESTION 8. (4 Marks)

Calculate the maximum demand of the single-phase sub-main to Unit 6.
Enter required information for each circuit as listed in the following Table.

Load group	Load description	Qty	Calculation	Demand
	Lighting			
	1 ph Power (10 A)			
	1 ph Power (15 A)			
	Air Conditioning			
	Quick Recovery HWS			
	Cook-top			
	Wall oven			
			Maximum Demand	

Maximum demand of the single-phase sub-main to Unit 6 is _____

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SECTION C – (Cont'd)

QUESTION 9. (4 Marks)

If the maximum demand of the sub-main to unit 4 was determined to be 100 A, what would be the minimum size of the active, neutral and earth conductors for a 2-core and earth V90 cable having circular copper conductors when installed in an underground trench together with six (6) other similar sub-main cables when all seven (7) conduits are in contact with each other?

Standard used: _____

Derating (if applicable)

Table No used: _____

Column: _____

Derating factor: _____

Required current carrying capacity: _____

Active conductor

Table No used: _____

Column: _____

Cross-sectional area: _____

Determine the current carrying capacity of the neutral

_____

_____

_____

Reference (_____)

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SECTION C – (Cont'd)

QUESTION 9. (cont)

Determine the size of the neutral conductor

Table No: _____

Column No: _____

Cross sectional area: _____

Determine the size of the earth conductor

Standard used: _____

Table No: _____

Cross sectional area: _____

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SECTION C – (Cont'd)

QUESTION 10. (5 Marks)

If the maximum demand of the sub-main to unit 6 was determined to be 100 A, and the 2-core and earth V90 cable had 16 mm^2 circular copper conductors, would the voltage drop be within the specified limit of 2.2%?

Standard used: _____

Table No: _____

mV/A.m rating: _____

_____

_____

_____

_____

Does this comply with the 2.2% specified limit?

_____

QUESTION 11. (3 Marks)

Final sub-circuit 1 supplies a load consisting of 100 W lighting points. A 10 A Type C circuit breaker protects the circuit of 1.5 mm^2 V90, TPS, 2-core and earth. Determine the maximum *measured* internal fault-loop impedance of the final sub-circuit, based on 230 V, when supply is unavailable and the ambient temperature is 20°C.

_____

_____

_____

_____

_____

_____

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SECTION C – (Cont'd)

Table 2 — Communal Schedule

This load connects to one single-phase meter.

Location	Appliance	A
Outside Unit 1 Garage	18 W Bollard	0.12
Outside Unit 2 Garage	18 W Bollard	0.12
Outside Unit 3 Garage	18 W Bollard	0.12
Outside Unit 4 Garage	18 W Bollard	0.12
Outside Unit 5 Garage	18 W Bollard	0.12
Outside Unit 6 Garage	18 W Bollard	0.12
Outside Unit 7 Garage	18 W Bollard	0.12
Outside Unit 8 Garage	18 W Bollard	0.12
Outside Unit 9 Garage	18 W Bollard	0.12
Outside Unit 10 Garage	18 W Bollard	0.12
RH side driveway entry	18 W Bollard	0.12
LH side driveway entry	18 W Bollard	0.12
Barbecue area	500 W halogen flood	2.5
	500 W halogen flood	2.5
	500 W halogen flood	2.5
	500 W halogen flood	2.5
Swimming pool area	500 W halogen flood	2.5
	500 W halogen flood	2.5
	500 W halogen flood	2.5
	500 W halogen flood	2.5

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SECTION C – (Cont'd)

QUESTION 12. (5 Marks)

Calculate the maximum demand of the installation if the Communal loading detailed in Table 3 is included.
Enter required information for each circuit as listed in the following Table.

Load group	Load description	Qty	Calculation	Demand (Red)	Demand (White)	Demand (Blue)
	Lighting					
	1 ph Power (10 A)					
	1 ph Power (15 A)					
	Air Conditioning					
	Quick Recovery HWS					
	Cook-top					
	Wall oven					
	Communal 1 – Bollards					
	Communal 2 – Barbecue					
	Communal 3 – Swimming pool					
			Maximum Demand			

Maximum demand of the installation is _____

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SECTION D – 20 Marks

INSTRUCTION: The questions in this section require some simple drawing. Ensure that the drawing is neat and legible. The use of pencil on the drawing is acceptable in this section only.

QUESTION 1. (4 Marks)

The equipment shown in Figure 6 is for a switchboard in a multiple-domestic installation. Arrangement of the circuits places them partially surrounded by bulk thermal insulation. Two (2) 16 A combination RCD/MCBs are required to protect two final sub-circuits supplying 10 A socket outlets from the switchboard. Show on the diagram the necessary Active, Neutral and Earth connections for these two final sub-circuits.

You will lose marks for each missing or incorrect connection.

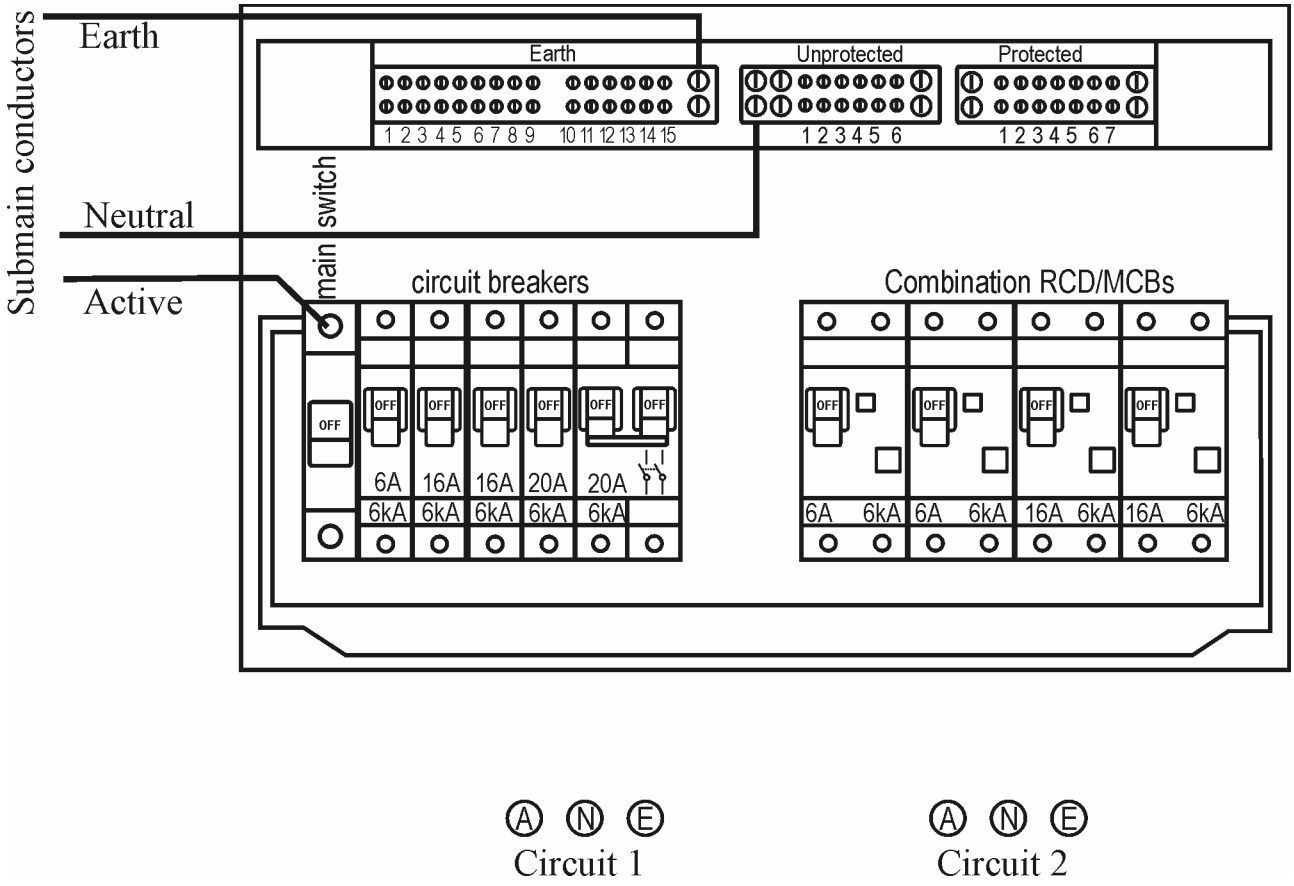

Figure 6

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SECTION D – (Cont'd)

QUESTION 2. (3 Marks)

Determine the suitability of a 16 A type C circuit breaker having a tripping characteristic in the range shown in *Figure 7*. The circuit breaker is to protect a circuit supplying a motor that takes 4.5 seconds to run up to speed and has a maximum starting current of 112 A. Show all working and show on the diagram how you arrived at the answer.

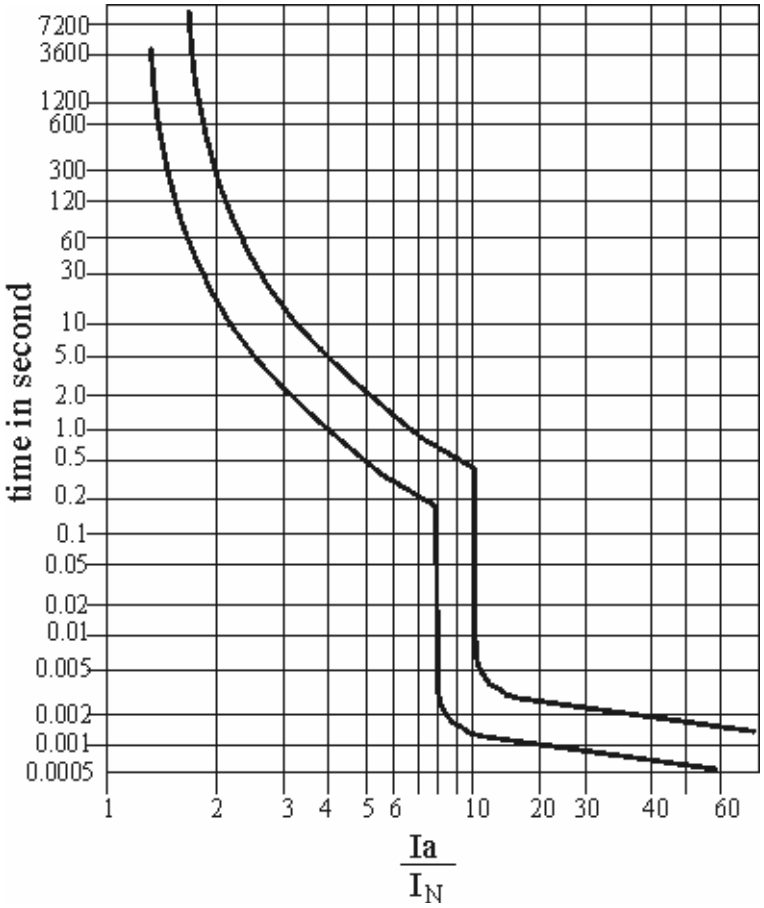

Figure 7

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SECTION D – (Cont'd)

QUESTION 3. (7 Marks)

INSTRUCTIONS: Blank spaces in the following statements represent omissions. Write the appropriate word, words or information in the spaces provided.

Insulation resistance test of complete 3-phase installation when supply is not connected:

Test sequence:

1. Disconnect any portable appliances and ensure that all circuit switches are in the _____.position.
2. Join all _____ _____ of the consumers mains together.
3. Turn main switch(es) to the _____ position.
4. Ensure that all circuit fuses are _____ and that all circuit breakers are in the _____ position.
5. Disconnect the _____ _____ at the neutral bar.
6. Set the meter to read _____ at _____ volts.
7. Connect one test lead to the _____ _____ conductor at the earth bar.
8. Connect the other test lead to the _____ _____.
9. Test that the resistance complies with the minimum specified.
10. If the test result is not satisfactory, test consumers mains, sub-mains and each _____ separately.
11. Disconnect the test leads, reconnect the _____ _____ , separate the _____ _____ of the consumers mains and reconnect portable appliances.

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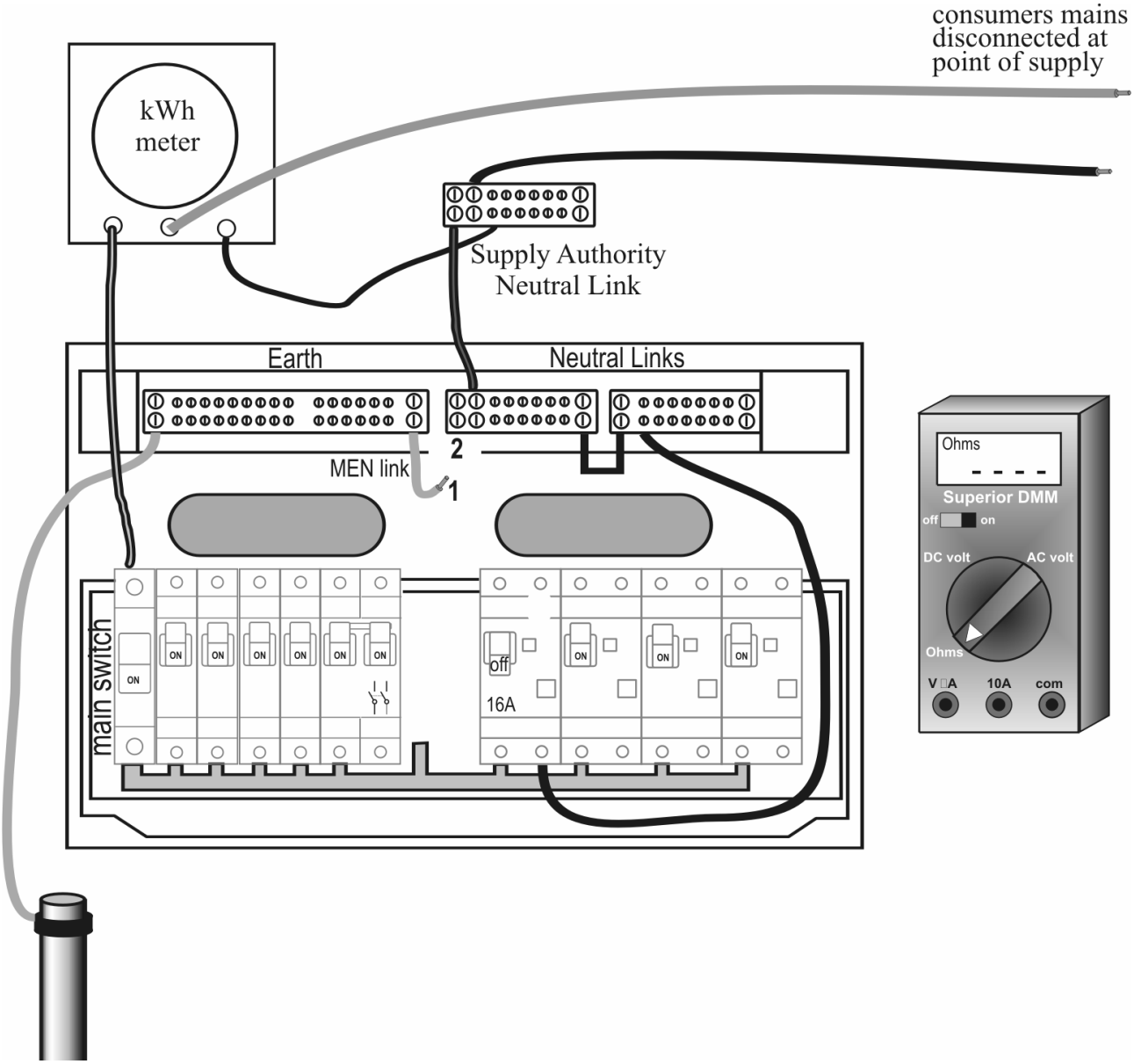
SECTION D – (Cont'd)

QUESTION 4. (3 Marks)

Complete the following diagram to show how the Ohmmeter would connect when testing the polarity of both the active and neutral conductors in a single-phase consumers main.



(a) The Men link would connect to Position1 / Position 2 (circle correct response) for the test.

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SECTION D – (Cont'd)

QUESTION 5. (3 Marks)

Complete the required switchboard marking, on the following diagram, for the circuit information provided in Table 3.

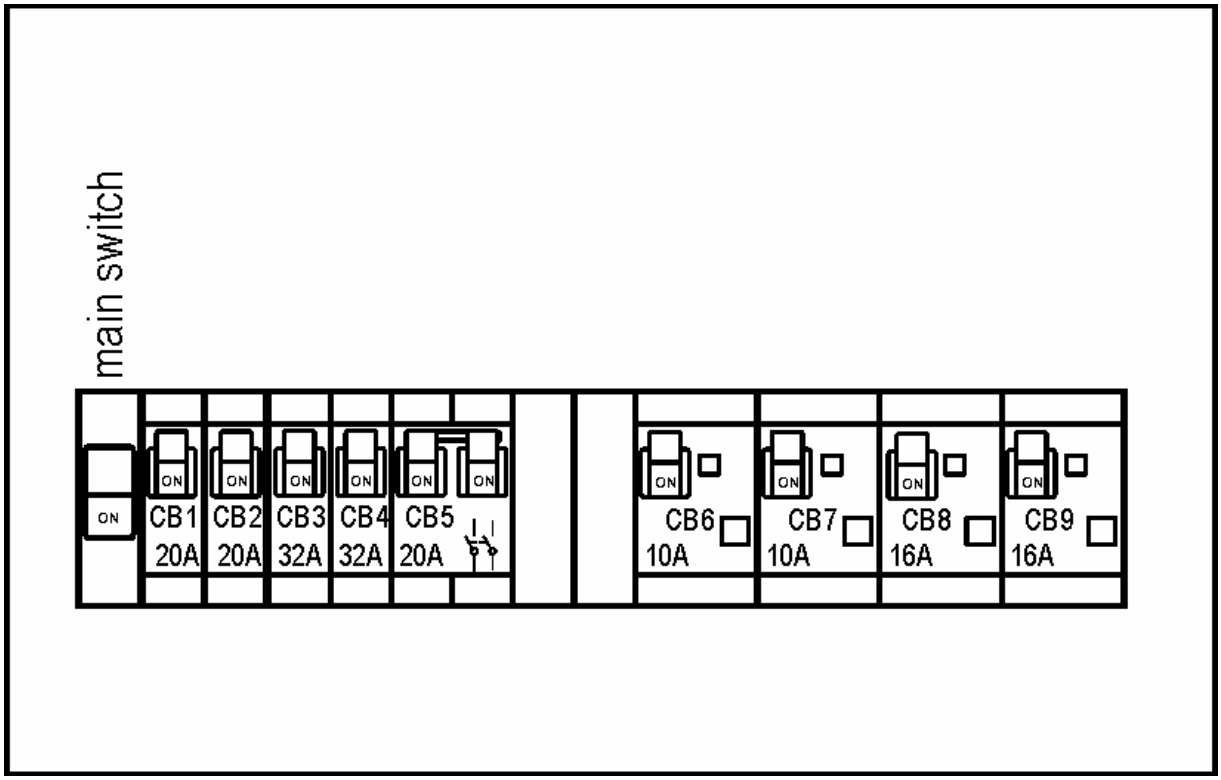

Table 3

Circuit	Description	CB	Neutral
1	Lights	6	1
2	Power	8	10
3	Air conditioner	3	5
4	Cook top	2	4
5	Dual element HWS	5	7

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Family Name .....

Given Name .....

Student Number.....

Centre .....

Signature .....

ANSWER SHEET – Section A (Multi-choice Questions)

November 2005

6077AC Electrical Systems Safety

Instructions:

- Enter your personal details in the top right hand corner of this sheet.
- Place an **X** in box of your choice. If you make a mistake, circle your answer (X) and choose again.

Question	(a)	(b)	(c)	(d)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
Totals				

Total Marks Section A: ..... /15

END OF EXAMINATION

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NEW SOUTH WALES
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AND TRAINING

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Family Name .....

Given Name .....

Student Number .....

Centre .....

Signature .....

June 2005

6077AC Electrical Systems Safety

Time allowed - Three hours plus Ten minutes reading time

34 Pages in this Question Booklet

ALL Questions to be attempted

TOTAL MARKS AVAILABLE =100

Section	Possible Mark	Actual Mark
A	15	
B	30	
C	20	
D	18	
E	17	
TOTAL	100	

Aids to be supplied by college:

- None.

Aids to be supplied by student:

- Australian/New Zealand Wiring rules AS/NZS 3000:2000 (AMDT 3 – July 2003)
- Australian/New Zealand Wiring rules AS/NZS 3008:2000
- NSW Service and Installation Rules
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Instructions to Students:

- **Mobile phones are to be turned off and removed from your person**. You cannot access a mobile phone during this examination.
- All questions to be answered in the space provided on this **examination paper**. Answers to Section A – multi-choice questions, are to be recorded on the Answer Sheet attached to this examination paper.
- You are not to use any other reference books in this examination.
- The whole of this paper is to be handed to the Supervisor upon completion.

Aids permitted where indicated:

Standard Dictionaries	Bilingual Dictionaries	Technical Dictionaries	Programmable Calculators	Non-programmable Calculators
No	No	No	No	Yes

SECTION A – (15 Marks)

INSTRUCTIONS: Select the best answer for the following statements and place an 'X' in the appropriate box on the Answer Sheet attached to the back of this examination paper. Each correct answer is worth one (1) mark.

QUESTION 1. (1 Mark)

The limit to circuit lengths, as set down in AS/NZS 3000, is required:

(a) to keep the cost of electrical installations as low as possible

(b) to limit the voltage drop in the circuit

(c) because shorter cable runs are the easier to install

(d) for protection against the danger of indirect contact

QUESTION 2. (1 Mark)

The minimum height above ground for bare aerial conductors over a roadway is

(a) 5.5 m

(b) 4.5 m

(c) 3.0 m

(d) bare conductors are not permitted over a roadway

QUESTION 3. (1 Mark)

Cables enclosed in heavy duty conduit, and chased into rock to a depth of not less than 50mm, fall into the underground wiring system category of:

(a) category C

(b) category B

(c) category A

(d) not permitted as under ground wiring

QUESTION 4. (1 Mark)

If a hazardous area is considered to be Zone 20, 21 or 22:

(a) explosive gas is present continuously

(b) explosive gas is likely to occur in normal operation

(c) explosive liquids, gas or vapours are likely to occur

(d) dust, fibres and flyings are likely to occur

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SECTION A – (Cont'd)

QUESTION 5. (1 Mark)

Before removing a meter connected to a current transformer, it is essential to:

(a) short circuit the CT primary to the secondary at the metering links

(b) open circuit the CT secondary at the metering links

(c) short circuit the CT secondary winding at the metering links

(d) short circuit the CT primary winding at the metering links

QUESTION 6. (1 Mark)

Underwater pool lighting must be supplied with a/an:

(a) earthing conductor connected to the light

(b) PEL V system installed close to the light

(c) PEL V or SEL V supply of 12 volts a.c. or less

(d) SEL V system not exceeding 30 volts d.c.

QUESTION 7. (1 Mark)

Special provisions are made in AS/NZS 3000 for underground cabling in areas of rock, where trenching may be difficult. This category of cabling method is referred to as:

(a) Category A

(b) Category B

(c) Category C

(d) Category R

QUESTION 8. (1 Mark)

The term 'equipotential bond' refers to:

(a) the bond the customer must pay prior to supply being connected

(b) the anchoring which bonds the cabling to the equipment

(c) the bonding of items to the earth potential

(d) the equipment guarantee bond between the supplier and the client

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SECTION A – (Cont'd)

QUESTION 9. (1 Mark)

The number of potential fuses required in a three phase CT metering system is:

(a) one

(b) three

(c) six

(d) nine

QUESTION 10. (1 Mark)

The location of a main switchboard in single domestic installations with a maximum demand of less than 100 amps per phase is determined by:

(a) Section 3 of AS/NZS 3000

(b) the height of the building above ground level

(c) using the New South Wales Service and Installation Rules

(d) the availability of water piping for the main earth

QUESTION 11. (1 Mark)

Devices installed for protection against over-current and short-circuit current must be capable of interrupting without damage a current not less than:

(a) the maximum demand current of the protected circuit

(b) the prospective fault current at the point of installation

(c) 1.45 times the rated current of the circuit breaker

(d) 1.6 times the rated current of the fuse

QUESTION 12. (1 Mark)

The International Protection Rating (IP) indicates the degree of protection of electrical equipment enclosures against penetration by:

(a) unauthorized persons

(b) hazardous gases

(c) flammable liquids and gases

(d) solid objects and water

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SECTION A – (Cont'd)

QUESTION 13. (1 Mark)

Protection against indirect contact is provided by circuit protective devices which will automatically disconnect supply to circuits when the touch voltage on the protected equipment exceeds:

(a) 240 V a.c.

(b) 120 V d.c.

(c) 110 Va.c.

(d) 50 V a.c.

QUESTION 14. (1 Mark)

A T.P .S. wiring system installed within a PVC conduit in a concrete floor on, or above the ground would be deemed to have the same current carrying capacity as cables installed:

(a) enclosed in air

(b) buried direct in the ground

(c) unenclosed in air

(d) enclosed in the ground

QUESTION 15. (1 Mark)

The minimum size of an insulated annealed copper aerial conductor is:

(a) 4 mm^2

(b) 6 mm^2

(c) 10 mm^2

(d) 16 mm^2

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SECTION B – (30 Marks)

INSTRUCTIONS: Use AS/NZS 3000:2000 to best answer each question in the space provided showing the AS/NZS 3000:2000 references used to obtain the answer.

QUESTION 1. (2 Marks)

AS/NZS 3000 suggests several methods for determining the maximum demand of an installation. Which of these is most suited for designing the electrical installation for a shopping complex having a department store, a supermarket and a number of specialty shops?

_____

Reference (_____)

QUESTION 2. (2 Marks)

What are the requirements for wiring systems associated with fire and smoke control equipment, evacuation equipment and lifts?

_____

_____

_____

Reference (_____)

QUESTION 3. (2 Marks)

The 2000 Edition of the Wiring Rules establishes (or sets out) the minimum requirements for the design, construction and testing of electrical installations. What is the intent of these requirements?

_____

_____

_____

Reference (_____)

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SECTION B – (Cont'd)

QUESTION 4. (2 Marks)

A domestic electrical installation has an electric wall oven and a gas cook-top. What are the requirements for the functional switch?

_____

_____

Reference (_____)

QUESTION 5. (2 Marks)

What is the minimum height, measured to the bottom of the enclosure, for a switchboard in a domestic installation?

_____

Reference (_____)

QUESTION 6. (2 Marks)

What is the maximum distance permitted for a span of insulated, 2-core, hard-drawn, 10mm^2, copper aerial cable?

_____

Reference (_____)

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SECTION B – (Cont'd)

QUESTION 7. (2 Marks)

Special precautions are needed for fire hazard prevention when installing fixed electrical equipment, which could attain high surface temperatures, next to other materials. What specific types of equipment are considered high temperature sources?

_____

_____

_____

Reference (_____)

QUESTION 8. (2 Marks)

A customer requests that a newly installed circuit to a 30 year old electrical installation be protected by a semi-enclosed rewireable fuse to match the existing circuit protection. Is this allowable? (Explain your answer)

_____

_____

_____

Reference (_____)

QUESTION 9. (2 Marks)

Persons and livestock must be protected against dangers that arise from direct contact with live parts. What is the intent of suitable protection methods?

_____

_____

_____

_____

Reference (_____)

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SECTION B – (Cont'd)

QUESTION 10. (2 Marks)

What is the maximum internal fault-loop impedance at 230 V, of a single-phase circuit wired in 4 mm^2 TPS cable when supplying a stationary cooking appliance in a domestic installation and protected by a 20 A type C circuit breaker?

_____

Reference (_____)

QUESTION 11. (2 Marks)

What are two (2) main reasons for dividing electrical installations into final sub-circuits?

_____

_____

Reference (_____)

QUESTION 12. (2 Marks)

In general, at what point in a circuit does AS/NZS 3000 require the placement of over-current devices?

_____

_____

_____

_____

Reference (_____)

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SECTION B – (Cont'd)

QUESTION 13. (2 Marks)
What are the requirements for the selection and installation of the devices to provide protection against indirect contact by automatic disconnection of supply?

_____

_____

Reference (_____)

SECTION B – (Cont'd)

QUESTION 14. (2 Marks)

Does the term 'exposed conductive part' apply to nameplates that cannot become live in the event of failure of insulation of live parts?

_____

Reference (_____)

QUESTION 15. (2 Marks)

What are the provisions for the restricted location of a switchboard where it may be affected by water splashing or steam?

_____

_____

_____

_____

Reference (_____)

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SECTION C – (20 Marks)

INSTRUCTIONS: This section involves calculations. Show all necessary working in the space provided, marks will be awarded accordingly. Answers are to be highlighted or underlined.

The questions in this section relate to a commercial installation comprising eight (8) separate occupancies. A main switchboard for the complex supplies a switchboard in each of the occupancies.

Details of the installation are provided in *Figure 1* **and** *Figure 2*

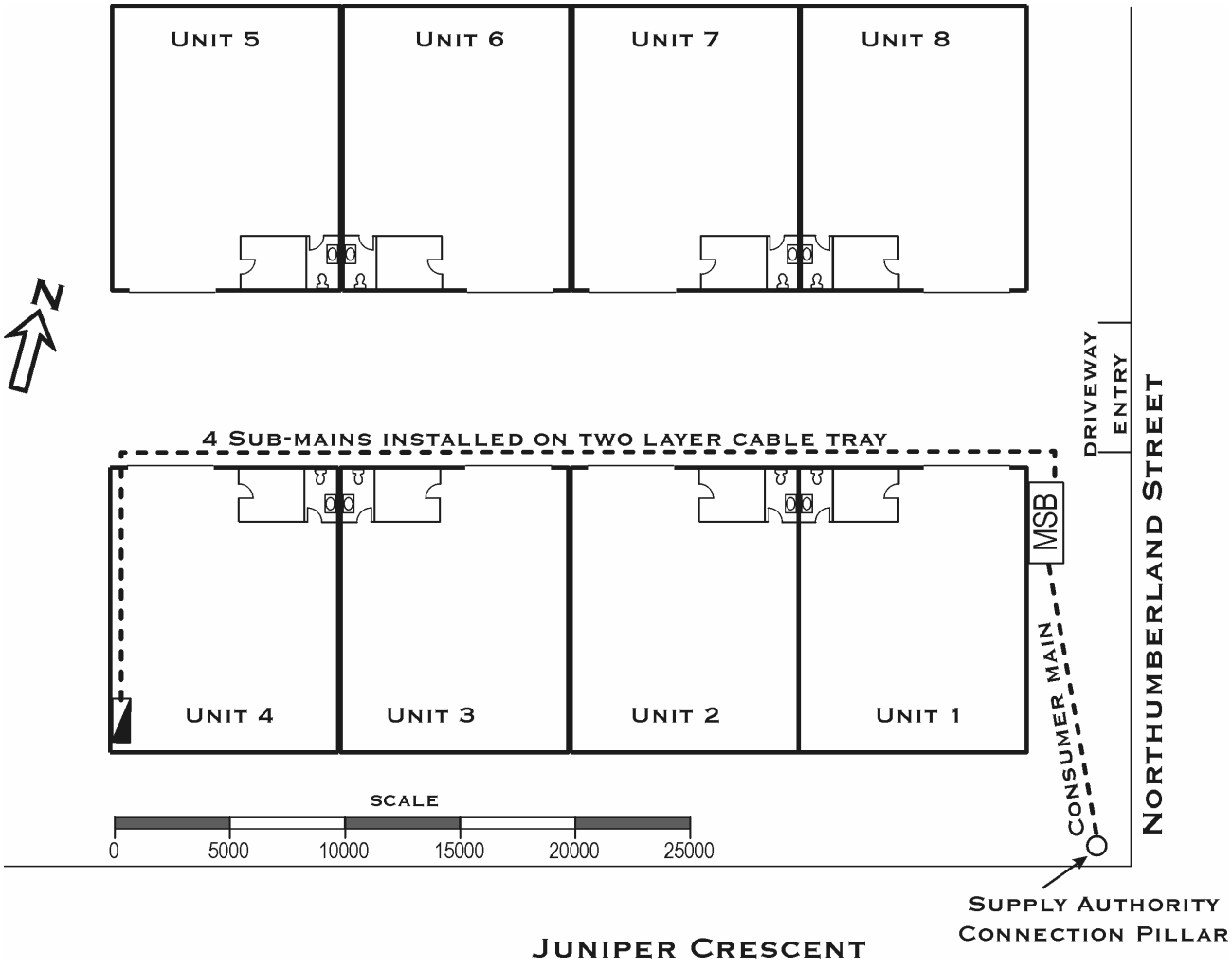

Figure 1

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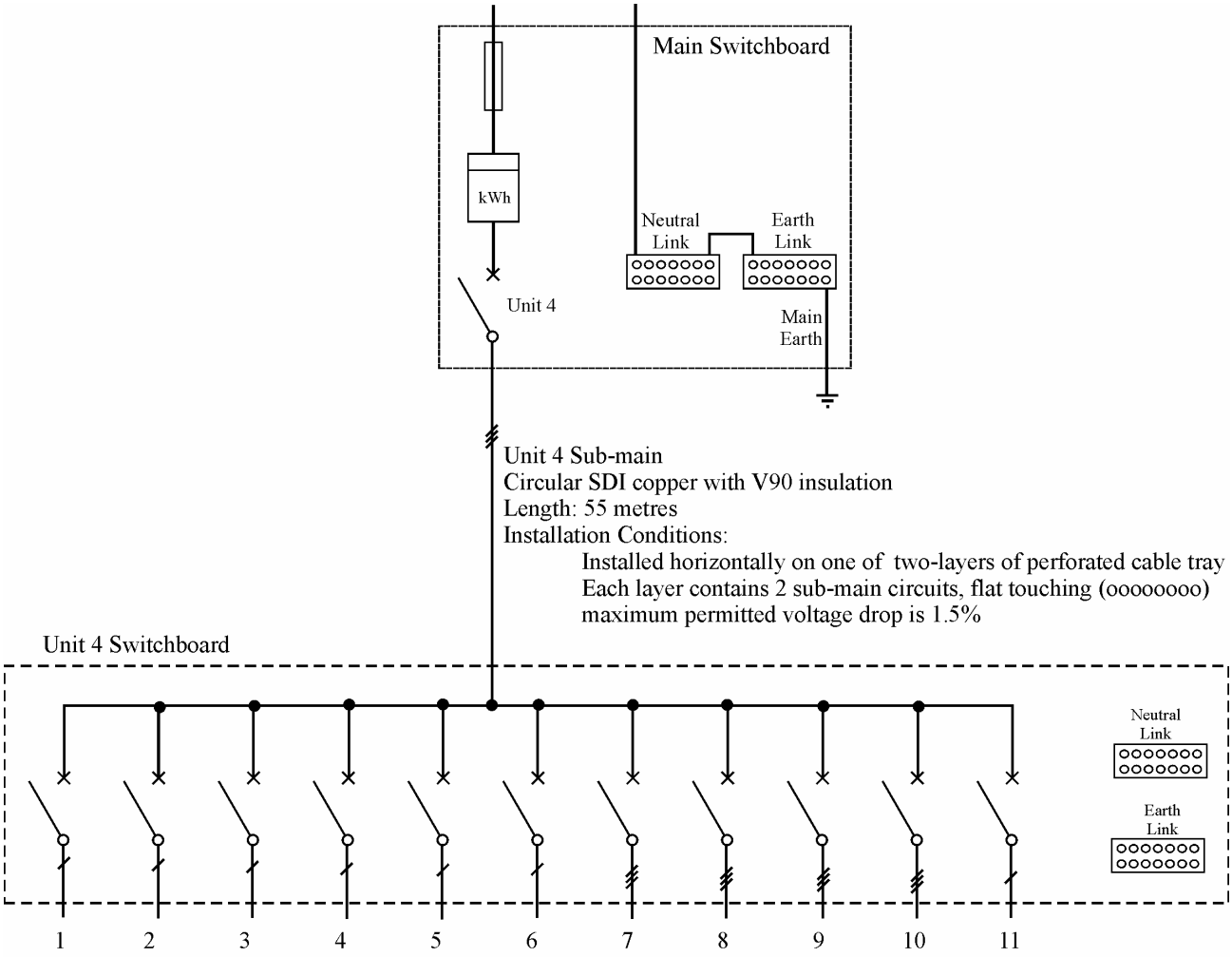
SECTION C – (Cont'd)



Circuit	Description	Quantity	Rating
1	Fluorescent Lighting	12	0.85A each
2	Fluorescent Lighting	10	0.85A each
3	Fluorescent Lighting	10	0.85A each
4	1 phase socket outlets	6	10A each
5	1 phase socket outlets	8	10A each
6	1 phase socket outlets	8	10A each
7	3 phase socket outlets	1	32A
8	3 phase socket outlets	1	20A
9	3 phase socket outlets	1	15A
10	3 phase socket outlets	2	10A
11	1 phase water heater instantaneous	1	15A

Figure 2

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SECTION C – (Cont'd)

Use the information in Table 1 to assist in answering Questions 1 and 6.

Table 1

Conductor size — mm^2	a.c. resistance at 50 Hz in Ω/km at 75°C
2.5	9.01
4	5.61
6	3.75
10	2.23
16	1.40
25	0.884
35	0.638
50	0.471
70	0.327
95	0.236
120	0.188
150	0.153
185	0.123

QUESTION 1. (2 Marks)

The 3-phase 400/230-volt consumer main to the block of factory units consists of SDI cables having circular copper conductors. The active conductors are 185 mm^2. The Supply Authority nominates the fault level at the point of supply as 30 kA. The soil resistivity for the installation is very low. The cable has a route length of 12 metres. Calculate the theoretical fault current (A to E) at the main switchboard board.
(Hint: assume the return path has negligible resistance due to the low soil resistivity)

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SECTION C – (Cont'd)

QUESTION 2. (4 Marks)

Calculate the maximum demand of the three-phase sub-main to Unit 4. The occupant intends to use rotating electrical machines in the unit.

Load group	Load description	Qty	Calculation	Demand (Red)	Demand (White)	Demand (Blue)
	Circuit 1 — Lighting					
	Circuit 2 — Lighting					
	Circuit 3 — Lighting					
	Circuit 4 — 1 ph Power					
	Circuit 5 — 1 ph Power					
	Circuit 6 — 3 ph Power					
	Circuit 7 — 3 ph Power					
	Circuit 8 — 3 ph Power					
	Circuit 9 — 3 ph Power					
	Circuit 10 — 3 ph Power					
	Circuit 11 — 1 ph HWS					
			Maximum Demand			

Maximum demand of the three-phase sub-main to Unit 4 is _____

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SECTION C – (Cont'd)

QUESTION 3. (4 Marks)

The maximum demand of the sub-main to unit 4 was determined to be 100 A and the major portion of the load connected between active and neutral. What would be the minimum size of the active, neutral and earth conductors for V90 SDI cables having copper conductors when installed on dual-layer perforated cable tray together with another similar sub-main cables when each cable is in contact with the next (that is flat touching)?

Standard used: _____

Derating (if applicable)

Table No used: _____

Column: _____

Derating factor: _____

Required current carrying capacity: _____

Active conductor

Table No used: _____

Column: _____

Cross-sectional area: _____

Determine the current carrying capacity of the neutral

_____

_____

_____

Reference (_____)

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SECTION C – (Cont'd)

QUESTION 3. (cont)

Determine the size of the neutral conductor

Table No: _____

Column No: _____

Cross sectional area: _____

Determine the size of the earth conductor

Standard used: _____

Table No: _____

Cross sectional area: _____

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SECTION C – (Cont'd)

QUESTION 4. (4 Marks)

If the maximum demand of the sub-main to unit 4 was determined to be 92 A, and the submain comprised V90 SDI cables having 35 mm^2 circular copper active and neutral conductors, would the voltage drop be within the specified limit of 1.5%?

Standard used: _____

Table No: _____

mV/A.m rating: _____

_____

_____

_____

_____

Does this comply with the 1.5% specified limit?

_____

QUESTION 5. (2 Marks)

If the maximum demand of the sub-main to unit 4 was determined to be 92 A, select a suitable protective device for the sub-main to unit 4.

Description of selected device: _____

Nominal current rating: _____

Category rating of device: _____

Maximum value of fault loop impedance for selected device: _____

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SECTION C – (Cont'd)

QUESTION 6. (2 Marks)

If the maximum demand of the sub-main to unit 4 was determined to be 92 A, and the submain comprised V90 SDI cables having 16 mm^2 copper active and neutral conductors with a 6 mm^2 earth conductor, calculate the fault current rating (A – E) of the main isolator for the switchboard of unit 4 when the fault current at the main switchboard is limited to 20 kA. (Use Table 1 for conductor resistances).

QUESTION 7. (2 Marks)

If the maximum demand of the sub-main to unit 4 was determined to be 92 A, and the submain comprised V90 SDI cables having 25 mm^2 copper active and neutral conductors with a 6 mm^2 earth conductor, verify that a 100 A type C circuit breaker would adequately protect the circuit with the fault-loop impedance limitations.

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SECTION D – (18 Mark)

INSTRUCTIONS: This section involves calculations. Show all necessary working in the space provided, marks will be awarded accordingly. Answers are to be highlighted or underlined.

The questions in this section relate to a multiple domestic installation comprising ten (10) separate occupancies. A main switchboard for the complex supplies a switchboard in each of the occupancies.

Details of the installation are provided in *Figure 3*, *Figure 4* **and** *Figure 5*

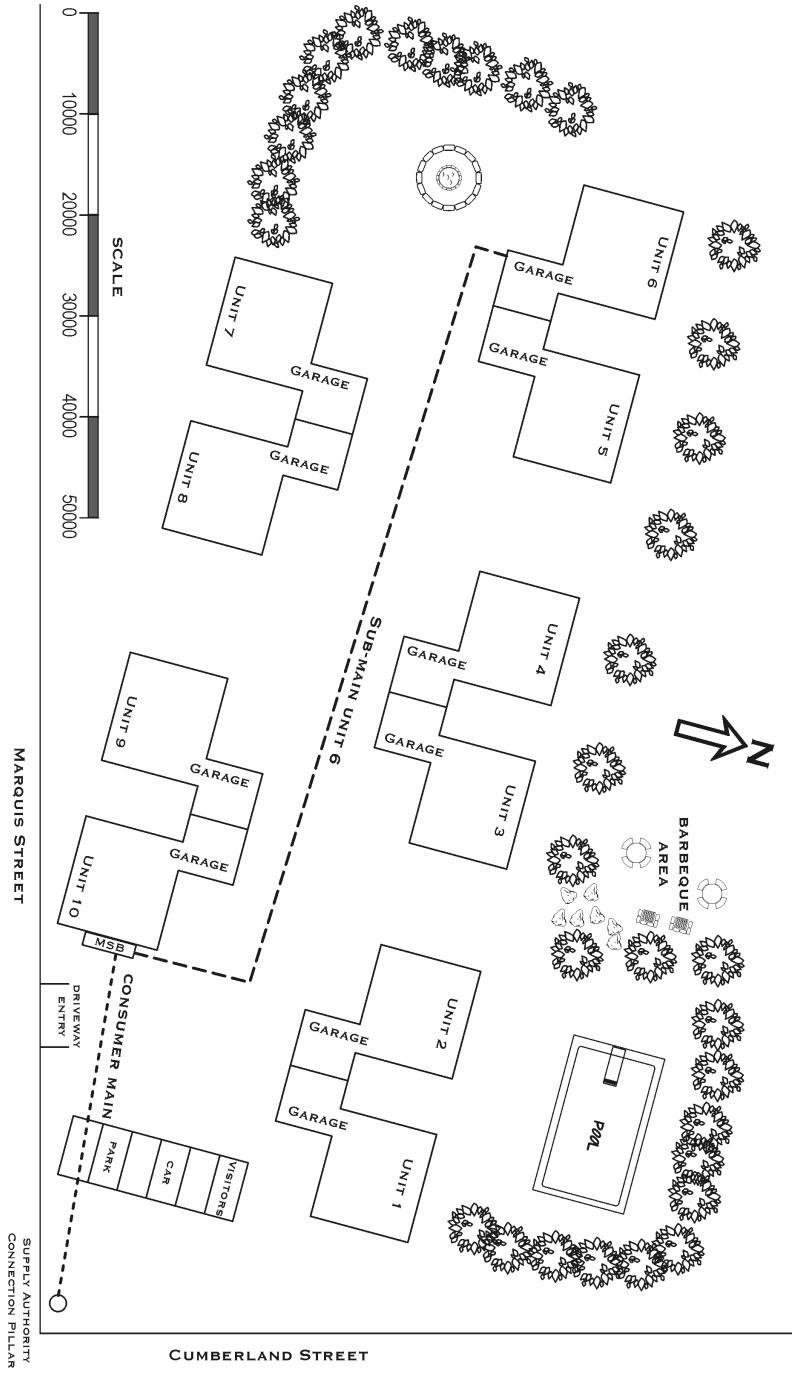

Figure 3

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SECTION D – (Cont'd)

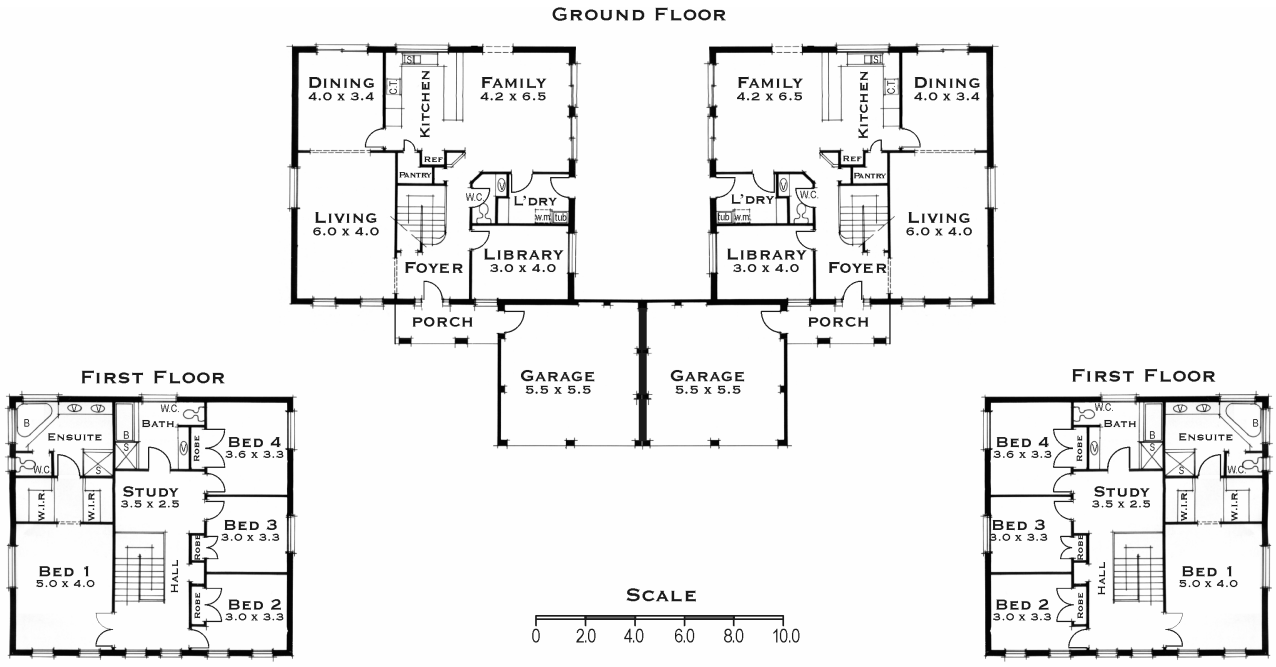

Figure 4

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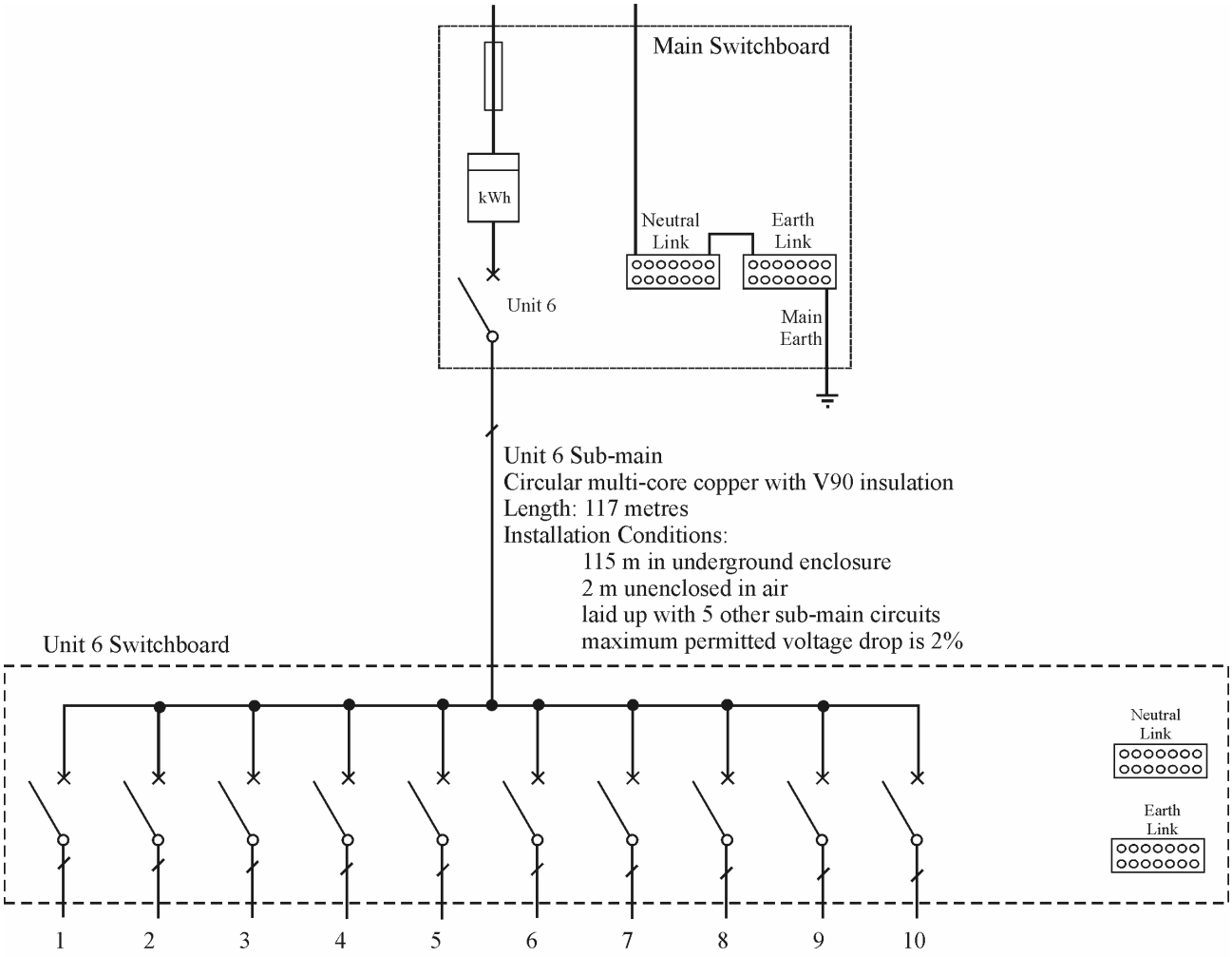
SECTION D – (Cont'd)



Circuit	Description	Quantity	Rating
1	Lighting	20	100 W each
2	Lighting	23	100 W each
3	1 phase socket outlets	10 double	10A each
4	1 phase socket outlets	5 double, 8 single	10A each
5	1 phase socket outlets	6 double, 8 single	10A each
6	1 phase security system	1	1.2A
7	1 phase air conditioner	1	24A
8	1 phase quick recovery HWS	1	20A
9	1 phase cook-top	1	9kW
10	1 phase wall oven	1	4kw

Figure 5

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SECTION D – (Cont'd)

QUESTION 1. (4 Marks)

Calculate the maximum demand of the single-phase sub-main to Unit 6.

Load group	Load description	Qty	Calculation	Demand
	Lighting			
	1 ph Power			
	Security			
	Air Cond			
	Quick Recovery HWS			
	Cook-top			
	Wall oven			
			Maximum Demand	

Maximum demand of the single-phase sub-main to Unit 6 is _____

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SECTION D – (Cont'd)

QUESTION 2. (4 Marks)

If the maximum demand of the sub-main to unit 4 was determined to be 80 A, what would be the minimum size of the active, neutral and earth conductors for a 2-core and earth V90 cable having copper conductors when installed in an underground trench together with five (5) other similar sub-main cables when all six (6) conduits are in contact with each other?

Standard used: _____

Derating (if applicable)

Table No used: _____

Column: _____

Derating factor: _____

Required current carrying capacity: _____

Active conductor

Table No used: _____

Column: _____

Cross-sectional area: _____

Determine the current carrying capacity of the neutral

_____

_____

_____

Reference (_____)

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SECTION D – (Cont'd)

QUESTION 2. (cont)

Determine the size of the neutral conductor

Table No: _____

Column No: _____

Cross sectional area: _____

Determine the size of the earth conductor

Standard used: _____

Table No: _____

Cross sectional area: _____

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SECTION D – (Cont'd)

QUESTION 3. (4 Marks)

If the maximum demand of the sub-main to unit 6 was determined to be 80 A, and the 2-core and earth V90 cable had 10 mm^2 circular copper conductors, would the voltage drop be within the specified limit of 2%?

Standard used: _____

Table No: _____

mV/A.m rating: _____

_____

_____

_____

_____

Does this comply with the 2% specified limit?

_____

QUESTION 4. (2 Marks)

Final sub-circuit 3 supplies a load consisting of 10A socket outlets. A 16A Type C circuit breaker protects the circuit. Determine the maximum *measured* internal fault-loop impedance of the final sub-circuit, based on 230V, when supply is unavailable and the ambient temperature is 20°C.

_____

_____

_____

_____

_____

_____

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SECTION D – (Cont'd)

Table 3 — Communal Schedule

This load connects to one single-phase meter.

Location	Appliance	A
Outside Unit 1 Garage	18W Bollard	0.12
Outside Unit 2 Garage	18W Bollard	0.12
Outside Unit 3 Garage	18W Bollard	0.12
Outside Unit 4 Garage	18W Bollard	0.12
Outside Unit 5 Garage	18W Bollard	0.12
Outside Unit 6 Garage	18W Bollard	0.12
Outside Unit 7 Garage	18W Bollard	0.12
Outside Unit 8 Garage	18W Bollard	0.12
Outside Unit 9 Garage	18W Bollard	0.12
Outside Unit 10 Garage	18W Bollard	0.12
RH side driveway entry	18W Bollard	0.12
LH side driveway entry	18W Bollard	0.12
Barbecue area	500W halogen flood	2.5
	500W halogen flood	2.5
	500W halogen flood	2.5
	500W halogen flood	2.5
Swimming pool area	500W halogen flood	2.5
	500W halogen flood	2.5
	500W halogen flood	2.5
	500W halogen flood	2.5
	pump motor	3.4

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SECTION D – (Cont'd)

QUESTION 5. (4 Marks)

Calculate the maximum demand of the installation if the Communal loading detailed in Table 3 is included.

Load group	Load description	Qty	Calculation	Demand (Red)	Demand (White)	Demand (Blue)
	Lighting					
	1 ph Power					
	Security					
	Air Cond					
	Quick Recovery HWS					
	Cook-top					
	Wall oven					
	Communal 1 – Bollards					
	Communal 2 – Barbecue					
	Communal 3 – Swimming pool					
	Communal 4 – Pump motor					
			Maximum Demand			

Maximum demand of the installation is _____

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SECTION E – 17 Marks

INSTRUCTION: The questions in this section require some simple drawing. Ensure that the drawing is neat and legible. The use of pencil on the drawing is acceptable in this section only.

QUESTION 1. (4 Marks)

The equipment shown in Figure 6 is for a switchboard in a multiple-domestic installation. Arrangement of the circuits places them partially surrounded by bulk thermal insulation. Two (2) 6A combination RCD/MCBs are required to protect two final sub-circuits supplying lighting points from the switchboard. Show on the diagram the necessary Active, Neutral and Earth connections.

You will lose marks for each missing or incorrect connection.

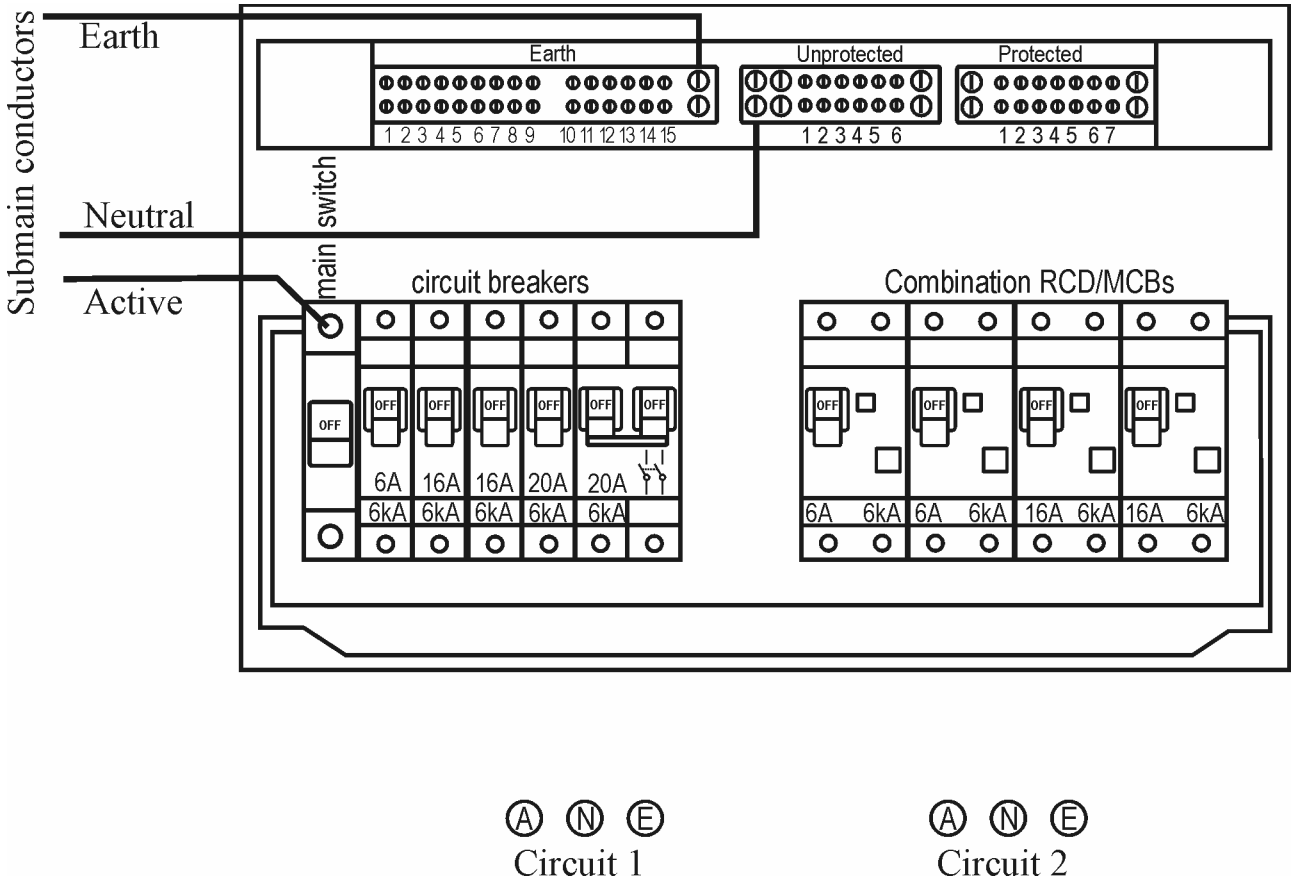

Figure 6

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SECTION E – (Cont'd)

QUESTION 2. (4 Marks)

The diagram below represents the main switchboard in a factory. The diagram also shows two items of equipment that the switchboard supplies. Note that the diagram does not show all equipment the switchboard supplies. Details of the installation are as follows:

The consumer mains is 3-phase 400V consisting of four (4) 35mm^2 SDI cables enclosed in HDUPVC conduit.

The consumer mains do not have short circuit protection on the supply side.

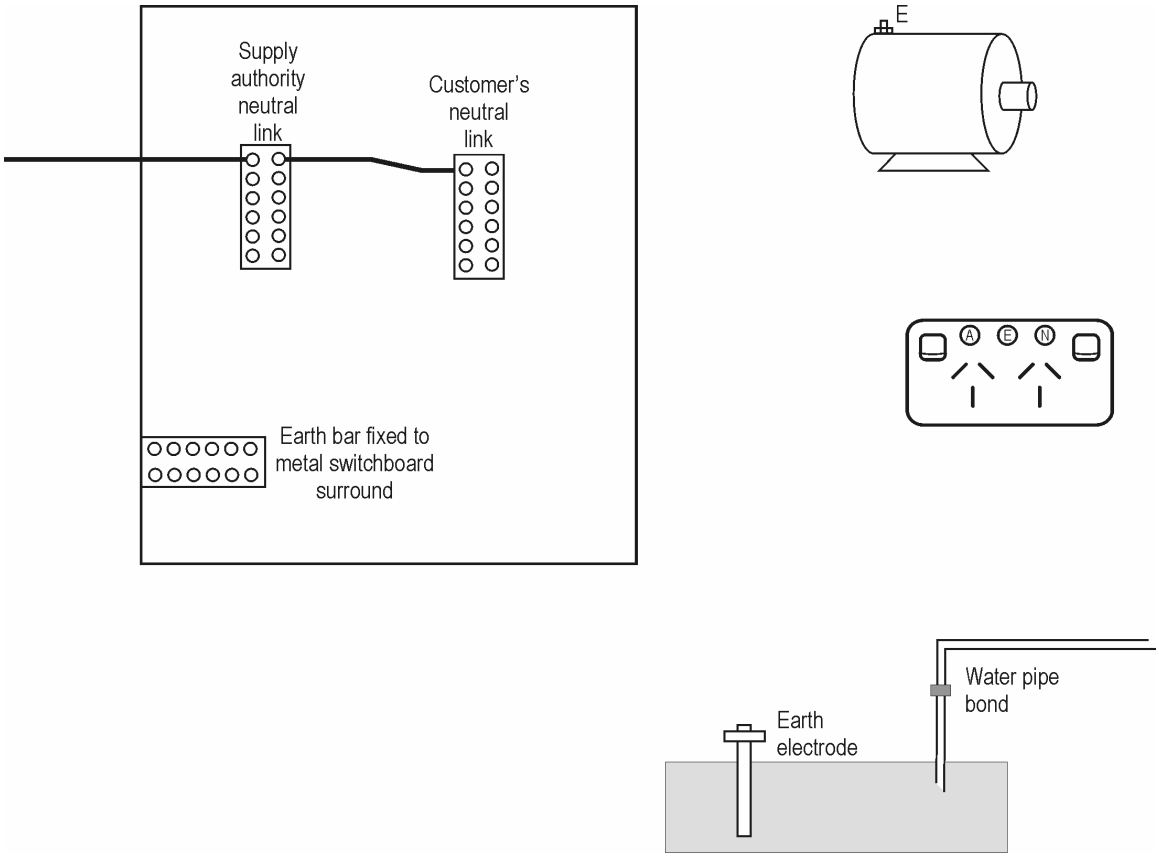
The main switchboard supplies the motor using 6mm^2 TPI cables enclosed in MDUPVC conduit.

The main switchboard supplies the socket outlets using 4mm^2 TPS installed in PVC trunking.

(a) Draw on the diagram all necessary **earthing** and **equipotential bonding** conductors necessary to effect the MEN system of earthing. DO NOT show active and neutral conductors.

(b) Identify on each cable the minimum conductor size.

Only correct connections, labelling and conductor sizes gain marks.



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SECTION E – (Cont'd)

QUESTION 3. (3 Marks)

Determine the suitability of a 16 A type C circuit breaker having a tripping characteristic in the range shown in *Figure 7*. The circuit breaker is to protect a circuit supplying a motor that takes 5 seconds to run up to speed and has a maximum starting current of 72 A. Show all working and show on the diagram how you arrived at the answer.

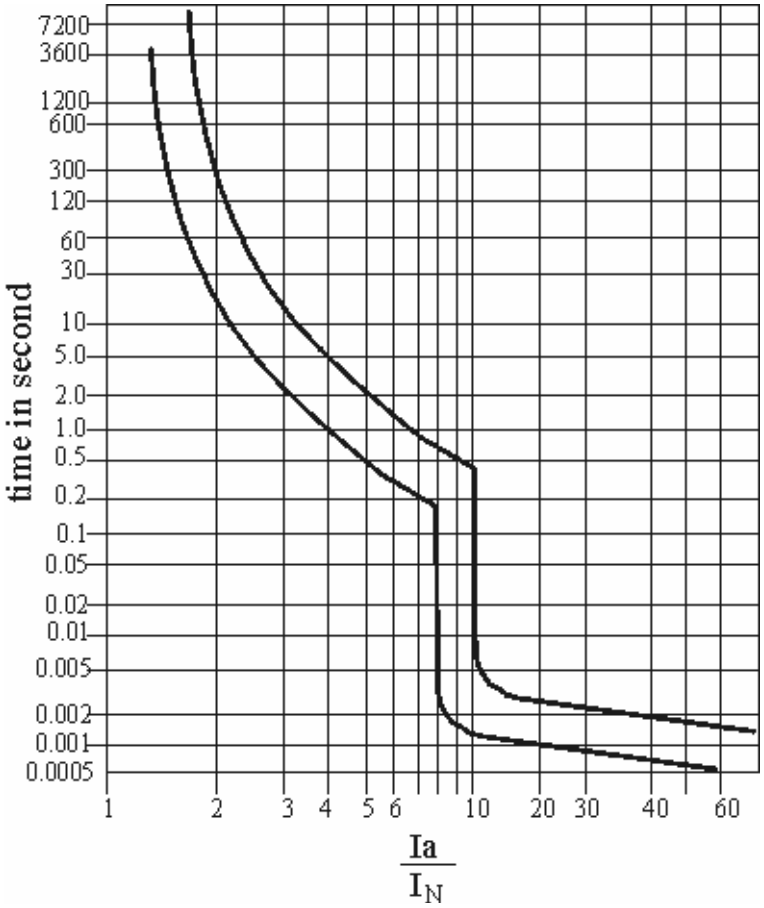

Figure 7

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SECTION E – (Cont'd)

QUESTION 4. (3 Marks)

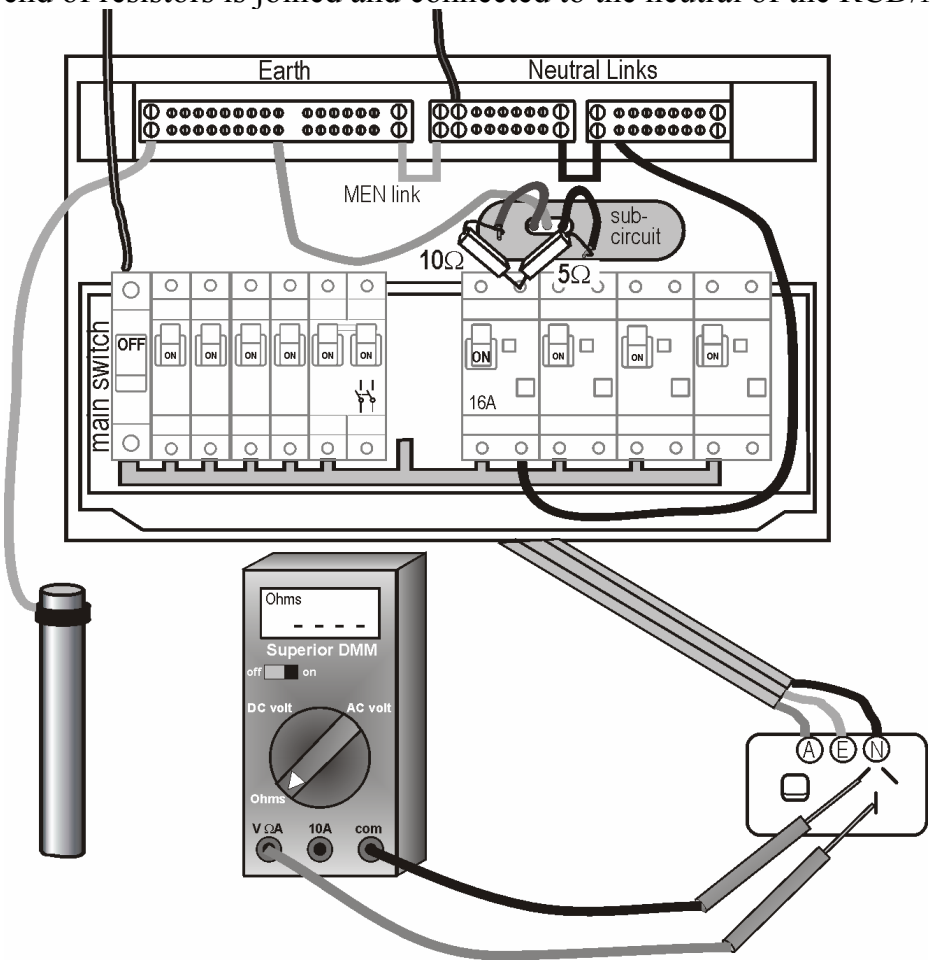
The following test circuit is connected to check the polarity and circuit connection of a circuit supplying single-phase socket outlets:

Supply is isolated and Main switch is OFF

Active disconnected from RCD/MCB and connected to one side of 10 Ω resistor

Neutral disconnected from RCD/MCB and connected to one side of 5 Ω resistor

Other end of resistors is joined and connected to the neutral of the RCD/MCB



Complete the following table by entering the expected measured resistance values at the socket outlet between the nominated points.

Earth to Active with switch off	
Earth to Active with switch on	
Earth to Neutral	
Neutral to Active with switch off	
Neutral to Active with switch on	

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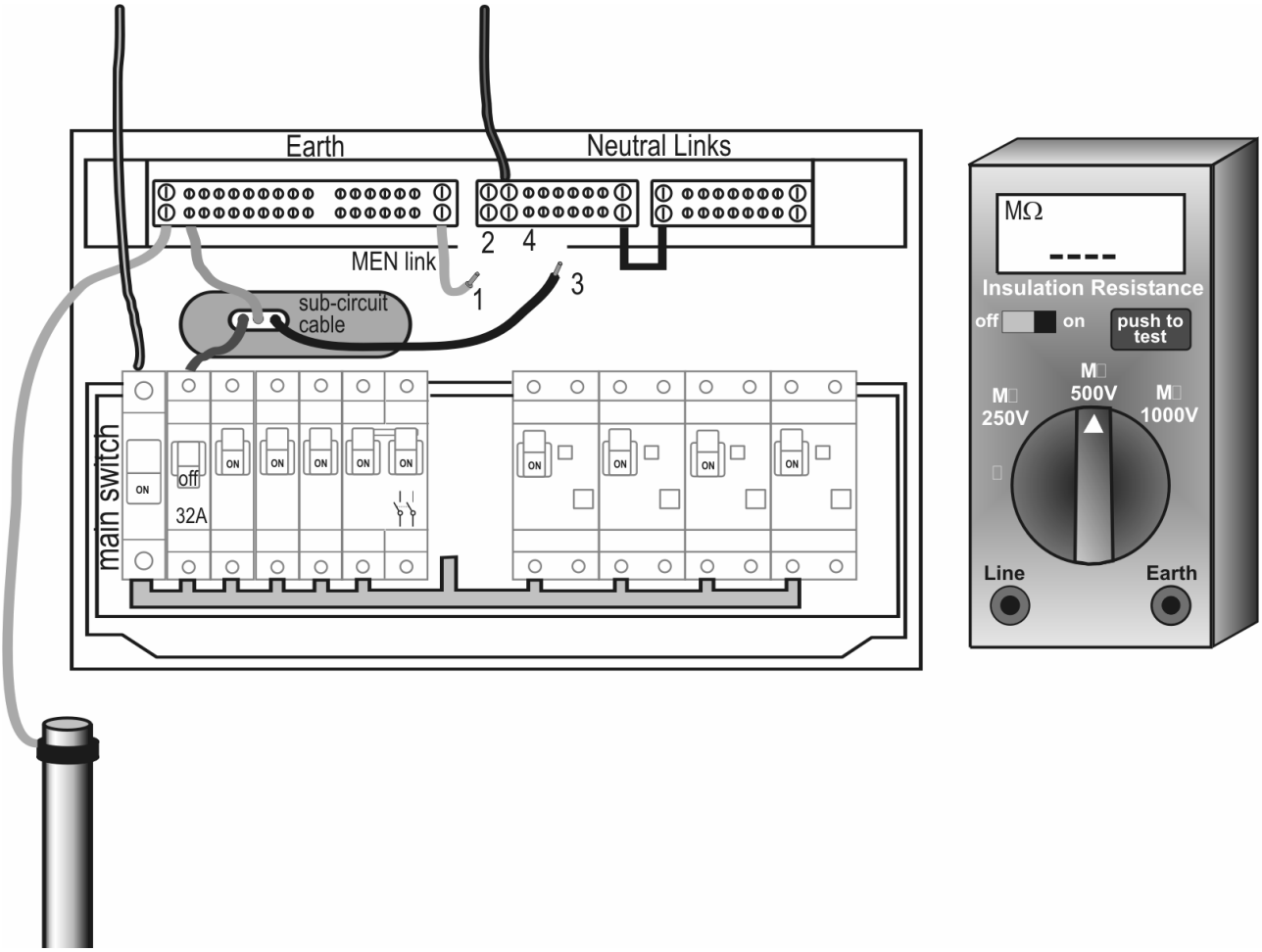
SECTION E – (Cont'd)

QUESTION 5. (3 Marks)

Complete the following diagram to show how the Insulation Resistance Tester would connect when testing a single-phase circuit supplying an air conditioner and protected by a 32 A circuit breaker.



(a) The Men link would connect to Position1 / Position 2 (circle correct response) for the test.

(b) The sub-circuit neutral conductor would connect to Position 3 / Position 4 (circle correct response) for the test.

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Family Name .....

Given Name .....

Student Number.....

Centre .....

Signature .....

ANSWER SHEET – Section A (Multi-choice Questions)

6 December 2004

6077AC Electrical Systems Safety

Instructions:

- Enter your personal details in the top right hand corner of this sheet.
- Place an **X** in box of your choice. If you make a mistake, circle your answer (X) and choose again.

Question	(a)	(b)	(c)	(d)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
Totals				

Total Marks Section A: ..... /15

END OF EXAMINATION

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NEW SOUTH WALES DEPARTMENT OF EDUCATION AND TRAINING

TAFE NSW

Family Name .....

Given Name .....

Student Number .....

Centre .....

Signature .....

November 2006

6077AC Electrical Systems Safety

Time allowed - Three hours plus Ten minutes reading time

32 Pages in this Question Booklet

ALL Questions to be attempted

TOTAL MARKS AVAILABLE =100

Section	Possible Mark	Actual Mark
A	15	
B	20	
C	45	
D	20	
TOTAL	100	

Aids to be supplied by college:

- None.

Aids to be supplied by student:

- Australian/New Zealand Wiring rules AS/NZS 3000:2000 (AMDT 3 – July 2003)
- Australian/New Zealand Standard Electrical Installations – Selection of Cables Part 1.1 AS/NZS 3008.1.1:1998
- NSW Service and Installation Rules
- Students own marginal notes, indexing and formal amendments may be included in the above regulation books.
- Pen, pencil, eraser, rule, calculator.

Instructions to Students:

- **Mobile phones are to be turned off and removed from your person**. You cannot access a mobile phone during this examination.
- All questions to be answered in the space provided on this **examination paper**. Answers to Section A – multi-choice questions, are to be recorded on the Answer Sheet attached to this examination paper.
- You are not to use any other reference books in this examination.
- The whole of this paper is to be handed to the Supervisor upon completion.

Aids permitted where indicated:

Standard Dictionaries	Bilingual Dictionaries	Technical Dictionaries	Programmable Calculators	Non-programmable Calculators
No	No	No	No	Yes

SECTION A – (15 Marks)

INSTRUCTIONS: Select the best answer for the following statements and place an 'X' in the appropriate box on the Answer Sheet attached to the back of this examination paper. Each correct answer is worth one (1) mark.

QUESTION 1. (1 Mark)

Polarity testing is performed on a socket outlet:

(a) to ensure conductors are not transposed

(b) only on the earth conductor

(c) only on the active conductor

(d) to ensure there is no intermix from other circuits

QUESTION 2. (1 Mark)

Tools and equipment used on a job site must be inspected for safe operation:

(a) weekly

(b) monthly

(c) quarterly

(d) yearly

QUESTION 3. (1 Mark)

When carrying out a short circuit test on a lighting circuit, it is necessary to:

(a) ensure all switches are off

(b) remove all lamps and leave switches on

(c) ensure switches are on and all lamps are installed

(d) disconnect the sub circuit neutral from the consumers neutral link

QUESTION 4. (1 Mark)

The first step an electrical worker should take when working in an environment where there is live electrical equipment is:

(a) ask for assistance in completing the work

(b) examine all available electrical diagrams

(c) obtain the correct personal protective equipment to complete the work

(d) evaluate the risks involved in completing the work and document in a safe work method statement

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SECTION A – (Cont'd)

QUESTION 5. (1 Mark)

Equipment used in an electrical installation must:

(a) carry the EMI compliant mark

(b) be rated for 230V, 50Hz operation

(c) be safe to use and not cause danger

(d) carry the regulatory compliant mark

QUESTION 6. (1 Mark)

A major hazard with confined spaces is:

(a) difficulty in using tools

(b) unable to stand upright when working

(c) only one person can work at a time

(d) flammable contaminants and oxygen depletion

QUESTION 7. (1 Mark)

The person or body responsible for new electrical work in a low voltage installation is:

(a) supply authority

(b) owner of the premises

(c) controller of the premises

(d) installing electrical contractor

QUESTION 8. (1 Mark)

A common cause of indirect contact with live electrical components is:

(a) insulation failure

(b) electrical overloads

(c) contact with bare machine terminals

(d) contact with non-insulated aerial conductors

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SECTION A – (Cont'd)

QUESTION 9. (1 Mark)

In the MEN system of earthing, the electrical installation earthing system connects to the general mass of earth by means of:

(a) an earth electrode

(b) metallic water piping

(c) the neutral conductor

(d) an equipotential bond

QUESTION 10. (1 Mark)

Automatic disconnection of the supply is required in any electrical installation where it is determined that due to a fault, the prospective touch voltage could rise to a value of:

(a) greater than 50 volts AC or DC

(b) greater than 50 volts AC

(c) greater than 120 volts AC

(d) the nominal phase volts of 230 volts AC or greater

QUESTION 11. (1 Mark)

When determining the fault loop impedance within an installation, it is necessary to consider:

(a) only final sub-circuit conductors

(b) only sub-mains and final sub-circuits

(c) all active and protective earth conductors including the distribution system

(d) only active conductors and protective earths from the consumers mains onwards

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SECTION A – (Cont'd)

QUESTION 12. (1 Mark)

When selecting a cable for a final sub-circuit, its continuous current carrying capacity should be:

(a) greater than the demand of the final sub-circuit and at least equal to the circuit breaker rating

(b) greater than the demand of the final sub-circuit and less than the circuit breaker rating

(c) less than the demand of the final sub-circuit and greater than the circuit breaker rating

(d) less than the demand of the final sub-circuit and less than the circuit breaker rating

QUESTION 13. (1 Mark)

Sub-mains and final sub-circuits having a rating exceeding 100 A per phase must:

(a) not be able to isolated in the event of over-current

(b) have over-voltage protection installed on the originating switchboard

(c) be controlled by a separate isolating switch on the originating switchboard

(d) have residual current protection installed on the originating switchboard

QUESTION 14. (1 Mark)

It is normal to divide an electrical installation into a number of circuits. One reason for this is to:

(a) maximise the number of cables used

(b) minimise the number of cables used

(c) reduce inconvenience in the event of a fault

(d) allow for the use of a single cable size

QUESTION 15. (1 Mark)

One method for determining the size of consumer mains and sub-mains of an electrical installation is:

(a) location of points

(b) safe design and construction

(c) demand of devices for isolation

(d) measuring the highest rate of electricity use in any 15 minute period

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SECTION B – (30 Marks)

INSTRUCTIONS: Use AS/NZS 3000:2000 to best answer each question in the space provided showing the AS/NZS 3000:2000 references used to obtain the answer.

QUESTION 1. (2 Marks)

The 2000 Edition of the Wiring Rules establishes (or sets out) the minimum requirements for the design, construction and testing of electrical installations. What is the intent of these requirements?

_____

_____

_____

Reference (_____)

QUESTION 2. (2 Marks)

What are the requirements where the actual measured maximum demand of a sub-mains is found to exceed that obtained by calculation?

_____

Reference (_____)

QUESTION 3. (2 Marks)

Which section of AS/NZS 3000 applies to the selection and installation of low-voltage wiring systems to determine the compliance with section 1 of AS/NZS 3000??

_____

Reference (_____)

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SECTION B – (Cont'd)

QUESTION 4. (2 Marks)

What does the term protective earthing conductor mean?

_____

_____

_____

Reference (_____)

QUESTION 5. (2 Marks)

What parts make up the fault loop in an MEN installation?

_____

_____

_____

Reference (_____)

QUESTION 6. (2 Marks)

What is the purpose of equipotential bonding?

_____

_____

_____

_____

_____

Reference (_____)

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SECTION B – (Cont'd)

QUESTION 7. (2 Marks)

What is the minimum distance required between a 100-watt incandescent spotlight and objects made from combustible material??

_____

Reference (_____)

QUESTION 8. (2 Marks)

To protect a cable from the heating effects of an electric current, a fuse must operate within a specified time with a prescribed value of current. What is the fusing current that will ensure a 16 A fuse will operate in conventional time?

_____

Reference (_____)

QUESTION 9. (2 Marks)

What devices are suitable for providing protection against both overload and short-circuit conditions?

_____

_____

_____

Reference (_____)

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SECTION B – (Cont'd)

QUESTION 10. (2 Marks)

When selecting equipment for an electrical installation, they must satisfy a number of provisions. What are these provisions?

_____

_____

_____

_____

_____

_____

_____

Reference (_____)

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SECTION C – (45 Marks)

INSTRUCTIONS: This section involves calculations. Show all necessary working in the space provided, marks will be awarded accordingly. Answers are to be highlighted or underlined.

The questions in this section relate to a factory installation. A main switchboard supplies a number of switchboards in the factory.

Figure 1 **and** ***Figure 2*** **provide the necessary details of the installation**

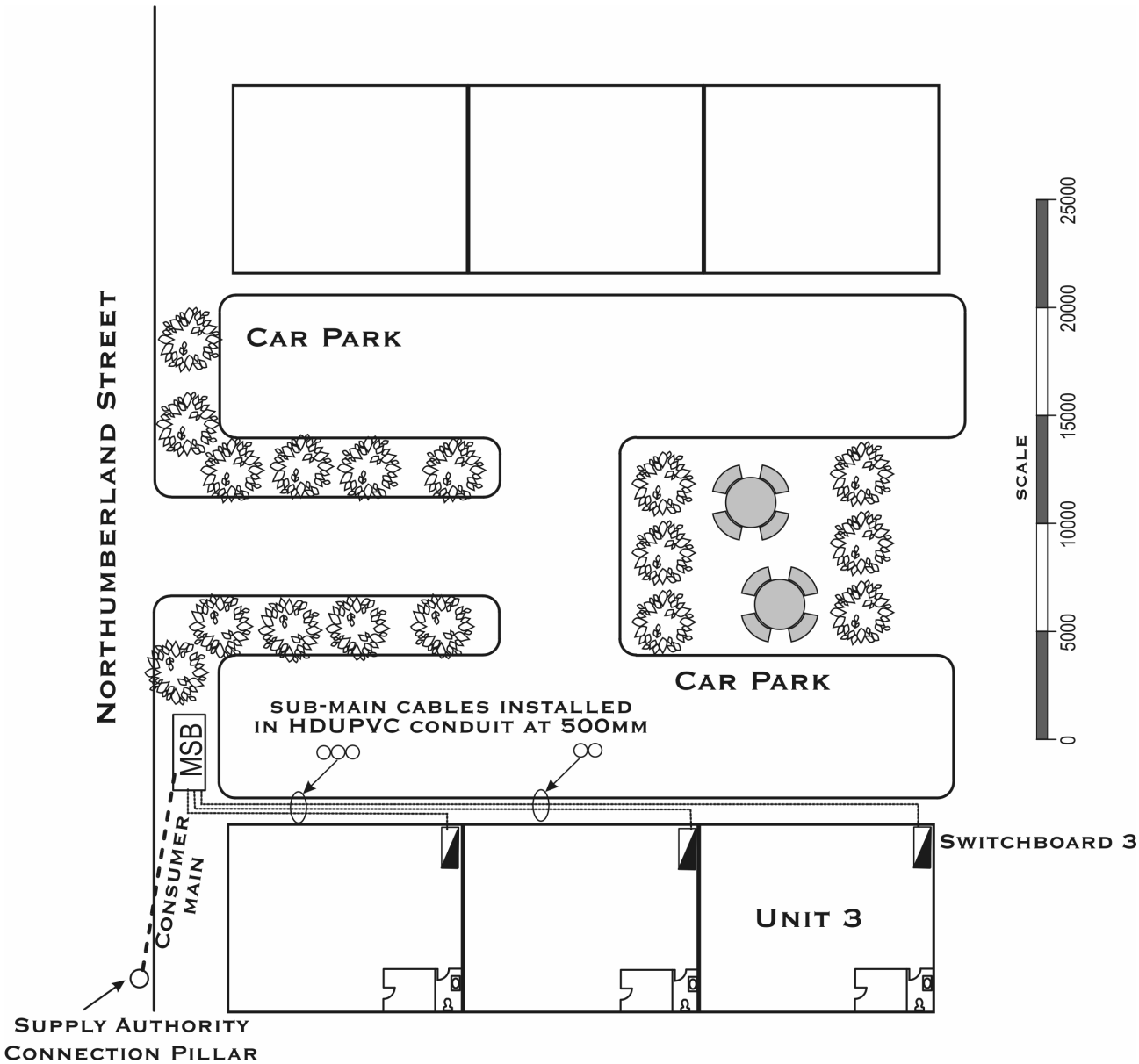

Figure 1

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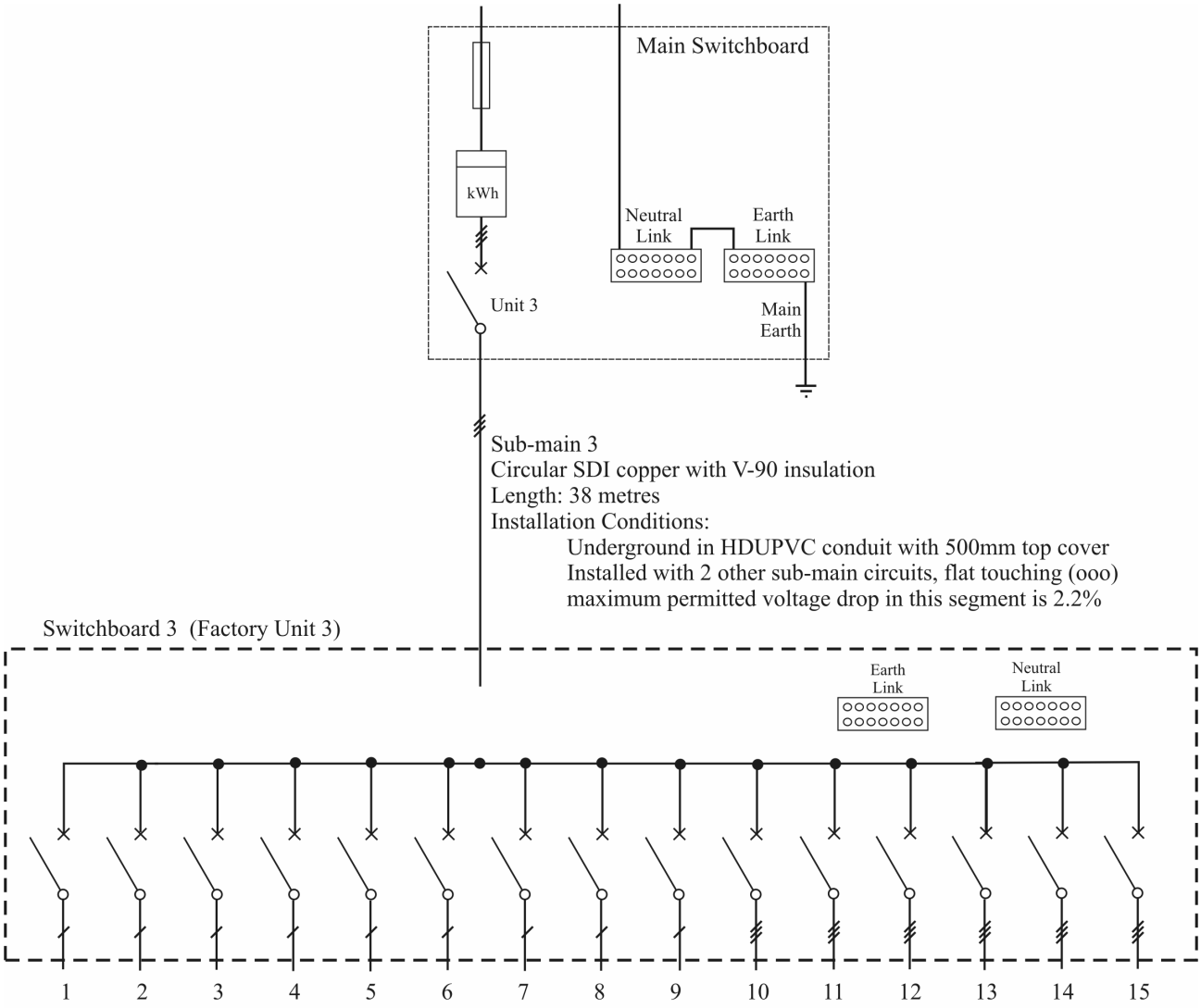
SECTION C – (Cont'd)



Circuit	Description	Quantity	Rating
1	Hi Bay Lighting	6	3.5A each
2	Hi Bay Lighting	6	3.5A each
3	Fluorescent Lighting	16	0.85A each
4	1-phase socket outlets	6	10A each
5	1-phase socket outlets	6	10A each
6	1-phase socket outlets	8	10A each
7	1-phase water heater instantaneous	1	15A
8	1-phase motors	2	5.2A each
9	1-phase motors	3	3.8A each
10	3-phase arc welder	1	20A
11	3-phase arc welder	1	20A
12	3-phase socket outlet	1	32A
13	3-phase socket outlet	1	20A
14	3-phase motor	1	18A
15	3-phase motor	1	14A

Figure 2

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SECTION C – (Cont'd)

Use the information in Table 1 to assist in answering Questions 1 and 6.

Table 1

Conductor size (mm^2)	a.c. resistance at 50 Hz in Ω/km		
	at 75°C	at 90°C	at 110°C
2.5	9.01	9.45	10.0
4	5.61	5.88	6.24
6	3.75	3.93	4.17
10	2.23	2.33	2.48
16	1.40	1.47	1.56
25	0.884	0.927	0.984
35	0.638	0.668	0.710
50	0.471	0.494	0.524
70	0.327	0.342	0.363
95	0.236	0.247	0.262
120	0.188	0.197	0.208
150	0.153	0.160	0.169
185	0.123	0.129	0.136

QUESTION 1. (4 Marks)

The 3-phase **240/415**-volt consumer main to the factory consists of X-HF-90 SDI cables having circular copper conductors. The active conductors are 185 mm^2. The Supply Authority nominates the fault level at the point of supply as 25 kA. The soil resistivity for the installation is very low. The cables have a route length of 13 metres. Calculate the theoretical fault current (A to E) at the main switchboard.
(Hint: assume the return path has negligible resistance due to the low soil resistivity)

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SECTION C – (Cont'd)

QUESTION 2. (5 Marks)

Calculate the maximum demand of the 240/415 volt, three-phase sub-main to Switchboard 3. The occupant intends to use rotating electrical machines in this area. The factory does not contain heating or cooling.
Enter required information for each circuit as listed in the following Table.
Complete the Table fully – marks are deducted for each incomplete or incorrect line.

Load group	Load description	Qty	Calculation	Demand (Red)	Demand (White)	Demand (Blue)
	Circuit 1 — Hi Bay Lighting					
	Circuit 2 — Hi Bay Lighting					
	Circuit 3 — Fluorescent Lighting					
	Circuit 4 — 1 ph Power					
	Circuit 5 — 1 ph Power					
	Circuit 6 — 1 ph Power					
	Circuit 7 — 1 ph HWS					
	Circuit 8 — 1 ph Motors					
	Circuit 9 — 1 ph Motors					
	Circuit 10 — 3 ph Welder					
	Circuit 11 — 3 ph Welder					
	Circuit 12 — 3 ph Power					
	Circuit 13 — 3 ph Power					
	Circuit 14 — 3 ph Motor					
	Circuit 15 — 3 ph Motor					
			Maximum Demand			

Maximum demand of the three-phase sub-main 3 is _____

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SECTION C – (Cont'd)

Table 2
Circuit Breakers for Power Distribution – Electrical Characteristics

Electrical Characteristic	Circuit Breaker Designation							
	CB1	CB2	CB3	CB4	CB5	CB6	CB7	CB8
								
Poles	1	1	3 or 4	3 or 4	3 or 4	3 or 4	3 or 4	3 or 4
Rated Current (A)	100	160	160	200	250	320	400	600
Rated Voltage (V)	240	690	690	690	690	690	690	690
Rated Short-Circuit capacity (kA)	25	25	25	40	40	65	65	70
Trip Unit	TMF	TMF	TMF	TMF	TMF	TMF	TMF	TMF
Category Rating (Type)	C	D	D	D	D	D	D	D
TMF= Thermo-magnetic trip unit with fixed thermal and magnetic threshold								

QUESTION 3. (2 Marks)

If the maximum demand of sub-main 3 was determined to be 190 A, use Table 2 (above) to select a suitable protective device for sub-main 3.

Designation of selected device: _____

Nominal current rating: _____

Category rating of device: _____

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SECTION C – (Cont'd)

QUESTION 4. (5 Marks)

The maximum demand of the sub-main 3 was determined to be 190 Ampere. A 220 Ampere type C circuit breaker protects the sub-main at the main switchboard. The major portion of the load connects between active and neutral conductors. What would be the minimum size of the active, neutral and earth conductors for V-90 SDI cables having circular copper conductors when installed underground in HDUPVC conduit with two similar sub-mains when each conduit is in contact with the next (that is touching)?

Standard used: _____

Derating (if applicable)

Table No used: _____

Column: _____

Derating factor: _____

Required current carrying capacity: _____

Active conductor

Table No used: _____

Column: _____

Cross-sectional area: _____

Determine the current carrying capacity of the neutral
(the greater portion of the load connects between active and neutral).

_____

_____

_____

Reference (_____)

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SECTION C – (Cont'd)

QUESTION 4. (cont)

Determine the minimum size of the neutral conductor

Table No: _____

Column No: _____

Cross sectional area: _____

Determine the minimum size of the earth conductor

Standard used: _____

Table No: _____

Cross sectional area: _____

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SECTION C – (Cont'd)

QUESTION 5. (5 Marks)

If the maximum demand of the 240/415 volt, sub-main 3 was determined to be 190 A, and the sub-main comprised V-90 SDI cables having 35 mm^2 circular copper active and neutral conductors, determine the voltage drop and state if it is within the specified limit of 2.2% when the route length of the circuit is 38 metres.

Standard used: _____

Table No: _____

mV/A.m rating: _____

_____

_____

_____

_____

Does this comply with the 2.2% specified limit?

_____

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SECTION C – (Cont'd)

QUESTION 6. (2 Marks)

If the maximum demand of the 240/415 volt, sub-main 3 was determined to be 190 Ampere, and the sub-main comprised V-90 SDI cables having 35 mm^2 circular copper active and neutral conductors with a 10 mm^2 earth conductor, verify that a 200 Ampere type D circuit breaker would adequately protect the circuit with the fault-loop impedance limitations.

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SECTION C – (Cont'd)

The remaining questions in this section relate to a multiple domestic installation comprising ten (10) separate occupancies. A main switchboard for the complex supplies a switchboard in each of the occupancies.

Details of the installation are provided in *Figure 3* **and** *Figure 4*

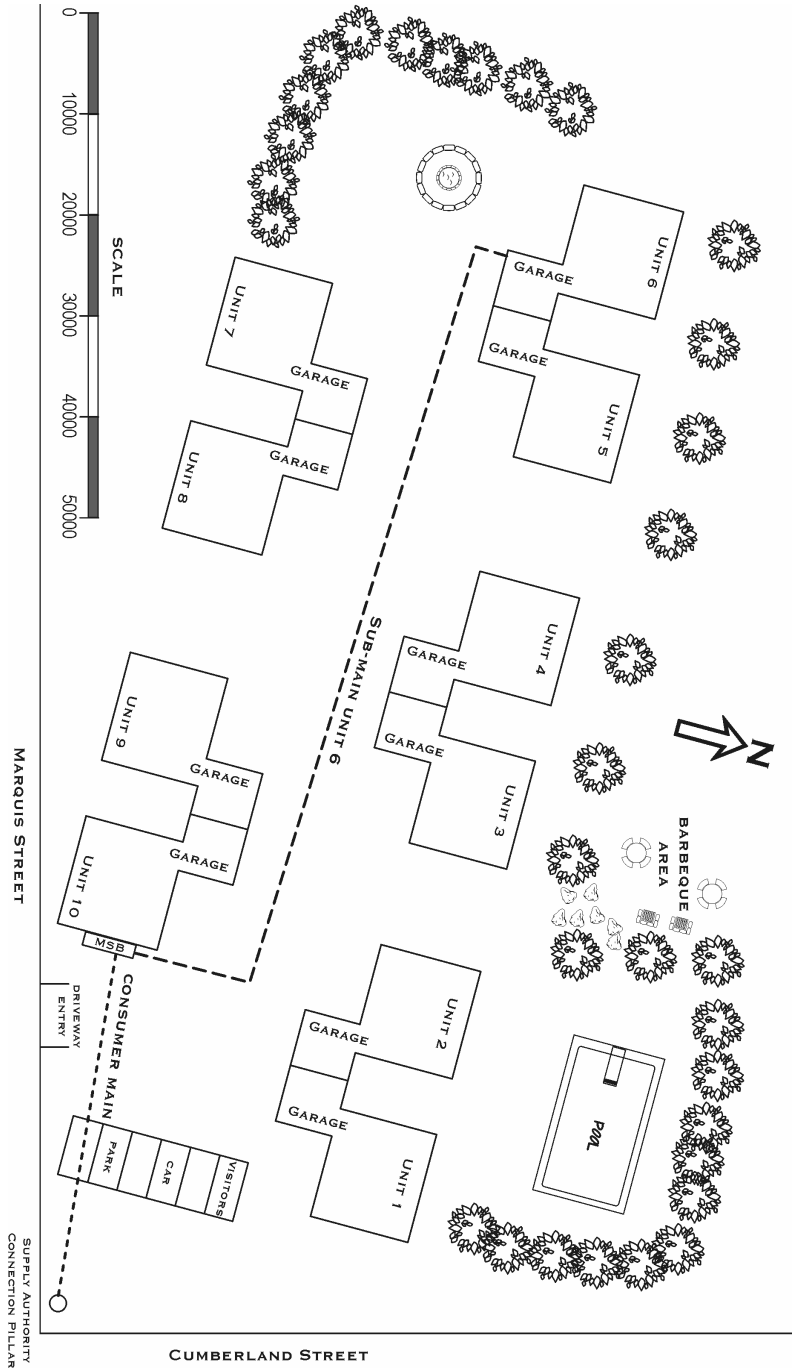

Figure 3

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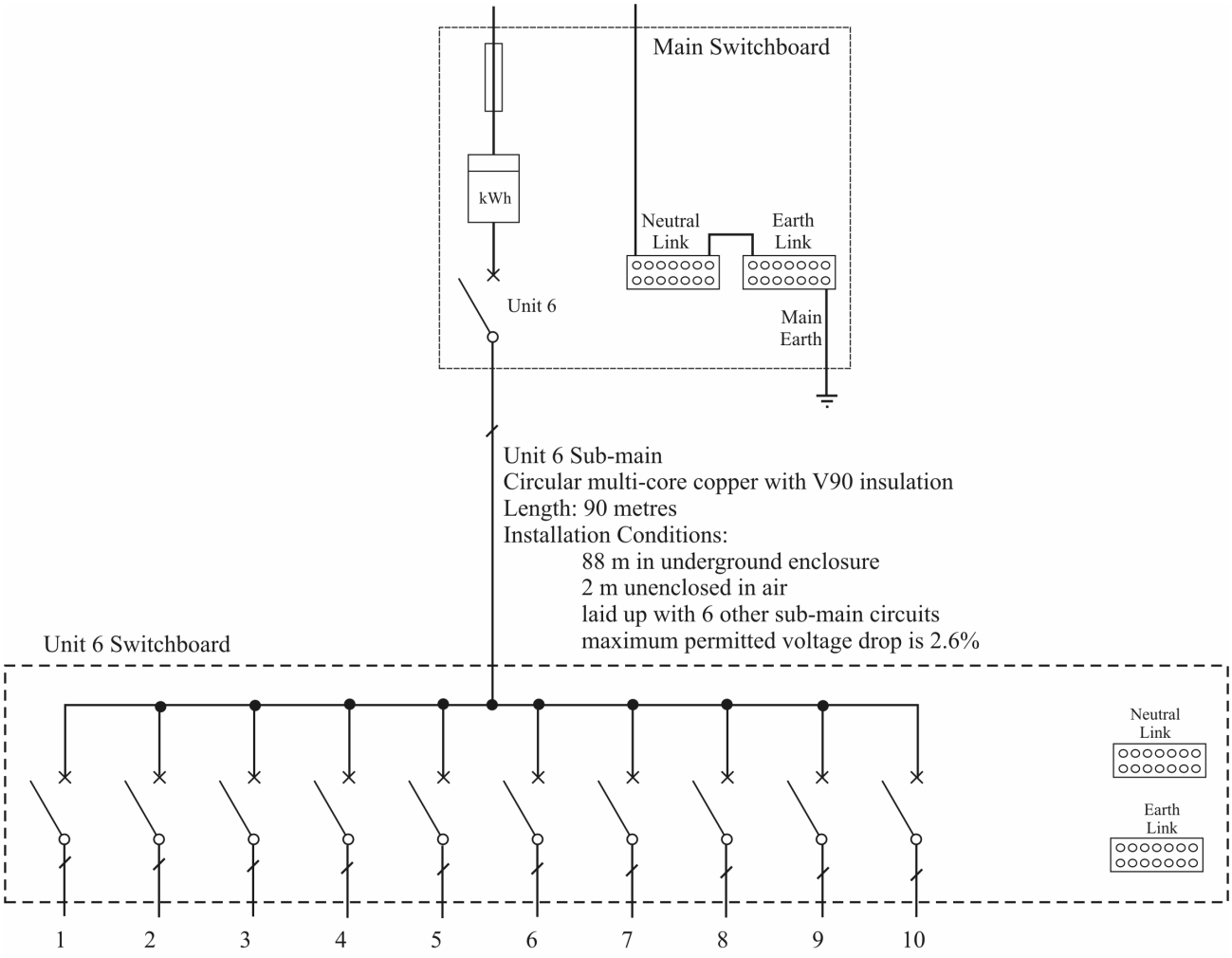
SECTION C – (Cont'd)



Circuit	Description	Quantity	Rating
1	Lighting	18	60 W each (nominal 240V)
2	Lighting	20	60 W each (nominal 240V)
3	1-phase socket outlets	8 double	10A each (nominal 240V)
4	1-phase socket outlets	4 double, 6 single	10A each (nominal 240V)
5	1-phase socket outlets	5 double, 6 single	10A each (nominal 240V)
6	1-phase socket outlet	1	15A (nominal 240V)
7	1-phase air conditioner	1	16A (nominal 240V)
8	1-phase quick recovery HWS	1	20A (nominal 240V)
9	1-phase cook-top	1	7.8kW (nominal 240V)
10	1-phase wall oven	1	4.2kw (nominal 240V)

Figure 4

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SECTION C – (Cont'd)

QUESTION 7. (4 Marks)

Calculate the maximum demand of the single-phase sub-main to Unit 6.
Enter required information for each circuit as listed in the following Table.

Load group	Load description	Qty	Calculation	Demand
	Lighting			
	1 ph Power (10 A)			
	1 ph Power (15 A)			
	Air Conditioning			
	Quick Recovery HWS			
	Cook-top			
	Wall oven			
			Maximum Demand	

Maximum demand of the single-phase sub-main to Unit 6 is _____

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SECTION C – (Cont'd)

QUESTION 8. (5 Marks)

The maximum demand of the 240 volt, sub-main to unit 6 was determined to be 95 Ampere. A 100 Ampere type D circuit breaker provides over-current protection at the main switchboard for this cable. What would be the minimum size of the active, neutral and earth conductors for a 2-core and earth V-90 cable having circular copper conductors when installed in an underground trench together with six (6) other similar sub-main cables when all seven (7) conduits are spaced 300mm from each other?

Standard used: _____

Derating (if applicable)

Table No used: _____

Column: _____

Derating factor: _____

Required current carrying capacity: _____

Active conductor

Table No used: _____

Column: _____

Cross-sectional area: _____

Determine the current carrying capacity of the neutral

_____

_____

_____

Reference (_____)

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SECTION C – (Cont'd)

QUESTION 8. (cont)

Determine the minimum size of the earth conductor

Standard used: _____

Table No: _____

Cross sectional area: _____

QUESTION 9. (5 Marks)

If the maximum demand of the 240 volt, sub-main to unit 6 was determined to be 95 Ampere, and the 2-core and earth V-90 cable had 25 mm^2 circular copper conductors, determine the voltage drop and state if it is within the specified limit of 2.6% when the route length is 17 metres.

Standard used: _____

Table No: _____

mV/A.m rating: _____

_____

_____

_____

_____

Does this comply with the 2.6% specified limit?

_____

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SECTION C – (Cont'd)

QUESTION 11. (3 Marks)

Final sub-circuit 1 supplies a load consisting of 60 W lighting points. A 10 A Type C circuit breaker protects the circuit of 1.5 mm^2 V-90, TPS, 2-core and earth. Determine the maximum *measured* internal fault-loop impedance of the final sub-circuit, based on **240 V**, when supply is unavailable and the ambient temperature is 20°C.

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SECTION C – (Cont'd)

Table 3 — Communal Schedule

This load connects to one single-phase meter.

Location	Appliance	A
Outside Unit 1 Garage	18 W Bollard	0.12
Outside Unit 2 Garage	18 W Bollard	0.12
Outside Unit 3 Garage	18 W Bollard	0.12
Outside Unit 4 Garage	18 W Bollard	0.12
Outside Unit 5 Garage	18 W Bollard	0.12
Outside Unit 6 Garage	18 W Bollard	0.12
Outside Unit 7 Garage	18 W Bollard	0.12
Outside Unit 8 Garage	18 W Bollard	0.12
Outside Unit 9 Garage	18 W Bollard	0.12
Outside Unit 10 Garage	18 W Bollard	0.12
RH side driveway entry	18 W Bollard	0.12
LH side driveway entry	18 W Bollard	0.12
Barbecue area	500 W halogen flood	2.5
	500 W halogen flood	2.5
	500 W halogen flood	2.5
	500 W halogen flood	2.5
Swimming pool area	500 W halogen flood	2.5
	500 W halogen flood	2.5
	500 W halogen flood	2.5
	500 W halogen flood	2.5

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SECTION C – (Cont'd)

QUESTION 12. (5 Marks)

Calculate the maximum demand of the ***whole*** installation detailed in ***Figure 3*** and ***Figure 4*** if each of the units has identical electrical loading and the Communal loading detailed in Table 3 is included.
Enter required information for each circuit as listed in the following Table.

Load group	Load description	Qty	Calculation	Demand (Red)	Demand (White)	Demand (Blue)
	Lighting					
	1 ph Power (10 A)					
	1 ph Power (15 A)					
	Air Conditioning					
	Quick Recovery HWS					
	Cook-top					
	Wall oven					
	Communal 1 – Bollards					
	Communal 2 – Barbecue					
	Communal 3 – Swimming pool					
			Maximum Demand			

Maximum demand of the installation is _____

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SECTION D – 20 Marks

INSTRUCTION: The questions in this section require some simple drawing. Ensure that the drawing is neat and legible. The use of pencil on the drawing is acceptable in this section only.

QUESTION 1. (4 Marks)

The equipment shown in Figure 6 is for a switchboard in a multiple-domestic installation. Arrangement of the circuits places them partially surrounded by bulk thermal insulation. Two (2) 16 A combination RCD/MCBs are required to protect two final sub-circuits supplying 10 A socket outlets from the switchboard. Show on the diagram the necessary Active, Neutral and Earth connections for these two final sub-circuits.

You will lose marks for each missing or incorrect connection.

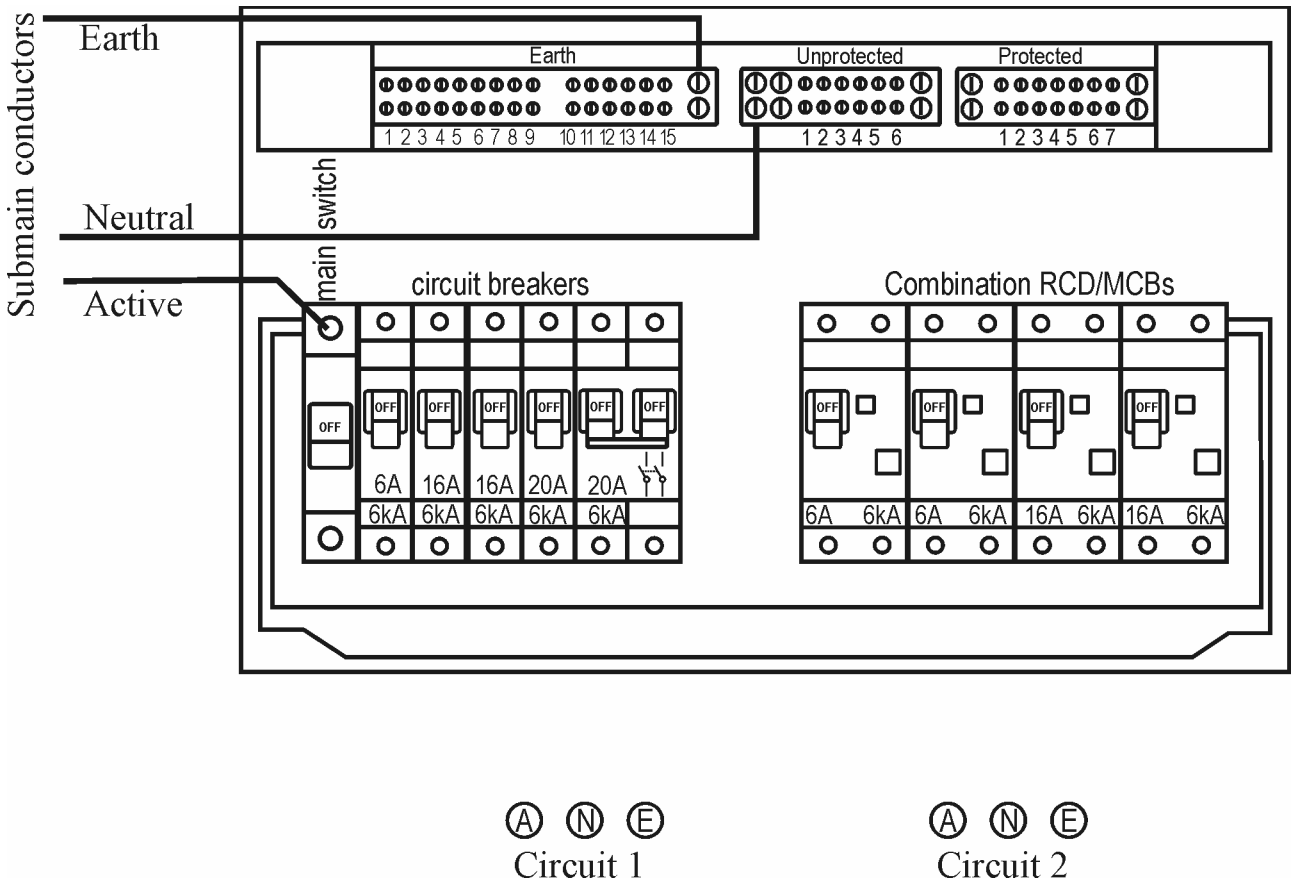

Figure 5

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SECTION D – (Cont'd)

QUESTION 2. (3 Marks)

Determine the suitability of a 20 A type D circuit breaker having a tripping characteristic in the range shown in *Figure 6*. The circuit breaker is to protect a circuit supplying a motor that takes 4.5 seconds to run up to speed and has a maximum starting current of 132 A. Show all working and show on the diagram how you arrived at the answer.

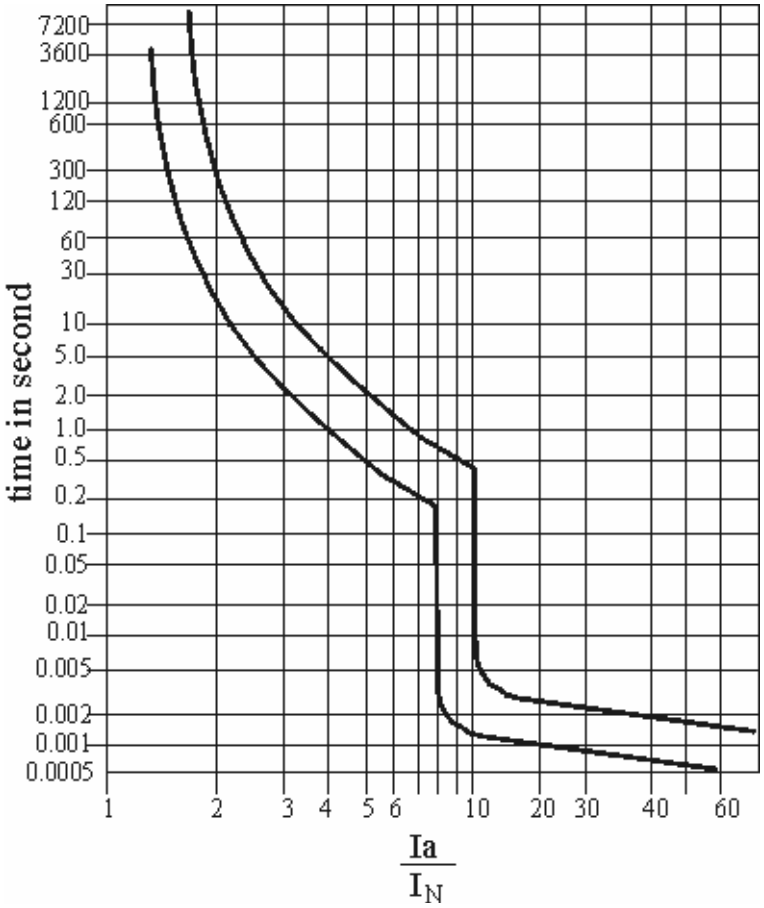

Figure 6

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SECTION D – (Cont'd)

QUESTION 3. (7 Marks)

INSTRUCTIONS: Blank spaces in the following statements represent omissions. Write the appropriate word, words or information in the spaces provided.

Resistance test of main earthing conductor in a complete 3-phase installation when supply is not connected:

Test sequence:

1. Ensure that the consumers mains are NOT _____.
2. Disconnect the _____ _____ conductor or _____ _____ from the neutral bar.
3. If using an analogue meter, set the meter to read _____ with the meter leads connected together.
4. Connect one test lead to the disconnected _____ _____ conductor or _____ _____.
5. Connect the other test lead to the _____ _____ conductor at the _____ _____.
6. Test that the resistance complies with the specified resistance.
7. Disconnect the test leads, reconnect the _____ _____ conductor or _____ _____ at the neutral bar.

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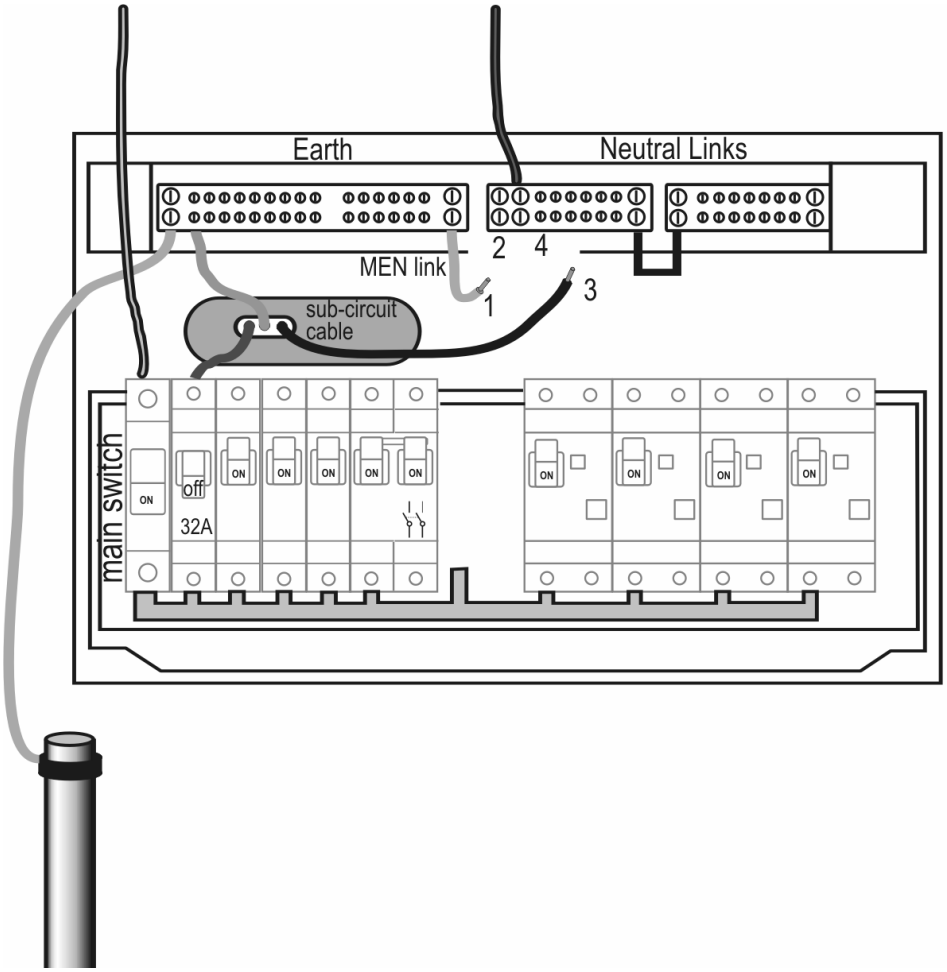
SECTION D – (Cont'd)

QUESTION 4. (3 Marks)

Complete the following diagram to show how the Insulation Resistance Tester would connect when testing a single-phase circuit supplying an air conditioner and protected by a 32 A circuit breaker.



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SECTION D – (Cont'd)

QUESTION 5. (3 Marks)

Complete the required switchboard marking, on the following diagram, for the circuit information provided in Table 4.

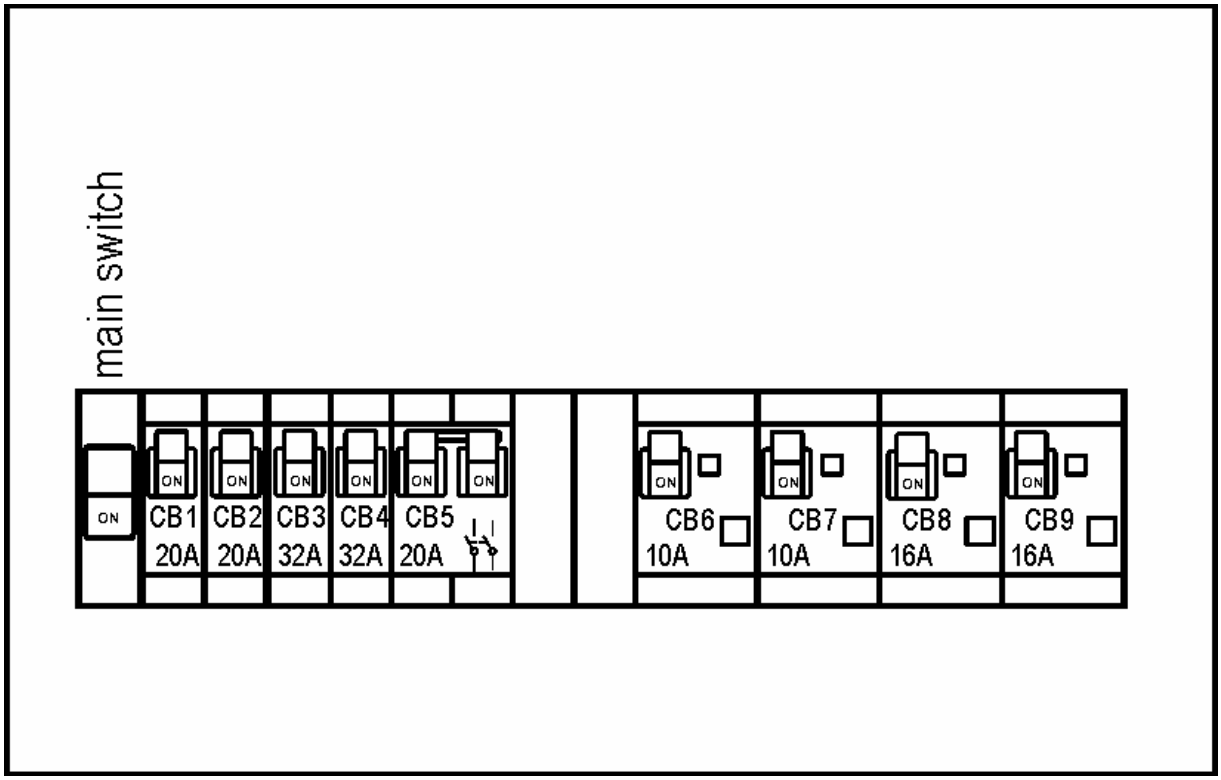

Table 4

Circuit	Description	CB	Neutral
1	Lights	6	2
2	Power	8	12
3	Air conditioner	3	5
4	Cook top	2	3
5	Dual element HWS	5	7

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Family Name .....

Given Name .....

Student Number.....

Centre .....

Signature .....

ANSWER SHEET – Section A (Multi-choice Questions)

November 2006

6077AC Electrical Systems Safety

Instructions:

- Enter your personal details in the top right hand corner of this sheet.
- Place an **X** in box of your choice. If you make a mistake, circle your answer (X) and choose again.

Question	(a)	(b)	(c)	(d)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
Totals				

Total Marks Section A: ..... /15

END OF EXAMINATION

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