FNU FIJI NATIONAL UNIVERSITY

COLLEGE: COLLEGE OF ENGINEERING, SCIENCE & TECHNOLOGY (CEST)

SCHOOL: SCHOOL OF ELECTRICAL & ELECTRONICS ENGINEERING

PROGRAMME: CERTIFICATE IV IN ELECTRICAL ENGINEERING-STAGE 5

UNIT CODE: EEE449

TITLE: ELECTRICAL INSTALLATION TECHNOLOGY C

FINAL EXAMINATION – PENSTER 3, 2015

DAY/DATE: FRIDAY/11/10/2013 **ROOM: AS PER TIMETABLE**
TIME: 9:00 – 11:10 AM

INSTRUCTIONS TO STUDENTS

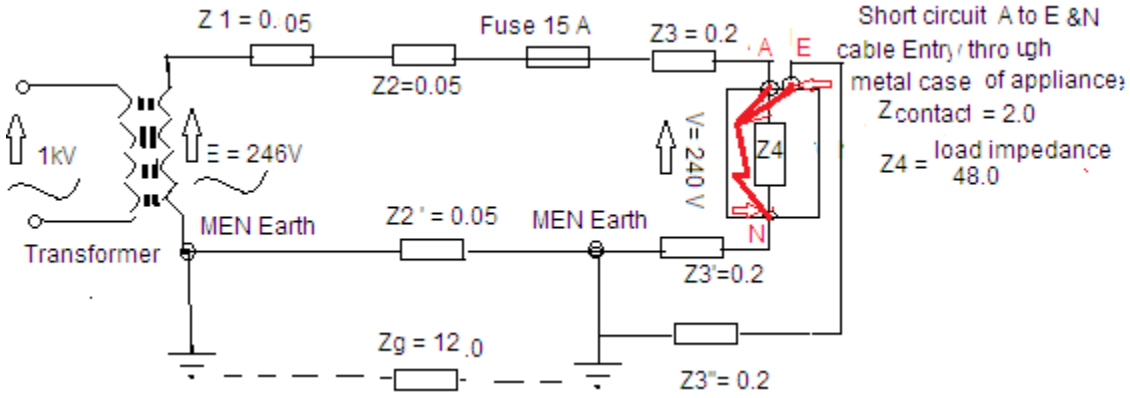
1. You are allowed 10 minutes extra reading time during which you are NOT to write.
2. Begin each SECTION on a fresh page and use both sides of the sheet.
3. Write your candidate number at the top of each attached sheet.
4. Insert all written foolscaps, graph paper, drawing paper, etc. in their correct sequence and secure with a string.
5. For all sheets of paper on which rough/draft work has been done, cross it through and ATTACH these to your answer scripts.
6. Write clearly the number(s) of the question(s) attempted on the top of each sheet.
7. Use of programmable calculator(s) is prohibited.
8. **ANSWER ALL QUESTIONS**
9. Show all working where necessary.
10. **ALWAYS CHECK YOUR WORK BEFORE YOU LEAVE THE EXAM ROOM**.

QUESTION 1 **CIRCUIT PROTECTION** **(20 MARKS)**

1.1 A pole mounted three phase 11kV/415V&240V, 50Hz, 120 kVA distribution transformer provides single phase low voltage supply to a single unit domestic installation that has maximum demand current of 25A consisting of a final sub circuit 15A socket outlet. If the transformer impedance is 5%
Calculate the:
i) full load current
ii) prospective short circuit fault current
iii) draw single line circuit diagram with label of the supply distribution and each of the supply cables and switchgear protection devices (8 marks)

1.2 State the definition and operation of following protection devices:
(a) ELCB (voltage operated earth leakage circuit breaker) (2 marks)
(b) RCD (residual current device) (2 marks)

1.3



Calculate the i) normal load current
ii) fault earth loop impedance
iii) fault current due to short circuit between active to neutral and earth at the appliance terminal block.

(4 marks)

1.4 An ELCB protective device is connected to the circuit above fig and it has current ratio 10: 1 and tripping current of 30mA
Calculate the: i) earth leakage current
ii) line and neutral currents at earth fault unbalance

(4marks)

QUESTION 2 ASSESSMENT OF MAXIMUM DEMAND AND CABLE SIZE

(20 MARKS)

2.1 In domestic installation a single phase 230V final sub circuit that is to be added to existing installation sub main has details as follows:

Consumers mains: Cable route length = 20 m underground enclosed in PVC Conduit
Maximum demand Current = 35A
Cable = $10mm^2$ twin core tough rubber sheath hard drawn copper

Sub main: Cable route length = 20 m enclosed in PVC conduit
Maximum demand current = 20A
Cable: $4mm^2$ twin core and earth wire PVC insulated in TPS copper

Final sub circuit: Cable route length = 20m on centenary wiring
Maximum demand current = 10A

Determine the: i) Cable size for the final sub circuit so that the voltage drop does not exceed permissible by the AS/NZS Rules
ii) HRC fuse protecting the consumer main
iii) RCCBO current rating protecting sub circuit
iv) MCB current rating protecting final sub circuit

8 marks

2.2 In a factory installation that has one main distribution switch board and has three final sub distribution switch boards and one of which has the following loads connected to the rated single phase (240V, 50Hz) and three phase (415V, 50Hz):
:

42 100W double lighting points
24 10A single general purpose outlets
4 15A three phase socket outlets
2 15A three phase motors
2 12A three phase motor
3 7.5A three phase motors

Determine the: i) heaviest loaded phase
ii) minimum size of sub main cable that of three core and neutral with single PVC insulated steel wire armoured and TPS copper conductors using HRC fuse switch protection.
iii) minimum size of each final sub circuit cable that of either two core or three core and earth single PVC insulated and TPS copper cable.
iv) current rating of the thermal and magnetic circuit breakers protecting each final sub circuit cable (12 marks)

QUESTION 3 DISTRIBUTION SYSTEM (20 MARKS)

3.1 State four(4) basic requirements and considerations when selecting and designing the suitable types of low voltage distribution, including high voltage installation in non domestic installation (e.g. FNU, Derrick Campus, Samabula) . (4 marks)

3.2 Draw with label diagram the circuit connections of each three switchgears used in low voltage supply distribution installation. (e.g. FNU, Derrick Campus, Samabula)

i) Three phase Automatic Change over switch (ACS) with two input supply mains and one output consumer main (3 marks)

ii) Three phase Main distribution switch board with one inlet consumer main and three (3) outlet sub mains feeders. (3 marks)

3.3 List down three(3) types of low voltage cables commonly used as sub main and sub- sub mains distribution in non domestic installation. (3 marks)

3.4 State three (3) common factors that are to be considered when selecting cables for any supply distribution installation (3 marks)

3.5 State two (2) applications of each of the following supply distribution and wiring systems:

i) bus bar and bus ways
ii) feeder pillars and link boxes (4 marks)

QUESTION 4 SPECIAL INSTALLATION (20MARKS)

AS/NZS or SAA Wiring Rules quote the clauses or rule number and content in brief

4.1 State the definition of hazardous location and work areas: class 1 zone 0 and class 2. zone 20 (3 marks)

4.2 What three (3) fixed wiring systems are NOT permissible in hazardous areas. (3 marks)

4.3 State two (3) types of wiring systems that are suitable for supply distribution to fire smoke control equipment? (3 marks)

4.4 Explain the segregation of wiring system in question 4.3 above (3 marks)

4.5 State at least four(4) circuit applications of Extra low voltage (ELV) supply.

(3 marks)

4.6 Draw a simple emergency lighting circuit diagram operation voltage is 24Vdc from a battery bank that is charged continuously by a full wave bridge rectifier and change over switch. (5 marks)

QUESTION 5 INSPECTION AND TESTING OF INSTALLATION (20MARKS)
AS/NZS or SAA Wiring Rules quote the clauses or rule number and content in brief

5.1 What is the general requirement on the labeling and marking of control and protection devices mounted on switchboard? (3 marks)

5.2 Explain how to prepare a fuse or circuit breaker switchboard chart that for a final sub distribution board in Question 2 part 2.2 (8 marks)

5.3 State four (4) different parts that for an electrical installation are important and must be visually inspected. (3 marks)

5.4 In verifying the satisfactory condition of an electrical installation, state at least four (4) important electrical tests to be conducted. (3 marks)

5.5 List four (4) emergency type of electrical circuits installation in building that for their effective operation depend on the power supply from the central battery bank or self contained unit (3 marks)

%%%%%%%%%%%%%%% END OF PAPER %%%%%%%%%%%%%%%

MARKING SCHEME/SOLUTION GUIDE

College:.....**CEST**.....

School/Department:**SEEE**...

Programme:**SCHOOL OF ELECTRICAL & ELECTRONICS ENG.**

Unit Code/Title:**EEE449- ELECTRICAL INSTALLATION TECHNOLOGY C**

Date of Exam: 29th**, JULY , 2015**

Time: **2:00 PM – 4:10 PM**

Examiner's Name: **MORITIKEI RAVULALA**

Signature:……

QUESTION 1 CIRCUIT PROTECTION (20 MARKS)

1.1

i) Full load current I_{FL} = kVA x 10^3 / ∫3 V_L

= 120 x 10^3 / 1.732 x 415

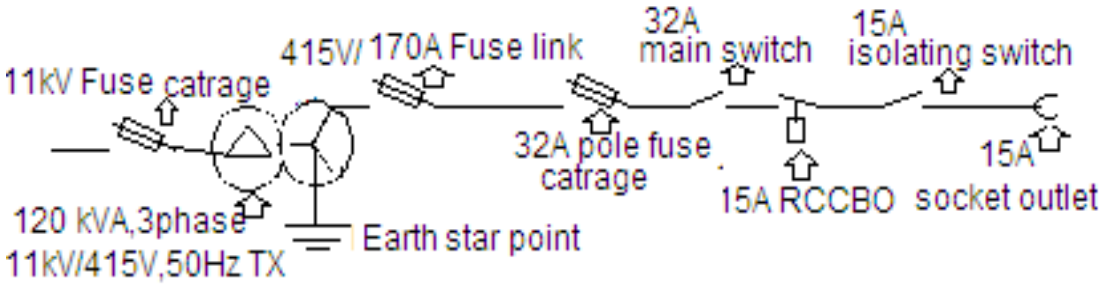
=166.95A 2 mark

ii)Prospective short circuit fault current I_{SCF} = 166.95 x100 / 5

= 3338.99A

= 3.34kA $1^{1/2}$ mark

iii)Supply Distribution system



$4^{1/2}$ mark

1.2

i) Rule 0.5.45 & F4.2

Voltage operated ELCB is an earthing system located inside switchboard in which all exposed metal parts of an installation from consumers main required to be earthed through ELCBs or relays. The ELCB is circuit protective device intended to isolate the supply in the event of voltage rise in any exposed metal to earth exceed a predetermined value. 2 mark

ii) Rule 0.5.74

Residual Current Circuit Breaker is circuit protective device intended to isolate supply to protect the circuit, socket outlet or equipment in the event of current flow to earth which exceed a predetermined value 2 mark

1.3

i) Normal load current I_{NL} = V / Z

= 240 / 48

= **5A** 2mark

ii) Earth fault loop impedance $Z_{EF} = Z_1 + Z_2 + Z_3 + Z_C + (Z_{3'} \times Z_{3''} / Z_{3'} + Z_{3''}) + (Z_{2'} \times Z_G / Z_{2'} + Z_G)$

= 0.05 + 0.05 + 0.2 + 2 +(0.2 x 0.2/ 0.2 + 0.2) + (0.05 x 12 / 0.05 + 12)

= 2.3 + 0.1 + 0.05

= **2.45Ω** 1 mark

ii) Fault current $I_F = E / Z_{EF}$

= 246 / 2.45

= **100.5A** 1 mark

1.4

i) Earth leakage fault current $I_{EF} = I_{Tp} \times I_{Ro}$

= 30 mA x 10 /1

= 300mA $1^{1/2}$ mark

ii)Unbalance: line current I_{LF} = 5.0 + 0.3 = **5.3A** $1^{1/2}$ mark

neutral current I_{NF} = 5.0 – 0.3 = **4.7A** 1 mark

QUESTION 2 ASSESSMENT OF MAXIMUM DEMAND AND CABLE SIZE (20 MARKS)

2.1

Determination of voltage drop Equation Appendix B 4.4.3& Table B2 Column22

$Vc = Vp \times 1000 / L \times I$

Vp = 5% x 230V

= **11.5V** 1 mark

$Vd = Vc \times L \times I / 1000$

Consumer main = $10mm^3$ **Vc = 4.5 mV/ Am**

Voltage drop Vd = 4.5 x 20 x 35 / 1000

Vd = 3.15V 1 mark

Sub main = $4mm^2$ **Vc = 11mV/Am**

. Voltage drop Vd= 11 x 20 x 20 / 1000

= 4.4V 1 mark

Final sub circuit = $2.5mm^2$ **Vc = 18 mV/Am**

Voltage drop Vd = 18 x 20 x 10 / 1000

= 3.6V 1 mark

Total Sum of voltage drops = 3.15V + 4.4V + 3.6V

= **11.15V < 11.5V**

i) Cable size final sub circuit = **$2.5mm^2$** 11/2 mark

ii) Protective device in consumer main: HRC current rating = maximum demand current = 50A (minimum

iii) Protection device in Sub main: RCCBO current rating = maximum demand current = 25A(minimum

iv)Protection device in final sub circuit: MCB current rating = maximum demand current = 10A (minimum

1/2 mark each (2 ½ mark)

2.2

Arrange load connection across the three phase supply as follows:

	Red	White	Blue
42 100W double lighting	14 x2 = 28pts	14 x2 = 28pts	14 x2 = 28pts
24 10A single GPO	8x10 = 8pts	8x10 = 8pts	8x10 = 8pts
4 15A 3ϕ socket outlet	4x15A	4x15A	4x15A
2 15A 3ϕ motor	2x15A	2x15A	2x15A
2 12A 3ϕ motor	2x12A	2x12A	2x12A
3 7.5A3ϕ motor	3x7.5A	3x7.5A	3x7.5A

1/2 mark each (3 mark)

Determine the heaviest loaded phase refer to Table 2.3 Column 3

	Red	White	Blue
42- 100W double lighting	11.67A	11.67A	11.67A
24- 10A single GPO	26.04A	26.04A	26.04A
4 - 15A 3ϕ socket outlet	48.75A	48.75A	48.75A
2- 15A 3ϕ motor			
2 - 12A 3ϕ motor	48.75A	48.75A	48.75A
3 -7.5A3ϕ motor			
Total sum of maximum demand	135.21A	135.21A	135.21A

1 mark each (5 mark)

i) Heaviest loaded phase = **<u>135.21A</u>** 1 mark

Determine the cable sizes and protective devices current rating Table B1 column 3(AS/NZS 3000-2007)

ii) minimum size of sub main = 50mm^2 HRC fuse current rating = 140A

iii)minimum size of final sub circuit lighting = 1.5mm^2 Circuit breaker current rating=12A

iv) minimum size of final sub circuit GPO = 2.5mm^2 Circuit breaker current rating=16A

v) minimum size of final sub circuit socket outlet = 4mm^2 Circuit breaker current rating=25A

vi) minimum size of final sub circuit 15A motor = 4mm^2 Circuit breaker current rating=32A

vii minimum size of final sub circuit 12Amotor = 4mm^2 Circuit breaker current rating=25A

viii) minimum size of final sub circuit 7.5Amotor = 2.5mm^2 Circuit breaker current rating=15A 1/2 mark each (3 mark)

<u>QUESTION 3</u> **<u>DISTRIBUTION SYSTEM</u>** **<u>(20 MARKS)</u>**

3 1

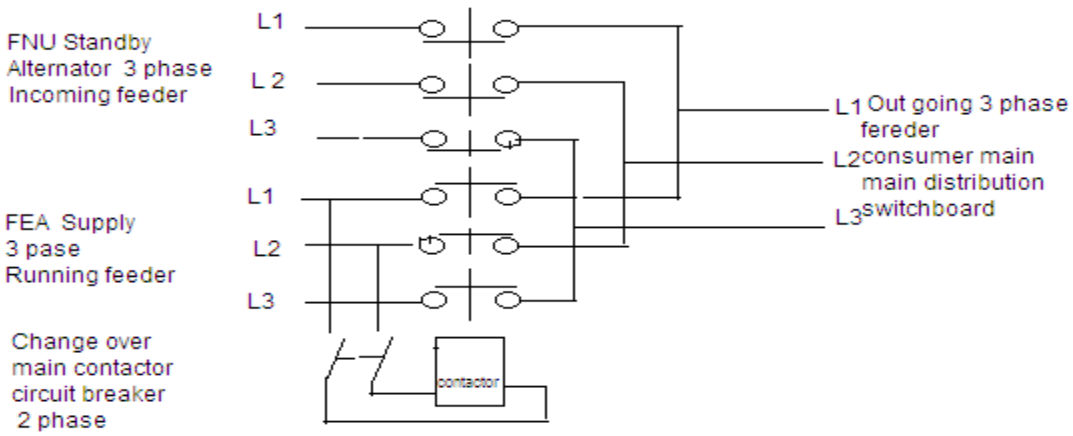
i) Functions of structure, present and future
ii) Life and flexibility of structure
iii) Locations of services entrance and distribution equipment, locations and characteristics of loads, locations of unit substations

iv) Demand and diversity factor of the loads
v) Source of power, including normal standby and emergency
vi) Continuity and quality of power available and required
vii) Energy efficiency and management
viii) Distribution and utilization voltages
ix) Bus and or feeder cables
x) Distribution equipment and motor control
xi) Power and lighting panel boards and motor control centers
xii) Types of lighting systems and installation methods
xiii) Power monitoring systems and energy utility requirements

any four(4) in list (4 marks)

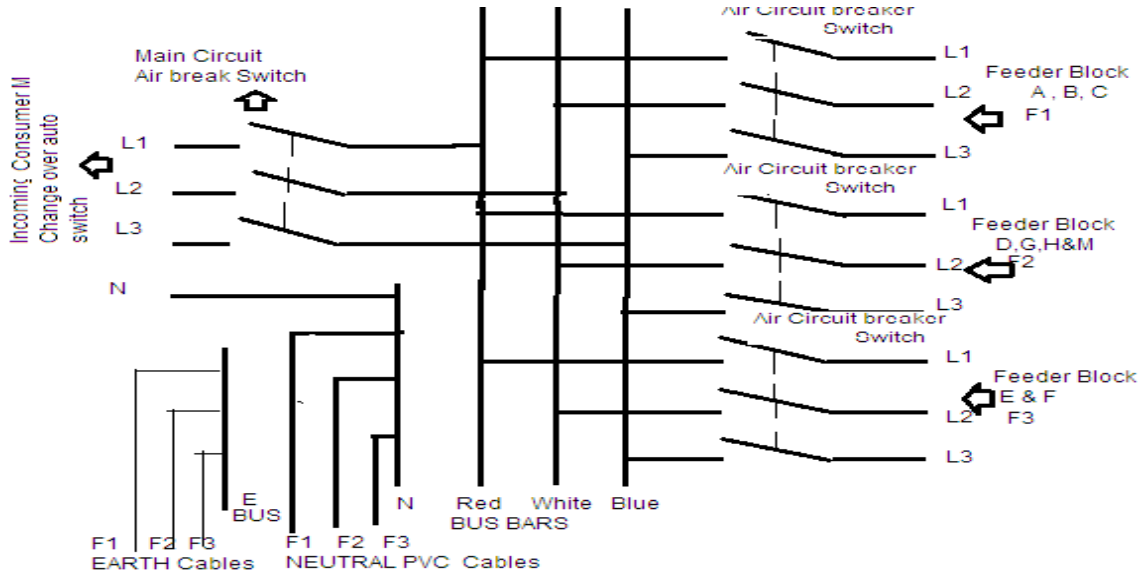
3.2

a)



3 marks

b)



3 marks

3.3

i) 3 core and earth thermoplastic insulated and thermoplastic sheathed copper or aluminum cable
ii) 3core and earth PVC insulated and sheathed steel wire armoured copper cable
iii) 3core and earth PVC insulated and sheathed steel wire armoured aluminum cable
iv) 3core paper insulated lead sheathed and bedding with steel wire armoured and PVC serving copper cable.
.

Any three(3) in list (3 mark)

3.4

A cable selected for a given supply distribution has to meet all requirements of the SAA / 1991 and AS/NZS /2007Wiring Rules. The following factors must be considered:

i) operating current carrying capacity
ii) operating Voltage rating.
iii) operating voltage drop consideration
iv) Mechanical and electrical protection consideration
v)Operating Environment temperature condition

For example a cable selected on the basis of current capability would be unsatisfactory in turns of voltage drop

Any three(3) in list (3 mark)

3.5

a) Bus bar system has wide application as conductor systems.

i) Use is confine to transmitting large currents through cubical or ducts in Switchboard wiring or switchgear interconnection.
ii) Radial and rising bus bar system in high rise building.
iii) Smaller bus bar systems are used in factories to supply machinery of the of plug in bus way systems

any two(2) in list (2 mark)

b) Feeder Pillars and link boxes are used in underground wiring. Usually link boxes with bigger bus bars on porcelain insulators connecting service main cables looping in to several consumers mains cables through smaller bus bar links.

Feeder pillars usually contain HRC fuses on phenolic board that connecting the service mains cable looping in to several consumers mains cables.

i) Located along the streets pedestrian footpaths in city shopping arcade
ii) Located along modern residential pedestrian footpaths
iii) in mines along main shaft and several levels bored holes

any two(2) in list (2 mark)

QUESTION 4 SPECIAL INSTALLATION (20MARKS)

4.1

Rule 9:4:2 (a) Class 1 zone 0 An area in which explosive atmosphere is always present continuously or present for a long period of time

(b) Class 2 zone 20 An area in which combustible dust as cloud is present continuously or frequently during normal operation, in sufficient quantity to be capable of producing an explosive dust

(3 marks)

4.2

Rule 9:6:2 Wiring system NOT permitted in hazardous areas:

i) Bare conductors and open wiring

ii) Earth Sheath return (ESR) and cable trunking wiring

iii) Bus ways and aerial wiring

(3 marks)

4.3

Rule 2:19:7:1 Wiring system associated with fire and smoke control and evacuation equipment and lifts

Cables which maintain supply to equipment when exposed to fire:

i) Copper sheathed MIMS cable

ii) Polymeric cables (fire rated) in a metallic enclosure

iii) Cables installed underground, buried in concrete or missionary walls or floors or installed in fire rated enclosures

(3 marks)

4.4

Rule 2:19:8:1 Cables in the same enclosure: Cables for fire and smoke control and evacuation equipment and lifts shall not with each other or be in the same enclosure as other system

i) if a duct or trough is divided into separate channels by means of fixed and continueous barriers which provide effective segregation each channel is separate ebclosure

ii) any other system approved by the authority responsible for system

4.5

Rule 0:5:95(b) ELV supply not exceeding 32V ac and 115V dc has the following Applications: i) Emergency power and lighting

ii)Alarm and signal circuit indicators

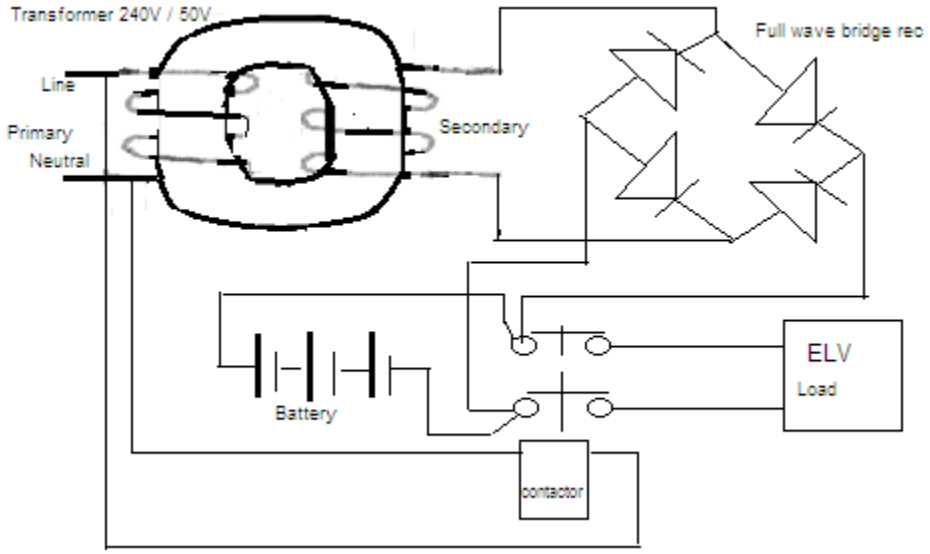
iii) Communications and telecom sounder and call point

iv) Radio Control circuits

v) Underwater pool pump motor or lighting

(3 marks)

4.6



(5 marks)

QUESTION 5 INSPECTION AND TESTING OF INSTALLATION (20MARKS)

5.1

Rule 2:23:5:1 Switchboards and equipment mounted on be clearly marked
Rule 2:23:5:2 Relationship of switches, circuit breakers, fuses, ELCBs and similar equipment shall be clearly marked
Rule 2:23:5:3 Bars and limks shall be marked to show whether active or neutral
Rule 2:23:5:4 Fuses marking on the fuse base should show the correct rating of the fuse element
Rule 2:23:5:5 Switches and emergency supplies that brings automatic operation of emergency or alternate supply shall be marked.
Rule 2:23:5:6 Common neutral shall be marked to show the associated active

(3 marks)

5.2

The arrangement of the circuit breakers that were mounted and connected to the busbars in the same order shown on the circuit breaker switchboard chart. Then the numbering had to be written down direct on the echelon plate or cover plate. in the relative position of the circuit breakers.
The circuit breaker switchboard chart is handy in assisting the operator in maintenance and repair to the existing or future additional installation.

(3 marks)

Circuit Breaker Switchboard Chart

No1 12A CB 1ϕ	Phase A 14lighting pts
No2 12A CB 1ϕ	Phase B 14lighting pts
No3 12A CB 1ϕ	Phase C 14 lighting pts
No4 16A CB 1ϕ	PhaseA 8 GPO pts
No5 16A CB 1ϕ	PhaseB 8 GPO pts
No6 16A CB 1ϕ	PhaseC 8 GPO pts
No7 20A CB 3ϕ	Socket outlet
No8 20A CB 3ϕ	Socket outlet
No9 20A CB 3ϕ	Socket outlet
No10 20 CB 3ϕ	Socket outlet
No 11 30 CB 3ϕ	motor
No 12 30 CB 3ϕ	motor
No 13 25A CB 3ϕ	motor
No14 25A CB 3ϕ	motor
No15 15A CB 3ϕ	motor
No16 15A CB 3ϕ	motor
No17 15A CB 3ϕ	motor

(5 marks)

5.3

Rule 8:2:2 AS/NZS 3000-2007

Checklist provides a guide to be checked during visual inspection to assess that the relevant standard is satisfied

a) General Protection: items i) - v)
b) Consumers mains: items i) - vi)
c) Switchboard: items i) - vii)
d) Wiring System items i) - vii)
e) Electrical Equiptment: items i) - vii)
f) Earthing: items i) - viii)

(3 marks)

5.4

Rule 8:3:3 AS/NZS 3000-2007

The following mandatory tests should be carried out to an electrical installation:

a) Continuity of the Earth system Clause 8:3:5
b) Insulation Resistance Clause 8:3:6
c) Polarity Clause 8:3:7
d) Correct connection Clause 8:3:7
e) Verification of impedance required for disconnection of the system Clause 8:3:9
f) Operation of RCDs Clause 8:3:10

(3 marks)

5.5

Battery charges for central battery banks either from solar panels or ac power supply are used for emergency supply following emergency circuits:

a) Fire and smoke detector
b) Alarm bells and signal siren
c) Evacuation warning lights
d) Emergency flood lights
e) Intercommunication circuits

(3 marks)

%%%%%%%%END OF MARKING SCHEME%%%%%%%%%