The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Electrical & Computer Engineering

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX4434 Electrical Installations**
Academic Year	: 2022/2023
Date	: 10th February 2024
Time	: 0930-1230 hrs
Duration	: **3 hours**

General Instructions

1. This question paper consists of **Five (5)** questions in **Five (5)** pages.
2. Answer **all** questions.
3. Relevant charts and tables are separately distributed.
3. Answer for each question should commence from a new page.
4. Page 04 of this paper should be attached to the end of the answer book.
5. This is a Closed Book Test (CBT).
6. Answers should be in clear handwriting.
7. Do not use Red colour pen.

Question 01 – [30 marks]

A small factory to be built in Sri Lanka requires an electrical installation. It consists of continuously operating 15 kW load for lighting and heating. There are 4 machines in the factory which run by induction motors as details given in Table Q1.1. (Assume 1 horsepower (hp) = 746 W). Supply to the factory would be 400 V, 3-phase. Table Q1.2 shows the current demand at start for each starting method of motors. The voltage drop limitations can be neglected in the calculations and the harmonic currents in motors can be negligible.

Table Q1.1

Motor	Capacity (hp)	Supply	Starting method	Starting power factor	Running power factor
A	15	3-phase	Star-Delta	0.7	0.8
B	5	1-phase	DOL	0.7	0.8
C	5	1-phase	Soft starter	0.7	0.8
D	5	1-phase	VFD	0.7	0.8

Table Q1.2

Type of starter	Starting current
DOL	6 times the full load current
Star-Delta	4 times the full load current
Soft Starter	2 times the full load current
VFD	1.5 times the full load current

Details of the wiring are as follows.

- Standby generator should be able to supply the maximum load in the factory.
- Ambient air and ground temperature is 25°C in the factory premises.
- Motor circuits are installed in thermally insulated walls in conduits using multicore PVC copper cables.
- Heating and lighting loads are distributed in the three phases and the circuits are installed in thermally insulated walls in conduits using single core copper cables.
- Both mains and standby generator supplies are PVC insulated multi core armoured copper cables laid underground, buried in cable ducts at 1 m depth with compact soil having 3 mK/W thermal resistivity.

Answer the following questions.

i. If the factory needs to install a standby generator, estimate the kVA rating of the generator. The switching order of motors is A – B – C – D. ***(10 marks)***

ii. Determine the appropriate protective devices and cable sizes for
   a. Motor circuits A, B, C and D
   b. Heating/Lighting system
   c. Mains and standby generator supply ***(10 marks)***

iii. Draw the complete wiring diagram indicating the mains, standby generator associated with switchgears and protective devices for all circuits. ***(10 marks)***

Question 02 – [20 marks]

i. Explain the method of "system earthing" used in Sri Lanka and in UK. Include an illustration in your answer. ***(4 marks)***

ii. Show the components of a typical earth fault loop path in Sri Lanka in the form of a simple circuit clearly defining all the components appearing in the circuit and write an expression for the earth loop impedance Z_S? ***(4 marks)***

iii. State briefly, the differences between MCB, RCCB and RCBO with respect to their operational characteristics? ***(4 marks)***

iv. An installation is protected against indirect contact using a circuit protective conductor (cpc) with BS3036 30 A fuse. The maximum earth fault loop impedance of the installation Z_s = 1.1 Ω, Using the adiabatic equation, find out whether 1 mm^2 cable is safe to be used as the cpc. Assume k = 115.

$$t = \frac{k^2 \times S^2}{I^2}$$

(5 marks)

v. Name the instrument you use to measure the insulation resistance of a domestic electrical installation, what voltage would you apply if the installation is wired for 110 V AC and state the value of the insulation resistance you would expect from an acceptable electrical installation as per the IET Regulations? ***(3 marks)***

Question 03 – [15 marks]

A three phase Y-connected, 400 V, electric appliance rated at 3.5 kW operating at 0.8 power factor is to be fed from a distribution board over 10 m with 2 bends. The PVC insulated copper (thermo-plastic) cable circuit recommended for this installation is enclosed in a conduit with 2 other similar size cable circuits embedded in a plastered brick work (Wall). The ambient temperature is 30.5 ^{0}C.

i. Determine the design current of the circuit. ***(1 mark)***

ii. Select the rating of the protective device if the circuit is to be protected by type B MCB to BS EN 60898. ***(1 mark)***

iii. Calculate the factor Ca for computing the cable rating. ***(2 marks)***

iv. What is the suitable value of Cg for computing the cable rating? ***(2 marks)***

v. Compute the required ampere rating of the cable. ***(1 mark)***

vi. What should be the suitable cable cross section area? ***(1 mark)***

vii. What voltage would be available at the appliance? ***(2 marks)***

viii. If the above appliance is fed from a power electronic converter which results in 50% triple (3^{rd}) harmonic currents, determine the suitable cable for the circuit. Assume that all other conditions remain same. ***(5 marks)***

Question 04 – [15 marks]

A domestic electrical installation consisting of the following accessories are as shown in figure Q4 on page 4. Assume all factors of cable selection as 1.0 and reference type A for installation.

- MCB1 – 100 W lamp1, 100 W lamp2, 100 W lamp3, florescent lamp
- MCB2 – Ring circuit – points 1 to 6
- MCB3 – Point 7 – supplying an instant water heater of 3000 W
- RCCB, Main switch, service main

i. Determine the ratings of MCB1, MCB2, MCB3 and the cable sizes for each circuit including protective conductor for each circuit. No need to consider adiabatic equation for cpc size estimation. ***(2 marks)***

ii. State the type of device you recommend to the main switch. ***(2 marks)***

iii. State whether a single device can replace both RCCB and main switch. Justify your answer. ***(2 marks)***

iv. If the conductors of circuits MCB1 and MCB3 are to be driven through a conduit of 5 m including 2 bends, determine the suitable conduit size and the bending radius. ***(4 marks)***

v. Draw the complete wiring diagram of the installation using the diagram provided on the question paper (page 4). You must detach the sheet from the question paper and attach it at the end of your answer book. You may use different colours (except red) and/or line styles (dashed/dotted) to indicate different wires in the diagram. ***(5 marks)***

Index number: .....

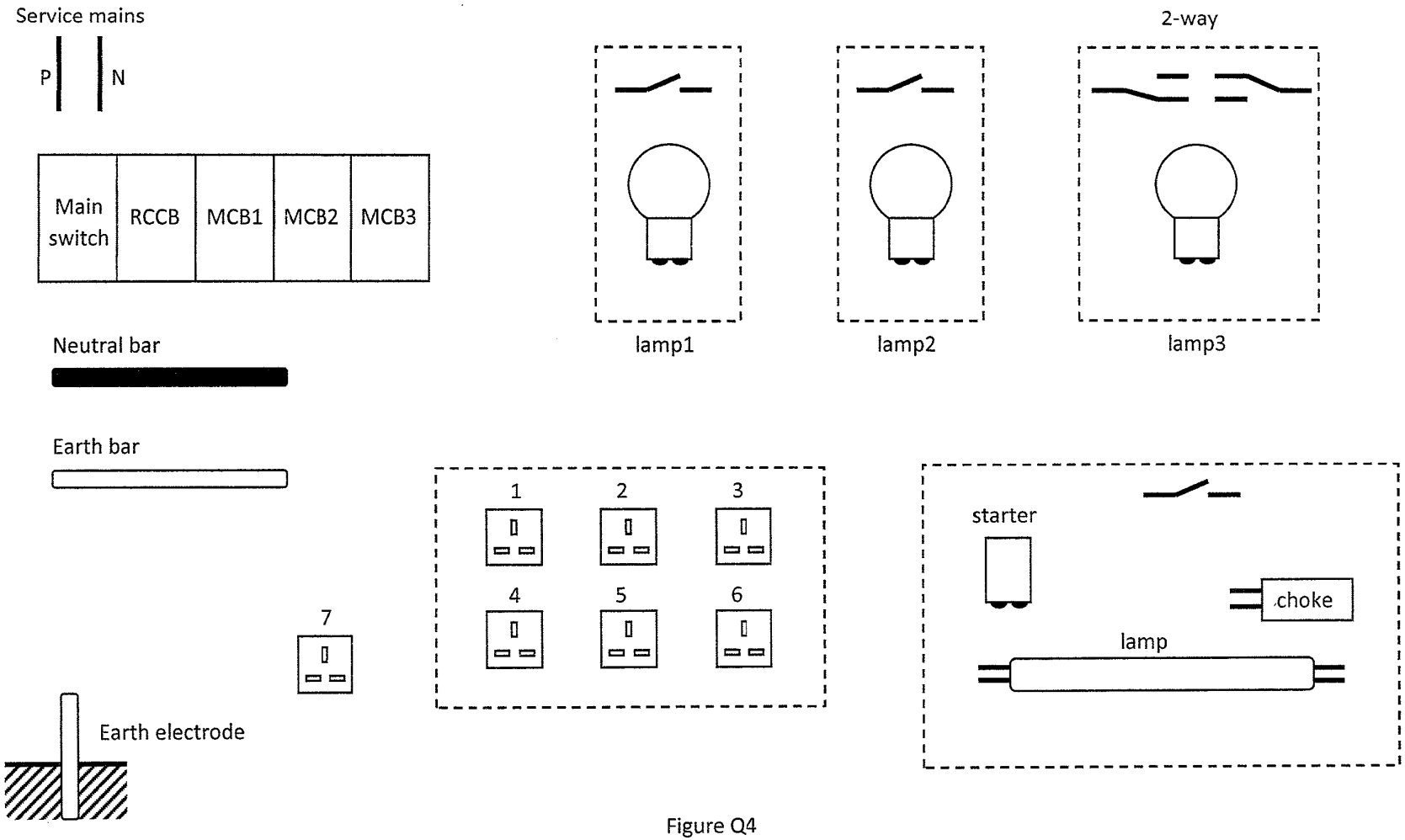


Figure Q4

Question 05 – [20 marks]

Figure Q5 shows the layout plan of a university laboratory building. All the dimensions are given in meters. Ceiling height of the entire section is 3 m and work plane is 0.8 m from the floor. Design illuminance level at each area is as indicated in the layout plan. Assume 0.7, 0.5 and 0.3 reflection factors for ceiling, wall and floor respectively. Maintenance factor is 0.8 for all the cases. Answer the following questions. Clearly state any assumptions you made. The relevant data sheets of 3xTL5 14 W and 13 W downlight are given in at the end of this paper.

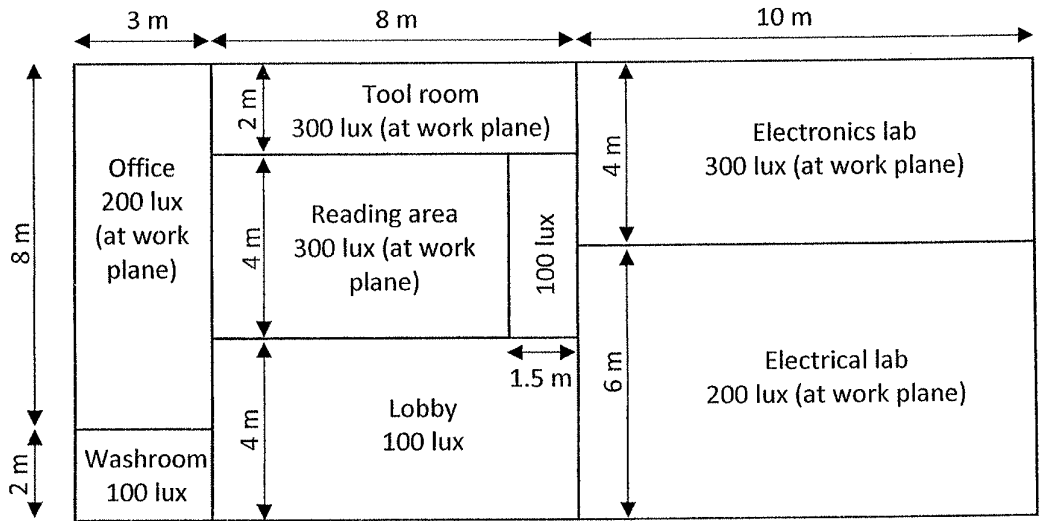


Figure Q5

i. What is the room index of the Electronics lab? ***(1 mark)***

ii. If 3xTL5 14W Fluorescent luminaire is selected for above section, what is the utilization factor? ***(1 mark)***

iii. Find the total lumens requirement for the Electronics lab. ***(1 mark)***

iv. Calculate the total number of 3xTL5 14W lighting fixtures required for the above requirement. ***(1 mark)***

v. Based on the answer of 'iv', propose suitable lighting fixture layout. Calculate the space to height ratio, lengthwise and widthwise for the selected layout. ***(4 marks)***

vi. Compare the answer of 'v' with the values given in the data sheet and state whether the proposed layout complies with the space to height ratio. ***(4 marks)***

vii. Calculate the number of lighting fixtures required for the office using 3xTL5 14W lighting fixtures. ***(3 marks)***

viii. Calculate the number of lighting fixtures required for the office using 13W downlight lighting fixtures. ***(3 marks)***

ix. If the price of a 3xTL5 14 W is Rs. 8000 and 13 W downlight is Rs. 3000, what is your choice of luminaire for the office? ***(2 marks)***