EXAMINATION FOR AUTHORISATION B

Paper 2

Date: **8th February 2024**

Time: **9:00 – 12:00 (Three hours)**

This examination paper includes six questions. Candidates are requested to choose and answer any FIVE questions clearly indicating the question number of the answered questions.

Write <u>only</u> your Index Number in the space provided in the booklet.

Candidates are requested to answer ALL FIVE questions in the booklet correctly listing the answered question number in the space provided on the booklet's front sheet.

Answers should be written in Blue/Black Ink. Diagrams can be drawn in pencil.

All answers should include the necessary workings, diagrams and formulae.

Use a separate page for each different question.

Each question carries 20 marks.

1. (a) A carpenter workshop consists of the following loads:

- Socket-outlets and Lighting circuits, 10kW at unity power factor.
- The combined power for a planer machine, press machine and profile edging machine amounts to 10kW at 0.8 power factor lagging.
- Office air-conditioners and workshop ventilation load is 20 kW at 0.6 power factor lagging.
- A 80kW capacitor bank unit set at 0.9 power factor leading.
- Three welding sets. The power per welding set is 30kW at 0.5 power factor lagging.

The loads are balanced over the three phase 400Volts, 50Hz supply. Determine:
(i)	The total kW	**(2 Marks)**
(ii)	The total kVAr	**(4 Marks)**
(iii)	The kVA	**(3 Marks)**
(iv)	The overall power factor	**(3 Marks)**
(v)	The line current.	**(3 Marks)**

(b) The carpenter workshop main switch needs replacement. If all the loads have an overall efficiency of 80%, from your experience:
(i) Estimate the rating (amps) and name the type of main switch you choose to control the switchgear i.e. 4-pole or 3-pole. **(3 Marks)**
(ii) Give an explanation for your answer in b(i). **(2 Marks)**

2. (a) An old bakery factory is being renovated. Two three-phase motors are coupled to a pastry mixer. The motors are protected against excessive currents. With the aid of a labelled diagram, explain the operation of:
(i) Thermal overload. **(4 Marks)**
(ii) Dashpot overload. **(4 Marks)**

(b) (i) List one advantage for each of the Thermal overload and Dashpot overload.
(2 Marks)
(ii) List one disadvantage for each of the Thermal overload and Dashpot overload.
(2 Marks)

(c) What is the recommended overload setting range (%) to protect the motor? **(2 Marks)**

(d) Explain the components which make a Stator of a motor. **(3 Marks)**

(e) The old bakery requires to use an old induction squirrel cage motor to be coupled with a diesel engine to generate electricity for the general lighting. Explain why this configuration is not possible. **(3 Marks)**

3. The electric load of a small factory consists of the following:

- A 50kW three phase motor having an efficiency of 85% at a power factor of 0.8
- Two by 8kW motors at an efficiency of 80% at a power factor of 0.8
- Fifty lighting points for 60Watt filament lamps
- Ten discharge lamps each rated at 1 kW
- Six ring circuits each feeding 10 single phase socket outlets
- Four single phase instant water heaters each rated at 2.5kW.

(a) Assume a three-phase supply of 400V / 230V with single-phase loads distributed between the phases to balance the installation as much as possible.
(i) Calculate the current demand for each of the above electric loads, indicating the assumed diversity factor where required. **(18 Marks)**
(ii) Calculate the total current demand for the main switchboard. **(2 Marks)**

4. A 230V 50Hz single phase supply extractor fan has a rating of 5kW at 0.8 p.f. lagging and is protected by a BS 88 Part 2 fuse. The distribution board is 40m away from the extractor fan. The cables used to supply the extractor fan are to be single core cables, PVC insulated, installed in steel trunking with three similar circuits. Assume an ambient temperature of 35⁰C and that the voltage drop in the cables is limited to 2.5%. Using the tables 4.1 to 4.4 and ignoring any diversity, calculate:

    (i)   The full load current of the motor (Ib) **(4 marks)**
    (ii) The rating of the fuse (In) **(3 marks)**
    (ii) Minimum current rating of cables **(5 marks)**
    (iv) Minimum cable c.s.a **(4 marks)**
    (v) Actual voltage drops in the cable. **(4 marks)**

Tables **4.1 to 4.4**

Table 4.1	Fuse to BS 88 Part 2 Rating				
6A	10A	16A	20A	32A	50A

Table 4.2	Grouping Factor						
No of Circuits	1	2	3	4	5	6	7
C_g	1.0	0.8	0.7	0.65	0.6	0.57	0.54

Table 4.3	single-core PVC cable							
Ambient temperature(⁰C)	25	30	35	40	45	50	55	60
C_a	1.03	1.0	0.94	0.87	0.79	0.71	0.61	0.50

Table 4.4	Single core 70⁰C PVC copper cables – Method B	
Cross Sectional Area mm²	Current carrying capacity (A)	Voltage drop mV/A/m
1	13.5	38
1.5	17.5	25
2.5	24	15
4	32	9.5
6	41	6.4
10	57	3.8
16	76	2.4

5.(a) Which one of the locations listed in the box below needs the BS761 requirement for an electrical installation? Give a reason for your answer.

> Lift installations
> Mobile offshore electrical systems
> Distributor's networks
> Locations containing a bath or shower

(5 marks)

(b) **Consumer's earth electrode** is normally installed for earthing arrangements.
   (i)   Name the electrical system that makes use of an earth electrode. **(2 marks)**

    (ii) Which of the following suits the electrical system named in (b)(i)?
        • No earth facility is supplied by the distributor.
        • The supply is from a low voltage generator.
        • Earthing is via the distributor's cable armour.
        • The electrical system is TN-C **(2 marks)**

    (iii) Explain why the consumer's earth electrode is required for the electrical system in b(i).
(3 marks)

(c) With the aid of a diagram explain in detail how the consumer's earth electrode is tested.
(8 marks)

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6. (a) (i) Explain the difference between earth wire and neutral wire. **(2 marks)**

   (ii) With the aid of a mathematical expression show that all line currents in a balanced three-phase system are equal. **(2 marks)**

   (b) Give TWO examples of balanced loads. **(2 marks)**

   (c) In a three-phase four-wire system the line voltage is 400 V. Inductive loads of 12 kW, 10 kW and 7 kW respectively are connected between the three-line conductors and the neutral as shown in Figure 6.1.
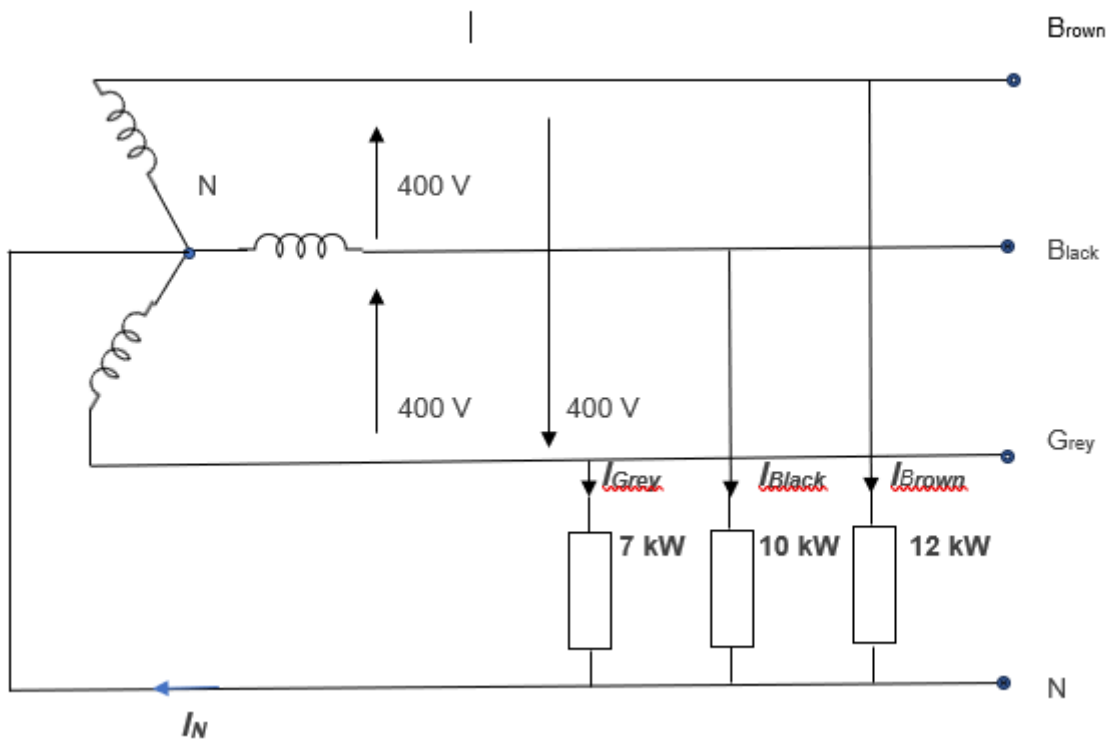
Figure 6.1

   (i) Calculate the current in each line (Brown, Black, Grey). (**6 marks)**

   (ii) Calculate the current in the neutral conductor. (**8 marks)**

END OF EXAMINATION PAPER