# EXAMINATION FOR AUTHORISATION B

# Paper 1

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| **Date:** | **Tuesday 28th January 2025** |
| **Time:** | **15:30 – 17:30 (Two hours)** |

**This examination paper includes ten questions. Candidates are requested to answer ALL 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 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 10 marks.**

1.  To improve the power factor, a particular installation requires a total of 48kVAR equally distributed over the three phases of a 415V 50Hz system.
    Calculate the value of the capacitors required (in microfarads) when the capacitors are connected in

    a)  Star **(5 marks)**
    b)  Delta. **(5 marks)**

2.  A Three-phase transformer supplies a block of flats at 250V AC line to neutral voltage. The total balanced load is 285kW at 0.95 power factor. The turns ratio of the transformer, primary to secondary is 44:1. The transformer primary winding is connected in Delta.
    a)  Draw the connection diagram for the transformer. **(2 marks)**
    b)  What is the primary line voltage? **(2 marks)**
    c)  Calculate the primary line and phase currents. **(3 marks)**
    d)  Calculate the line current in the secondary winding. **(3 marks)**

3.  a)  Write down the equation for resistivity ρ in terms of Resistance (R), length of conductor (L) and the cross-sectional area of the conductor (A). **(1 mark)**

    b)  Calculate the resistance of 10mm$^2$,100m cable considering Copper and Aluminium material.
        Take the resistivity of copper as 17.5 x 10$^{-9}$ Ωm and the resistivity of Aluminium as 28.5 x 10$^{-9}$ Ωm. **(4 marks)**

    c)  The field winding of a generator has a resistance of 150Ω at an ambient temperature of 20ºC. After operating for some time, the mean temperature rises to 45ºC.
        Calculate the new winding resistance given that the copper temperature co-efficient is 0.004/ºC. **(5 marks)**

4.  The following three types of motors are used in the industry and may require a change in the direction of rotation:

    - Single phase Universal series motor
    - Single phase induction motor with capacitor on one winding leg
    - 3 phase induction motor (delta wound).

    a)  For each motor
    (i)   Draw up an equivalent schematic drawing showing and labelling the components.
                                                                                      **(3 marks)**
    (ii)  Explain what is required to change the rotational direction.          **(6 marks)**
    (iii) For a 50Hz supply calculate the synchronous speed for an induction machine having 4 poles.                                                                         **(1 mark)**

5.  a)  The distribution system network in Malta operates using the voltages listed below:
        - Low Voltage (LV)
        - Medium Voltage (MV)
        - High Voltage (HV).

        List the Distribution Nominal Voltages for each of the above.          **(6 marks)**

    b)  An insulation resistance test has been carried out on a 6-way consumer unit. The recorded values for each circuit are: 5.6 MΩ, 8.7 MΩ, >200 MΩ, >200 MΩ, 12 MΩ and 7 MΩ.
        **NOTE:** Any values which are indicated as greater than (>) can be disregarded as the true value is unknown.

        (i)   Calculate the total resistance of the installation.              **(2 marks)**
        (ii)  State if the calculated value for the installation is acceptable or not. Give reasons for your answer.                                                                    **(2 marks)**

6. A small shop with a takeaway outlet has the following single-phase loads, The loads are balanced as evenly as possible across the 400V three-phase supply.

- **2 x 6kW** Ovens
- **1 x 4kW** Oven
- **3 x 30A ring circuits** supplying 13A sockets.

a) With reference to the Table 6.1 below, calculate the maximum current demand for the small shop and takeaway outlet, after applying the allowance for diversity.

**(10 marks)**

| Table 6.1 - Allowance for diversity | |
|---|---|
| Ovens | 100% of X + 80% of Y + 60% of Z |
| Sockets and stationary equipment | 100% of X + 75% of (Y+Z) |

**Note** the following abbreviations:

X is the full load current of the largest appliance or circuit
Y is the full load current of the second largest appliance or circuit
Z is the full load current of the remaining appliances or circuits.

7. a) Explain why Earthing in an electrical installation is critical and important. List **at least four basic essentials** of earthing. **(6 marks)**

b) The TT system, used for local installations, requires installing a suitable **earth electrode**. Draw a diagram of a TT system showing the protective earthing in the installation as well as the other earthing at the source. **(4 marks)**

8. A seasonal amusement park in Valletta needs to be supplied with 3-phase 400V, neutral and earth. The IET wiring regulations BS 7671, Section 740, consider the amusement park as a special installation.

a) What is the maximum permissible 3-phase voltage? **(2 marks)**

b) What is the permissible maximum operating current of a residual current device? **(2 marks)**

c) What is the minimum degree of protection required for external equipment? **(2 marks)**

d) What is the minimum rated voltage for cables used in these installations? **(2 marks)**

e) The amusement device operated by an electrical supply (e.g. gaming booth) requires that a permanently sign is attached clearly showing electrical ratings. Mention at least two electrical ratings which should be marked. **(2 marks)**

9.  A 400V, 50Hz, 3-phase and neutral main switchboard of a factory requires a current transformer and an ammeter to be connected to a 3-way selector switch, to measure a current of 200 Amps.

    a)  Draw and describe two types of current transformer which can be used with the ammeter of full-scale deflection of 5 Amps. You are expected to mention the necessary safety precautions to be taken when using current transformers and explain why.  **(6 marks)**

    b)  Calculate the current transformer *current ratio* for the ammeter used in (a) to give a graduated scale to indicate the values up to 200 Amps max.  **(1 mark)**

    c)  The ammeter used in (a) has a resistance of 10Ω and takes 30mA to produce the full-scale deflection of 5 Amps. What is the expected shunt resistance value of the ammeter?

    **(3 marks)**

10. (a)  The testing of the earth electrode, for a standby generator used to power a restaurant, requires shifting the metal test spikes (auxiliary testing electrodes) to different locations.

    The resistance readings obtained during the testing are 49Ω, 48Ω, 49.5Ω, 51Ω and 49.5Ω.

    (i)   What is the average resistance value of the earth electrode?  **(2 marks)**
    (ii)  Is the average resistance value obtained in 10(a)(i) acceptable as recommended for local earthing systems by the Regulator for Energy and Water Services regulations?  Give a reason for your answer.  **(2 marks)**
    (iii) Explain why the shifting of the metal spikes is required when testing the earth electrode.  **(1 mark)**

    (b)  Draw a labelled diagram showing the measurement of the current flowing in the neutral using one instrument to a TT system, 3-phase 400V star and Neutral + E connected load.

    **(5 marks)**

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