# EXAMINATION FOR AUTHORISATION B

# Paper 2

**Date:** **Thursday 30th January 2025**

**Time:** **15:30 – 18:30 (Three hours)**

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

**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.**

**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 three-phase induction motor rated at 400V, 30kW with a power factor of 0.92 is connected to a star/delta starter.

   a) Calculate the full load current of the motor. **(3 marks)**

   b) Assuming a starting current of 6.5 times the full load current, calculate the current when the motor is starting in star connection. **(4 marks)**

   c) The motor keeps on blowing the main incoming fuse and the engineer decided to connect the machine to an autotransformer starter. The new required line starting current must be reduced to 63A. Figure 1 below represents the circuit diagram showing the primary and secondary voltage connections, and the connection to the load.
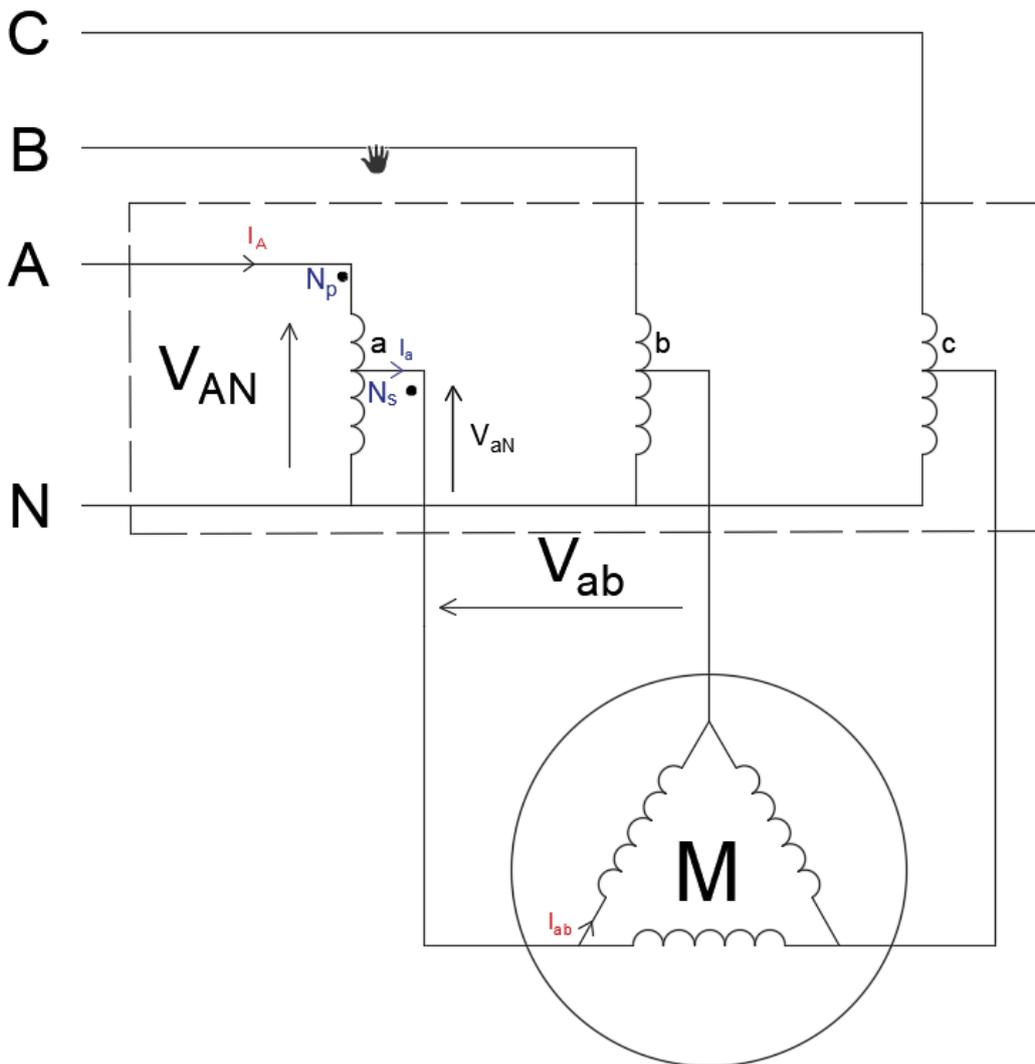


*Figure 1*: AUTO TRANSFORMER STARTER/(initial setup before motor goes DOL)

i) State the relation between primary phase voltage $V_{AN}$ and secondary phase voltage $V_{aN}$ in terms of Np/Ns. **(2 marks)**

ii) State the relationship between primary line voltage $V_{AB}$ and secondary line voltage across the motor winding $V_{ab}$ **(2 marks)**

iii) State the relation between primary line current $I_A$ and secondary line $I_a$ current in terms of Np/Ns **(2 marks)**

iv) State the relationship between secondary line current $I_A$ and phase current going into the winding across ab $I_{ab}$ **(2 marks)**

v) Calculate the turns ratio Np/Ns of the auto transformer. **(5 marks)**

2. A three phase 400V AC50 Hz inverter is powered by a battery setup consisting of 4 parallel batteries, each string equipped with batteries at 12 V 20Ah. The inverter is rated for a maximum load of 10 kVA at 0.85 pf.

a) Calculate the number of batteries required to generate 576V DC. **(2 marks)**

b) Draw a diagram of the battery setup including an internal resistance of 0.05 Ohms for each 12V unit battery. **(2 marks)**

c) Calculate the maximum AC inverter load current in Amps. **(2 marks)**

d) Calculate the DC current required from the battery to sustain this load. **(3 marks)**

e) Calculate the current drawn from each string. **(2 marks)**

f) Calculate the autonomous time the battery can provide in hours at maximum load **(4 marks)**

g) A charger is used to charge the battery while supplying the load. A trickle charge of 2A flows in each string. Calculate the voltage generated (EMF) by the charger assuming that the charger has an internal resistance of 0.2 Ohms, and an average total diode voltage drops of 1.5V. **(5 marks)**

3. a) The IET Wiring Regulations, BS 7671, provides guidelines for cable sizing to ensure electrical performance and safety in electrical installations.

i) List and briefly explain three consequences of incorrect cable sizing. **(6 marks)**

ii) Name and briefly explain three correction factors commonly applied to ensure that the cable can carry more than the rating of the protective device. **(6 marks)**

b) A single-phase 230V motor is rated at 11.5 kW. It is installed in a boiler house that has an ambient air temperature of 35°. The cable is a 90° thermosetting three core steel wire armour cable which will be secured to a perforated cable tray & grouped with one other circuit. The cable does not encounter any thermal insulation throughout its forty-five-meter run. Calculate, the

i) design current $I_b$ **(2 marks)**

ii) recommended protective device rating $I_n$ **(2 marks)**

iii) breaker type. **(1 marks)**

(c) What test must be performed to obtain the earthing resistance value between the substation earthing and the customer earthing system in an TT system? **(1 mark)**

(d) List two occurrences when an RCD cannot provide protection for in an Electrical Installation. **(2 marks)**

4. (a) Three identical loads, each having a resistance of 25Ω and an inductive reactance of 45Ω are connected first in **star** and then in **delta** to a 400V 50Hz three-phase supply. For each connection method, calculate the following:

    i)  impedance of load **(2 marks)**

    ii)  the phase currents **(4 marks)**

    iii)  the line currents. **(4 marks)**

(b) With the aid of a diagram, explain what is meant by discrimination in an electrical installation. **(3 marks)**

(c) The AC motor starters consist of two devices. Name and briefly explain the two components and their respective purpose in starting a motor. **(4 marks)**

(d) List three AC motor starters that are commonly used in industry. **(3 marks)**

5. A Blacksmith 20m by 20m workshop requires to be connected to the national electrical grid. The workshop requires to be supplied with 3-phase 400V and 1-phase 230V, 50Hz (assume 0.8 power factor). The workshop is equipped with several types of machines. Refer to the workshop plan layout drawing on page 5.

(a) Recommend the number of single pole switches required for the workshop and office.
**(2 marks)**

(b) What type of conduit and trunking is used for the workshop? **(2 marks)**

(c) Refer to the workshop plan drawing that includes two incorrect symbols in the drawing. Name the two incorrect symbols and for each draw the correct symbol.
**(2 marks)**

(d) Which are the components required to assemble the distribution board? **(4 marks)**

(e) Construct a bill of quantities (BOQ) table showing three columns for symbol, description of the accessory and quantity. BOQ must also include isolators, starters, double pole switches and switches to control the lighting as listed in part (a).

**(10 marks)**

Blacksmith Workshop Plan drawing
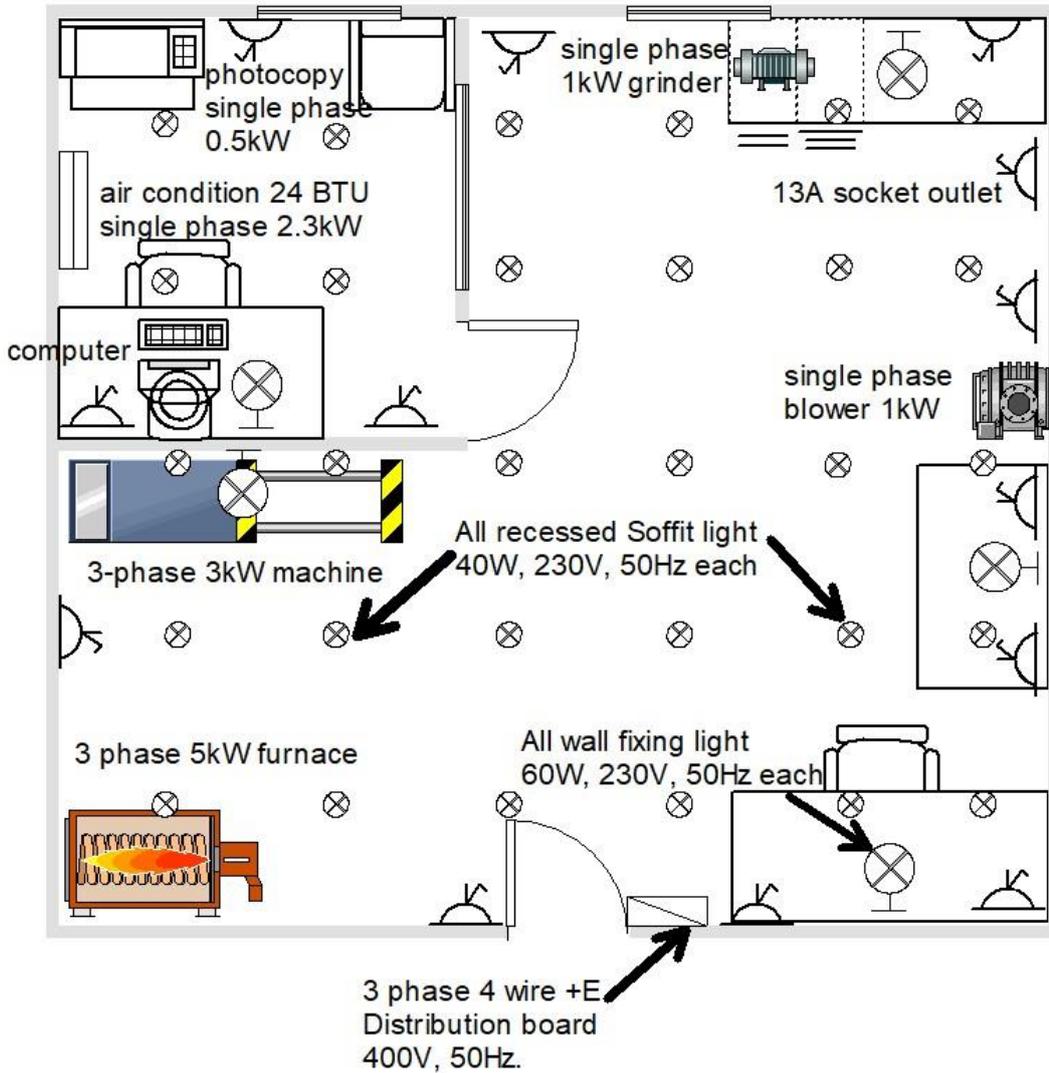
6.(a) List four I.E.T regulations (537) requirements when switching-off for mechanical maintenance. **(4 marks)**

(b) Describe how to carry-out the maintenance requirements for:

i) Hi-bay SON floodlights. **(4 marks)**

ii) Oil-immersed, air-cooled step-down double wound transformer. **(4 marks)**

iii) Motor direct-on-line starter used for a tower crane. **(4 marks)**

iv) A wound rotor induction motor used for speed control of a cement conveyor.

**(4 marks)**

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