

# MCL431: CAM and Automation

## Major Exam

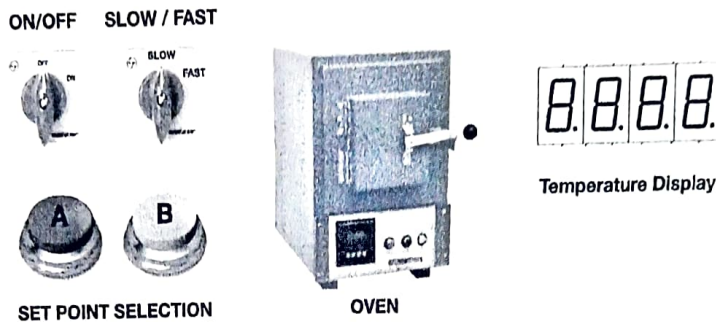
MAX MARKS: 70

MAX TIME: 120 min

**Instructions:**

- Only Hand written notes are allowed in the exam.
- No printed or Xeroxed material allowed except Lecture Slides, G&M Codes, Electrical Symbols.
- Make suitable assumptions wherever necessary and state them clearly.
- Late Submission will attract **-5 marks penalty**.

**Q1.** Write set-point control ladder logic for a PLC (16-bit) of a temperature controller. In this application, a PLC is used to provide power control of the electric heating elements of an oven. Electric Heating elements are controlled by proportional power control system which provides 10kW to heater at 10V. A control switch S1 is used to ON/Off the system and S2 to select SLOW/FAST Heating option. At SLOW Heating option Heater shall get 2kW power and for FAST Heating option it is 8kW. A temperature sensor measures 0-1023°F and produces 0-10V is connected to 10-bit Analog I/P on slot 2 of PLC. Proportional heater controller is connected to Analog Output Channel 2 on Slot 3 with DAC Resolution of 12-bit. A Temperature display reads N7:1 and display temperature value on 4-digit display updating every 5 seconds. The operation of the program can be summarised as follows:



Oven is to maintain an average set-point temperature of 600°F or 800°F selectable by push buttons A or B with a variation of about 1 % between the off and on cycles. The electric heaters are controlled by selectable SLOW and FAST Power control system which get turned on when the temperature of the oven is 597°F / 796°F or less and will stay on until the temperature rises to 603°F / 804°F or more respectively for two presets. The electric heaters stay off until the temperature drops to 597°F / 796°F, at which time the cycle repeats itself.

**[20 Marks]**

**Q2.** DC Stepper Motors with step angle 1.8° drive the X and Y-axis of a CNC milling machine worktable. The motors are coupled through Gear Box with ratio 3:1 in X-axis and 5:1 in Y-axis to the table leadscrew, whose pitch is 5 mm. An optical encoder with 720 slots is connected to the lead screw of each axis for feedback to motion controller. Current position of the tool is (X = 87.5, Y = 30.0). The repeatability of X and Y-axis is  $\pm 0.0025$  mm. Stepper drives are commanded by 16-bit PLC. To execute the following part program:

```

001122
N10 G90 G21 G80 G40 G49
N15 G01 X25.0 Y200.0 F200
N20 M30

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Determine,

- (i) Control resolution of the system for the X and Y-axis
- (ii) Rotational speed of the X and Y motor
- (iii) Frequency of pulse train emitted by the optical encoder of X and Y-axis.
- (iv) What is positioning accuracy of both axes?
- (v) Percentage error in positioning after execution of N15 block.

[15 Marks]

**Q3.** A hydraulic system shown in Fig. below is designed to lift a load of 8.5 Metric Ton at an average speed of 1600 mm/min using Hydraulic chain hoist driven by a Hydraulic motor having volumetric displacement of 120 cc. Volumetric & Mechanical efficiency of Motor is 95% and 89% respectively. Hoist pulley dia is 350 cm. A Vane pump having volumetric displacement of 170 cc is used to drive the system. Pump has Volumetric & Mechanical efficiency of 92% and 85% respectively. Hydraulic oil: Specific gravity 0.9, Kinematic viscosity 130 cS. Considering losses in hydraulic circuit, calculate the following:

- i) Pressure at Pump outlet [15 Marks]
- ii) Electric Motor RPM and HP [ 5 Marks]

Volumetric displacement is the volume of fluid displaced in one rotation of pump or Motor.  
 Pipe 1: L = 1m, D = 30 mm; Pipe 2: L = 3.85m, D = 25 mm; Pipe 3: L = 1.40m, D = 25 mm; Pipe 4:  
 L = 4.50 m, D = 30 mm;

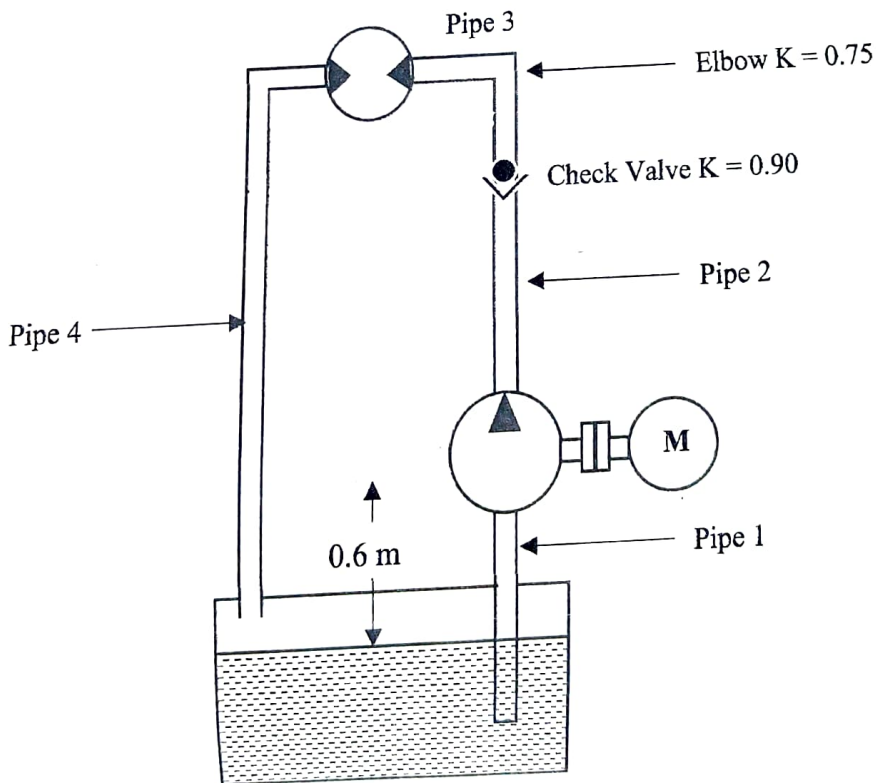


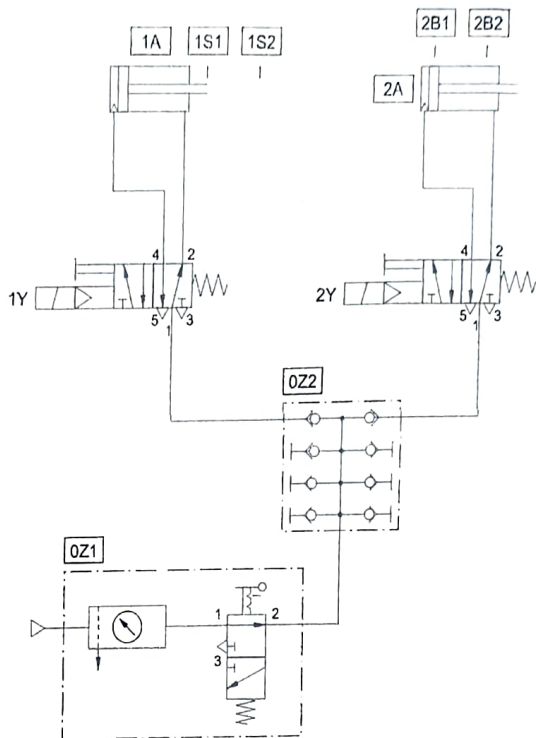
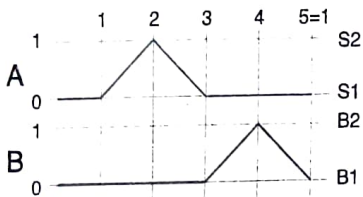
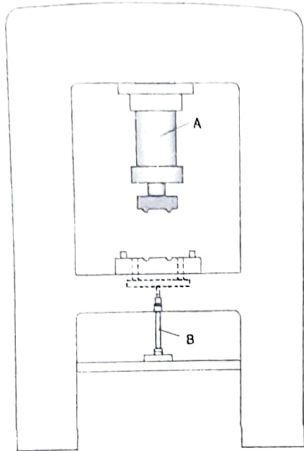
Fig. for Q3: Hydraulic System

**Q4. Draw Electrical Circuit Diagram** for the following problem:

A metal plate is inserted by hand into the forming press. A profile is to be stamped into the metal plate by means of a two-handed operation. When the operation is complete, the formed metal part is to be ejected by means of ejecting cylinder B.

The START signal is obtained through a two-hand safety control. When the EMERGENCY-STOP button is pressed, the two cylinders must return immediately to their initial positions.

Label all components, current paths and draw contact element tables for all relays.



[15 Marks]