**Instructions**: *This exam is closed book, except for an 8½"x11" sheet of handwritten notes.*
Show all of your work, make sure that your work is legible and that your logic can be followed, and place all final answers in the spaces provided. No credit will be given for illegible, illogical or unjustified work.

Problem #1) Specify whether each of the following statements are "**TRUE**" or "**FALSE**".

_____FALSE_____ Instead of resetting a drive fault by pressing the red "Stop" button on the VFD's control panel, the **logic instruction** (shown to the right) can be utilized to reset the VFD whenever it becomes faulted.

VFD:O.ResetFaults
—(L)—
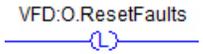
_____TRUE_____ Provided that the VFD has already been activated by latching and unlatching the required **START** and **STOP** bits, using a MOV instruction to write a value of **300** into the tag location **O.FreqCommand** within the VFD will cause the drive to output a set of 30Hz AC voltages.

_____TRUE_____ A typical thermal **Overload Relay** consists of a set of **heaters** that "detect" an overload and a **normally-closed contact** that opens to indicate the occurrence of an overload.

_____FALSE_____ The **logic instruction** GoTimer.TT —] [— will return a "**TRUE**" state whenever GoTimer is transitioning from either an enabled state to a disabled state or from a disabled state to an enabled state.

_____FALSE_____ A basic "stop-start" 3Φ motor controller with overload protection requires a 3Φ contactor that contains at least three **NO** (main) contacts and at least one **NC** auxiliary contact that will open whenever an overload occurs in order to shut-down the motor.

_____TRUE_____ The resistors utilized within a **series-resistance, reduced-voltage, motor starter** can theoretically be replaced by a set of appropriately-sized inductors and the starter will still limit the amount of current drawn by the motor at startup.

_____TRUE_____ The logical "**OR**" function can be duplicated within a ladder program by placing two logic instructions in parallel with each other on a rung. For example, as shown to the right: Latch Go if either **A or B** is **TRUE.**
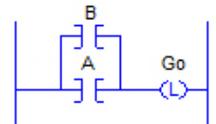
_____FALSE_____ Since a **Boolean-type Tag** is only associated with a single bit in memory, Boolean Tags can only be assigned to logic instructions that can only take on two states (**TRUE** or **FALSE**), such as an OTE, a TON, or a MOV instruction.

_____TRUE_____ The "**Stop**" instruction in the rung shown to the right is configured to work properly provided that a **NC** pushbutton is connected between +24V_DC and Input-1.
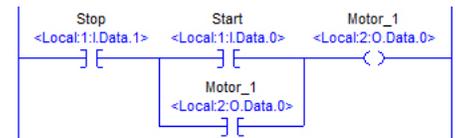
_____TRUE_____ In order for **BOOTP** to assign a pre-determined IP address to any control system device that requests an IP address, both the MAC (hardware) address of the control system device and the intended IP address must first be entered into BOOTP's Relation List.
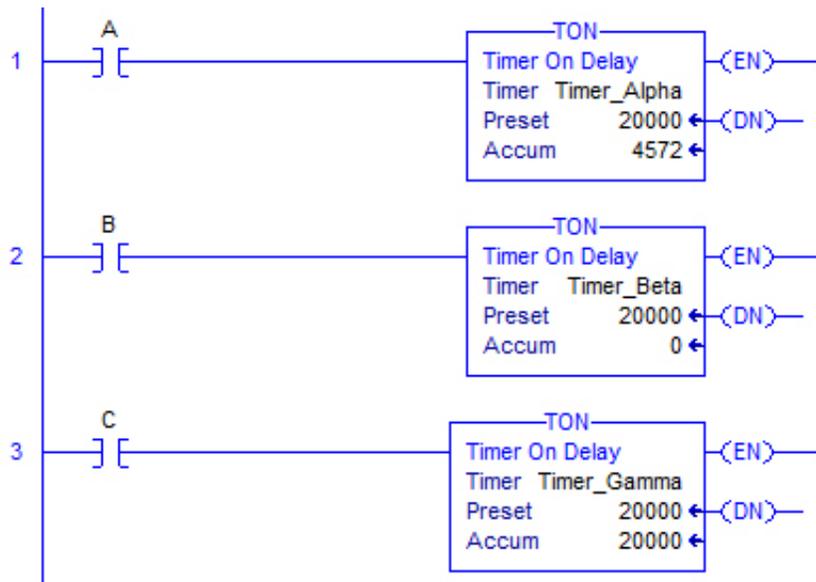
_____FALSE_____ With respect to PLCs, **relay-type** output modules are used to create the voltages required to energize relays, contactors, or other similar types of control-system devices.

PRINT either the word "True" or "False" in the blanks. Do NOT only write "T" or "F".

Problem #2) Match the symbols shown in the left-hand column with the items listed in the right-hand column.

__A__ (symbol: normally-open pushbutton)

__N__ (symbol: normally-closed pushbutton)

__G__ (symbol: ─┤/├─)

__E__ (symbol: ─( )─)

__L__ (symbol: contact curve)

__I__ (symbol: ─(M)─)

__C__ (symbol: ─✻─ lamp)

__K__ (symbol: ─┤├─)

A) Normally-Closed Pushbutton

B) Normally-Open Pushbutton

C) Indicator Lamp

D) OTE – "Output Execute" Instruction

E) OTE – "Output Energize" Instruction

F) OTP – "Output Port" Instruction

G) XIO – "Examine if Open" Instruction

H) XIC – "Examine if Closed" Instruction

I) Main Contactor's Field Coil

J) Normally-Closed Contact

K) Normally-Open Contact

L) Overload Relay's Heater (Thermal Element)

M) Overload Relay's Trip Contact

N) None of the above

Problem #3) The following rungs were screen-captured in real-time from a program that a PLC was executing:

Rung 1:
A ─┤├─ ── TON ─ Timer On Delay ─(EN)─
Timer Timer_Alpha
Preset 20000 ─(DN)─
Accum 4572

Rung 2:
B ─┤├─ ── TON ─ Timer On Delay ─(EN)─
Timer Timer_Beta
Preset 20000 ─(DN)─
Accum 0

Rung 3:
C ─┤├─ ── TON ─ Timer On Delay ─(EN)─
Timer Timer_Gamma
Preset 20000 ─(DN)─
Accum 20000

Assuming that, at the time the screen-shot was taken, the logic states of the XICs were:

A-XIC ≡ TRUE,   B-XIC ≡ FALSE,   C-XIC ≡ TRUE,

Specify the **values** (0 or 1) of the following **bits** at that same instant of time:

Timer_Alpha.EN = __1__   Timer_Alpha.TT = __1__   Timer_Alpha.DN = __0__

Timer_Beta.EN = __0__   Timer_Beta.TT = __0__   Timer_Beta.DN = __0__

Timer_Gamma.EN = __1__   Timer_Gamma.TT = __0__   Timer_Gamma.DN = __1__

Problem #4) The following rungs were screen-captured from a ladder-logic program that a PLC was executing:

A	B	C	D	M	X
1	0	0	1	1	
1	0	0	1	1	0
1	1	0	1	1	0
1	1	0	1	1	0
1	1	1	0	1	0
1	0	1	0	1	0
1	0	1	0	1	0
1	0	1	0	1	0
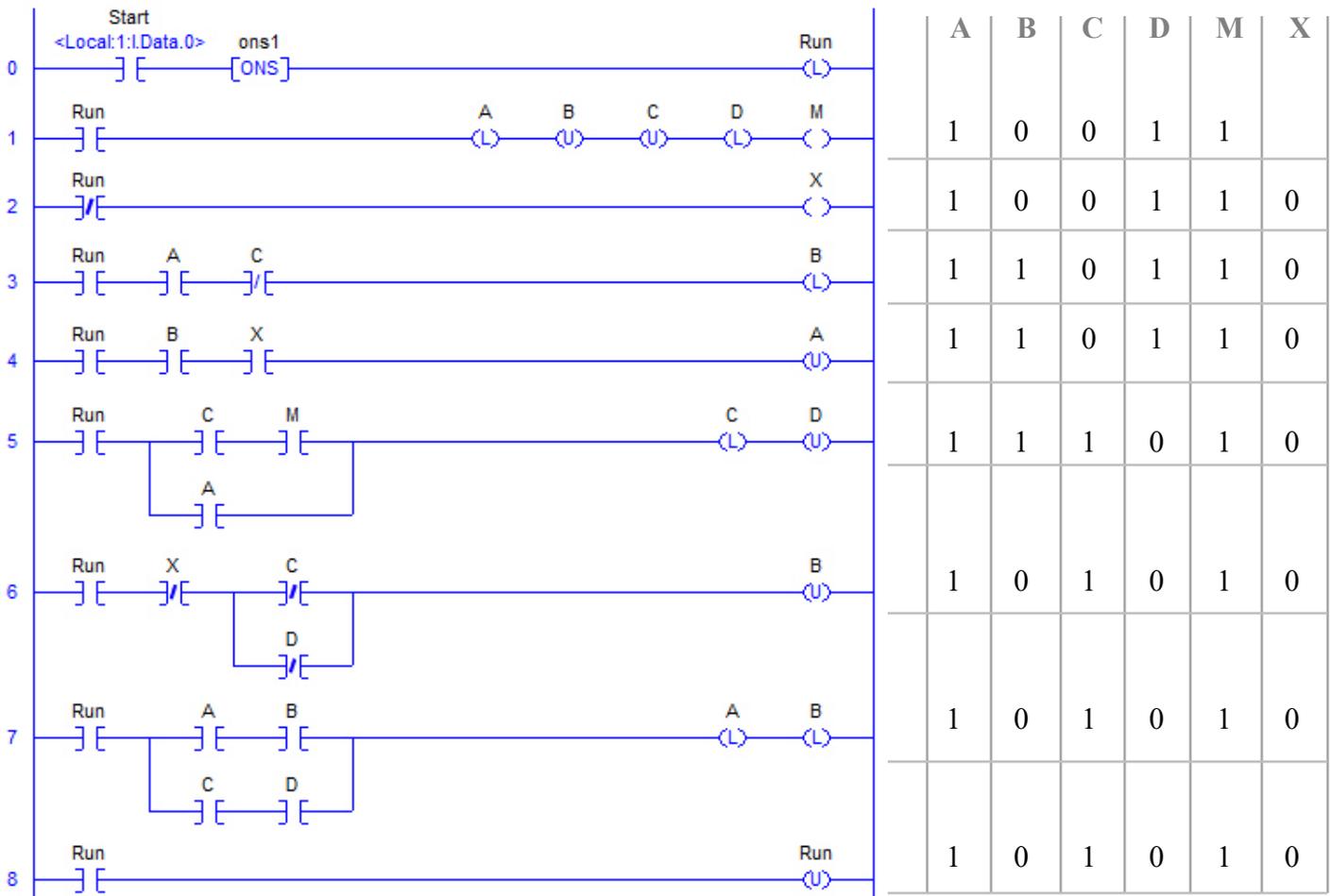
A normally-open (NO) "Start" pushbutton is wired to Input-0 of the PLC such that +24V$_{DC}$ is applied to the input when the button is pressed. If the "Start" button is pressed, causing both the **Start-XIC** and the overall rung-condition of Rung 0 to become TRUE, in-turn causing the **Run** bit to be latched (**Run = 1**), specify the **values** (0 or 1) of the following **bits** after Run is unlatched on Rung 8:

$$A = \underline{\textbf{1}} \qquad B = \underline{\textbf{0}} \qquad C = \underline{\textbf{1}} \qquad D = \underline{\textbf{0}}$$

Problem #5) Describe the exact operation of the following circuit when button PB-C is pressed-and-released:
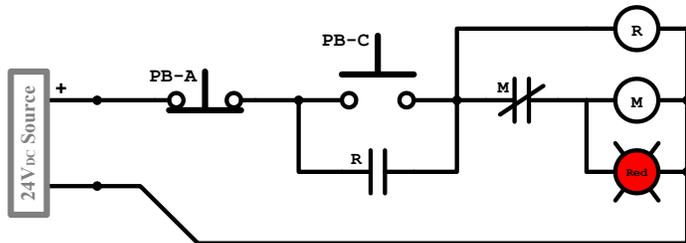
When Pb-C is pressed, the **red indicator is illuminated** and **coils R and M are energized**, causing the **contacts to actuate** (NO-R closes & NC-M opens).
The NO-R acts as a hold-in contact, allowing the operator to release Pb-C.
But, **when the NC-M contact opens**, the **red indicator turns off** and the **M coil is de-energized**, causing **NC-M contact to re-close**, in-turn **re-illuminating the indicator** and **re-energizing coil M**. This **process will keep repeating**, resulting the contactor M to "jackhammering" unless Pb-A is pressed.