UNIVERSITY OF JOHANNESBURG

PROGRAM	:	NATIONAL DIPLOMA *ENGINEERING: INDUSTRIAL*
SUBJECT	:	**AUTOMATION III**
CODE	:	**BAU 3111**
DATE	:	SUMMER SSA EXAMINATION 2015 10 DECEMBER 2015
DURATION	:	(SESSION 1) 08:00 - 11:00
WEIGHT	:	40: 60
TOTAL MARKS	:	100

ASSESSOR	:	MR. G. MUYENGWA
MODERATOR	:	DR. K. MPOFU
NUMBER OF PAGES	:	4

2320

INSTRUCTIONS : ONLY ONE POCKET CALCULATOR PER CANDIDATE MAY BE USED.

INSTRUCTIONS TO STUDENTS

PLEASE ANSWER ALL QUESTIONS.
UNDERLINE EACH AND EVERY ANSWER

QUESTION 1

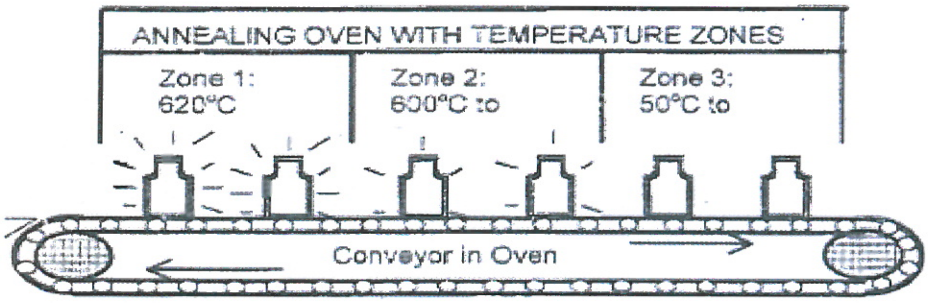


Figure Q1: Annealing of Glass

Figure Q1, shows annealing of glass bottles through three temperature zones. Discuss the activities and parameters associated with this operation.

(10 marks)

QUESTION 2

A manufacturing company in Durban specializes in machine-shop production and would like to determine the break-even point for two production methods, one a manual method and the other automated. The manual method requires two workers at R 15.00/hr each. Together, they produce at a rate of 40 units/hr. The automated method has an initial cost of R135 000.00, a 5-year service life, no salvage value, and annual maintenance costs = R 5000.00 No labor (except for maintenance) is required to operate the machine, but the power required to run the machine is 60 kW (when running). Cost of electric power is $0.075/kWh. If the production rate for the automated machine is 120 units/hr, determine the break-even point for the two methods, using a rate of return = 20%.

(15 marks)

QUESTION 3

Discuss the application of adaptive control in a machining operation. **(10 marks)**

QUESTION 4

A design Industrial Engineer would like to establish the operating characteristics of a DC servomotor from the following information. The motor will be directly coupled to a blower shaft for an industrial process. A voltage of 30 V is applied to a DC servomotor whose torque constant = 0.125 N-m/A and voltage constant = 0.0875 V/(rad/sec). Armature resistance = 2.05 ohms.

(a) What is the stall torque of the motor?, (2 marks)

(b) Determine the operating point of the motor if the torque-speed characteristic of the blower is given by the following equation: $T_L = K_{L1}\omega + K_{L2}\omega^2$, where T_L = load torque, N-m; ω = angular velocity, rad/sec; K_{L1} = 0.075 N-m/(rad/sec), and K_{L2} = 0.0005 N-m/(rad/sec)^2. (10 marks)

(c) What horsepower is being generated by the motor at the operating point? (3 marks)

[Total marks 15]

QUESTION 5

The two axes of an *x-y* positioning table are each driven by a stepping motor connected to a lead screw with a 8:1 gear reduction. The number of step angles on each stepping motor is 180. Each lead screw has a pitch = 6 mm and provides an axis range = 350 mm. There are 12 bits in each binary register used by the controller to store position data for the two axes.

Determine:

(a) the control resolution of each axis, (5 marks)

(b) the required rotational speeds and corresponding pulse train frequencies of each stepping motor in order to drive the table at 590 mm/min in a straight line from point (20,20) to point (250,140). Ignore acceleration and deceleration. (15 marks)

[Total Marks 20]

QUESTION 6

Stepping motors are used to drive the two axes of an insertion machine used for electronic assembly. A printed circuit board is mounted on the table which must be positioned accurately for reliable insertion of components into the board. Range of each axis = 700 mm. The lead screw used to drive each of the two axes has a pitch of 3.0 mm. The inherent mechanical errors in the table positioning can be characterized by a Normal distribution with standard deviation = 0.005 mm. If the required accuracy for the table is 0.04 mm;

Determine:

(a) the number of step angles that the stepping motor must have, and (5 marks)

(b) how many bits are required in the control memory for each axis to uniquely identify each control position? (5 marks)

[Total marks 10]

4/...

QUESTION 7

Two clips are to be riveted together on a semi-automatic press as shown in Figure Q7 below. Components and rivet are positioned by hand and then removed by hand on completion of the riveting operation. The automated part of the working cycle consists of the holding and clamping of the components (Cylinder A) and also riveting (Cylinder B), and the cycle should be performed ending at the starting position after operating a push button. Both speeds of clamping and riveting are controlled. The circuit is operated when sufficient pressure is available. Draw an appropriate circuit for this operation.

(20 marks)

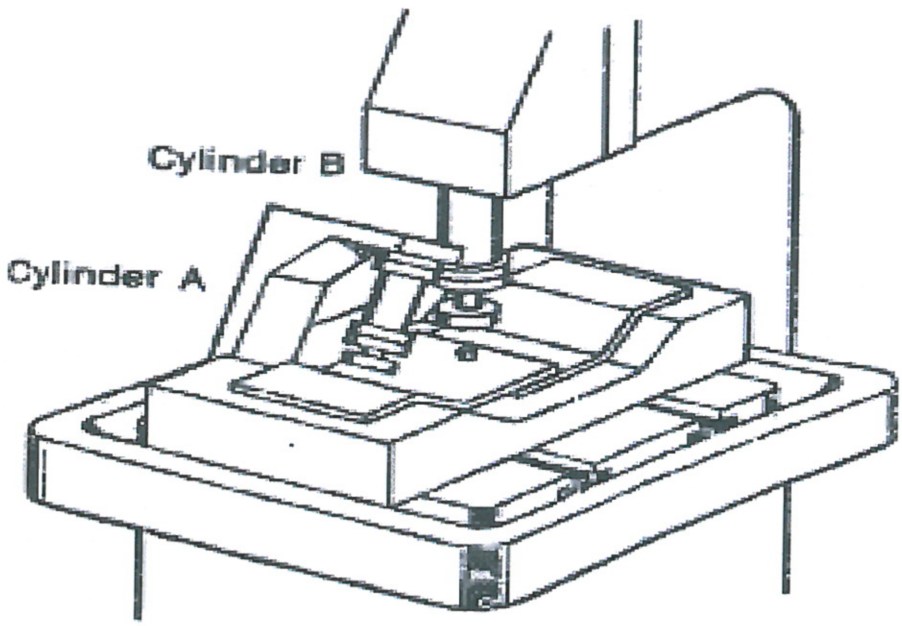


Figure Q7: Riveting of two clips

TOTAL = 100

BAU 3111 AUTOMATION

FORMULAE SHEET

$Q_f = \sum_{j=1}^{p} Q_j$; $n_{pf} = \sum_{j=1}^{p} Q_j n_{pj}$; $n_{of} = \sum_{j=1}^{p} Q_j n_{pj} \sum_{k=1}^{npj} n_{ojk}$; $Q_f = PQ$; $n_{pf} = PQn_p$;

$n_{of} = PQn_p n_o$; $T_c = T_o + T_h + T_{th}$; $T_b = T_{su} + QT_c$; $T_p = \frac{T_b}{Q}$; $R_p = \frac{60}{T_p}$; $T_b = T_{su} + QT_c$

$PC = \frac{n S_w H_{sh} R_p}{n_o}$; $U = \frac{Q}{PC}$; $A = \frac{MTBF - MTTR}{MTBF}$

$MLT = n_o\,(T_{su} + QT_c + T_{no})$; $MLT = n\,(T_r + Max\ T_o) = nT_c$

$WIP = \frac{AU(PC)(MLT)}{S_w H_{sh}}$; $FOHR = \frac{FOHC}{DLC}$; $COHR = \frac{COHC}{DLC}$; $UAC = IC\,(A/P,\ i,\ n)$

$(A/P, i, n) = \frac{i(1+i)^n}{(1+i)^n - 1}$; $C_o = C_L\,(1 + FOHR_L) + C_m\,(1 + FOHR_m)$

$S = C + ms$; $T = K_t I_a$; $E_b = K_v \omega$; $N = \frac{60\omega}{2\pi}$; $I_a = \frac{V_{in}}{R_a}$; $I_a = \frac{V_{in} - E_b}{R_a} = \frac{V_{in} - K_{v\omega}}{R_a}$

$T = K_t(\frac{V_{in} - K_{v\omega}}{R_a})$; $P = T\omega$; $HP = \frac{T\omega}{745.7}$; 745.7 W = 1 hp

$\alpha = \frac{360}{n_s}$; $A_m = n_p \alpha$; $\omega = \frac{2\pi fp}{n_s}$; $N = \frac{60\,fp}{n_s}$; $v = \frac{Q}{A}$; $F = pA$;

$\omega = KQ$; $N_q = 2^n$; $R_{ADC} = \frac{L}{N_q - 1} = \frac{L}{2^n - 1}$;

$E_o = E_{ref}\{0.5B_1 + 0.25B_2 + 0.125B_3 + \ldots + (2^n)^{-1} B_n\}$

$E(t) = E_o$; $E(t) = E_o + \alpha t$; $\alpha = \frac{E_o - E(-\tau)}{\tau}$

$$N = \frac{v}{\pi D}, \quad f_r = N n_t f, \quad \alpha = \frac{360}{n_s}, \quad A_m = n_p \alpha, \quad A = \frac{n_p \alpha}{r_g}, \quad A = \frac{A_m}{A} = \frac{N_m}{N}$$

$$x = \frac{pA}{360}, \quad n_p = \frac{360 x r_g}{p\alpha} = \frac{n_s x r_g}{p}, \quad N = \frac{60 f_p}{n_s r_g}, \quad v_t = f_r = N_p,$$

$$f = \frac{v_t n_s r_g}{60p} \text{ or } \frac{f_r n_s r_g}{60p}, \quad n_p = \frac{A}{\alpha}, \quad x = \frac{p n_p}{n_s}, \quad v = f_r = \frac{60 p f_p}{n_s}, \quad CR_1 = \frac{p}{n_s r_g}$$

$$CR_2 = \frac{L}{2^B - 1}, \quad CR = Max(CR_1, CR_2), \quad Accuracy = \frac{CR}{2} + 3\sigma, \quad Repeatability = \pm 3\sigma$$

Common G-words (Preparatory Word)

G-word	*Function*
G00	Point-to-point movement (rapid traverse) between previous point and endpoint defined in current block. Block must include *x-y-z* coordinates of end position.
G01	Linear interpolation movement. Block must include *x-y-z* coordinates of end position. Feed rate must also be specified.
G02	Circular interpolation, clockwise. Block must include either arc radius or arc center; coordinates of end position must also be specified.
G03	Circular interpolation, counterclockwise. Block must include either arc radius or arc center; coordinates of end position must also be specified.
G04	Dwell for a specified time.
G10	Input of cutter offset data, followed by a P-code and an R-code.
G17	Selection of *x-y* plane in milling.
G18	Selection of *x-z* plane in milling.
G19	Selection of *y-z* plane in milling.
G20	Input values specified in inches.
G21	Input values specified in millimeters.
G28	Return to reference point.
G32	Thread cutting in turning.
G40	Cancel offset compensation for cutter radius (nose radius in turning).
G41	Cutter offset compensation, left of part surface. Cutter radius (nose radius in turning) must be specified in block.
G42	Cutter offset compensation, right of part surface. Cutter radius (nose radius in turning) must be specified in block.
G50	Specify location of coordinate axis system origin relative to starting location of cutting tool. Used in some lathes. Milling and drilling machines use G92.
G90	Programming in absolute coordinates.
G91	Programming in incremental coordinates.
G92	Specify location of coordinate axis system origin relative to starting location of cutting tool. Used in milling and drilling machines and some lathes. Other lathes use G50.
G94	Specify feed per minute in milling and drilling.
G95	Specify feed per revolution in milling and drilling.
G98	Specify feed per minute in turning.
G99	Specify feed per revolution in turning.

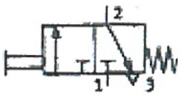
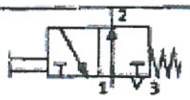
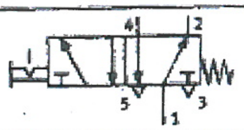
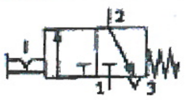
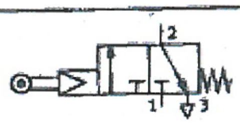
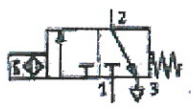
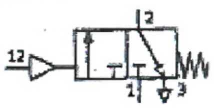
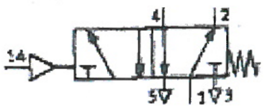
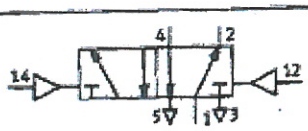
Note: Some G-words apply to milling and/or drilling only, whereas others apply to turning only.

Common M-words Used in Word Address Format

M-Word	Function
M00	Program stop; used in middle of program. Operator must restart machine.
M01	Optional program stop; active only when optional stop button on control panel has been depressed.
M02	End of program. Machine stop.
M03	Start spindle in clockwise direction for milling machine (forward for turning machine).
M04	Start spindle in counterclockwise direction for milling machine (reverse for turning machine).
M05	Spindle stop.
M06	Execute tool change, either manually or automatically. If manually, operator must restart machine. Does not include selection of tool, which is done by T-word if automatic, by operator if manual.
M07	Turn cutting fluid on flood.
M08	Turn cutting fluid on mist.
M09	Turn cutting fluid off.
M10	Automatic clamping of fixture, machine slides, etc.
M11	Automatic unclamping.
M13	Start spindle in clockwise direction for milling machine (forward for turning machine) and turn on cutting fluid.
M14	Start spindle in counterclockwise direction for milling machine (reverse for turning machine) and turn on cutting fluid.
M17	Spindle and cutting fluid off.
M19	Turn spindle off at oriented position.
M30	End of program. Machine stop. Rewind tape (on tape-controlled machines).

Common Word Prefixes Used in Word Address Format

Word Prefix	Example	Function
N	N01	Sequence number; identifies block of instruction. One to four digits can be used.
G	G21	Preparatory word; prepares controller for instructions given in the block. See Table A7.2. There may be more than one G-word in a block. (Example specifies that numerical values are in millimeters.)
X, Y, Z	X75.0	Coordinate data for three linear axes. Can be specified in either inches or millimeters. (Example defines *x*-axis value as 75 mm.)
U, W	U25.0	Coordinate data for incremental moves in turning in the *x*- and *z*-directions, respectively. (Example specifies an incremental move of 25 mm in the *x*-direction.)
A, B, C	A90.0	Coordinate data for three rotational axes. A is the rotational axis about *x*-axis; B rotates about *y*-axis; and C rotates about *z*-axis. Specified in degrees of rotation. (Example defines 90° of rotation about *x*-axis.)
R	R100.0	Radius of arc; used in circular interpolation. (Example defines radius = 100 mm for circular interpolation.) The R-code can also be used to enter cutter radius data for defining the tool path offset distance from the part edge.
I, J, K	I32 J67	Coordinate values of arc center, corresponding to *x*-, *y*-, and *z*-axes, respectively; used in circular interpolation. (Example defines center of arc for circular interpolation to be at x = 32 mm and y = 67 mm.)
F	G94 F40	Feed rate per minute or per revolution in either inches or millimeters, as specified by G-words in Table A7.2. (Example specifies feed rate = 40 mm/min in milling or drilling operation.)
S	S0800	Spindle rotation speed in revolutions per minute, expressed in four digits. For some machines, spindle rotation speed is expressed as a percentage of maximum speed available on machine, expressed in two digits.
T	T14	Tool selection, used for machine tools with automatic tool changers or tool turrets. (Example specifies that the cutting tool to be used in the present instruction block is in position 14 in the tool drum.)
D	D05	Tool diameter word used in contouring moves for offsetting the tool from the workpart by a distance stored in the indicated register; usually the distance is the cutter radius. (Example indicates that the radius offset distance is stored in offset register number 05 in the controller.)
P	P05 R15.0	Used to store cutter radius data in offset register number 05. (Example indicates that a cutter radius value of 15.0 mm is to be stored in offset register 05.)
M	M03	Miscellaneous command. See Table A7.3. (Example commands the machine to start spindle rotation in clockwise direction.)

	Symbol
	
	
	
	
	
	
	
	
	
oth	

Symbol