UNIVERSITY OF JOHANNESBURG

PROGRAM	:	NATIONAL DIPLOMA *ENGINEERING: INDUSTRIAL*
SUBJECT	:	**AUTOMATION III**
CODE	:	**BAU 3111**
DATE	:	NOVEMBER EXAMINATION 2016 19 NOVEMBER 2016
DURATION	:	SESSION 1: (8:30-11:30)
WEIGHT	:	40: 60
TOTAL MARKS	:	100

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NUMBER OF PAGES	:	5 PAGES	

INSTRUCTIONS:: ONLY ONE POCKET CALCULATOR PER CANDIDATE MAY BE USED.
UNDERLINE EACH AND EVERY CALCULATION ANSWER
PLEASE ANSWER ALL QUESTIONS.

QUESTION 1

In manufacturing engineering, a plant layout is a design for the floor plan which aims to improve efficiency by arranging equipment according to its function. The production activities are ideally designed to eliminate waste in material flows, inventory handling and management. A good plant layout provides better visual control of activities, utilises space and labour efficiently, eliminates bottlenecks and facilitates communication and interaction between workers and supervisors.

With the aid of appropriate sketches, discuss the following plant layouts in terms of (i) quantity of products made, (ii) types of products made and (iii) type of equipment used:

a) Fixed position; (4 marks)
b) Process layout; (4 marks)
c) Cellular layout; (4 marks)
d) Product layout and (4 marks)
e) Sketch a well labelled graph that shows the relationship between plant layout and type of production facility. (4 marks)

[Total Marks 20]

QUESTION 2

Discuss the five levels of automation that can be found in a manufacturing plant. **(5 marks)**

QUESTION 3

Quality Auto is an engine manufacturing company based in Isando-Gauteng. This company produces two types of engines which are assembled out of several components as shown in the figure Q3 below. These two engines are known as Engine P1 for petrol cars and Engine D1 for diesel cars. Annual production of Engine P1 is 4600 units and of Engine D1 is 3500 units. Engine P1 is made up of 68 components. 45 % of these components are made in the plant while 55 % are purchased parts. Engine D1 is made up of 54 components. 40 % of the components are made in the plant, while 60 % are purchased.

For these two types of engines taken together, what is the total number of:

a) Components made in the plant and (5 marks)
b) Components purchased. (5 marks)

[Total Marks 10]

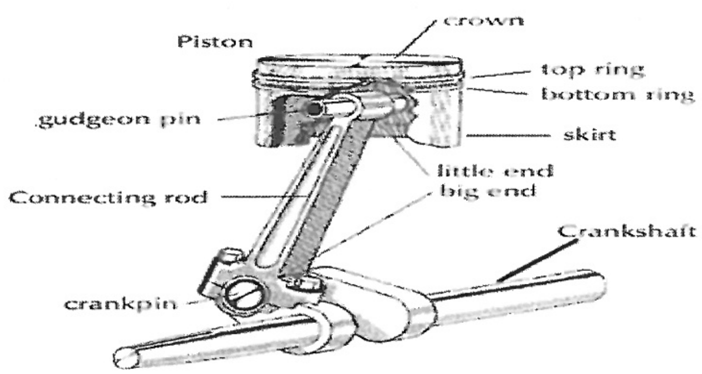

Figure Q3

QUESTION 4

Pump Masters is a Johannesburg based company that specialises in the manufacturing of pump parts. This company produces pump parts in batches and it uses semi-automated production machines as shown in figure Q4 below. An Industrial Engineer was tasked to assess the efficiency of this workshop and he recorded the following information. The company's Planning Officer issued job cards with a batch size of 300 units. The Industrial Engineer observed that setup time was 75 minutes. For each cycle the worker took 2 minutes to load and unload the machine. The machine processing time was 4.5 minutes / cycle and tool handling time was negligible. One part was produced each cycle.

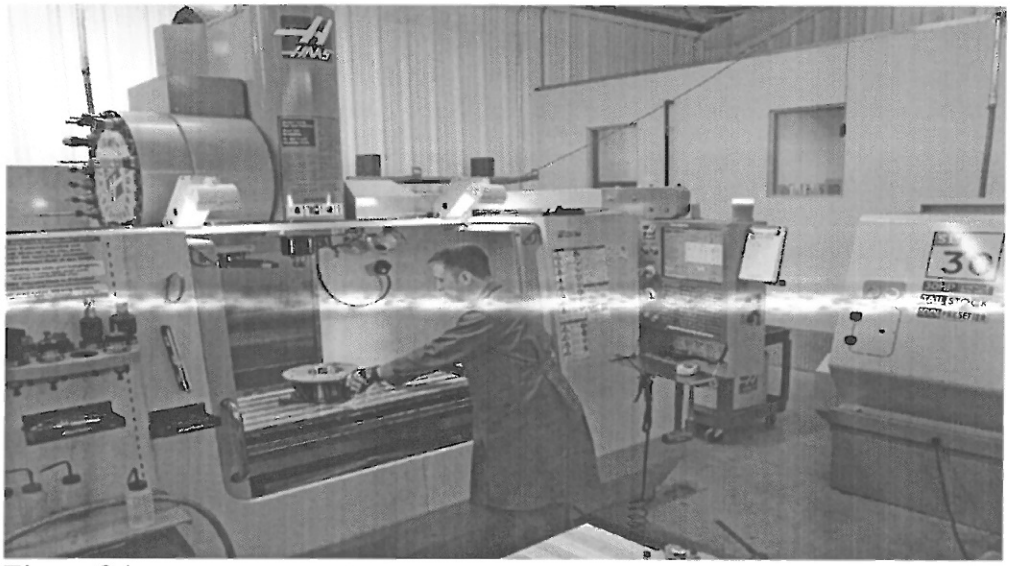

Figure Q4

Determine:

a) Average cycle time; (3 marks)
b) Batch time and (3 marks)
c) Average production rate. (4 marks)

[Total Marks 10]

QUESTION 5

The table below presents production data for four batches of parts processed through a Pump Masters machine shop. The production rates (R_p) are given in parts per hour. Utilisations fractions (f) are the fractions of time during the 40-hour week that the machine is devoted to the production of these parts. The parts do not proceed through the machines in the same order.

Table Q5

	Machine 1		Machine 2		Machine 3	
Part	R_{p1}	f_1	R_{p2}	f_2	R_{p3}	f_3
A	20	0.4	25	0.2	27	0.25
B	14	0.3	15.5	0.3	15	0.45
C	25	0.3	12	0.2		
D			20	0.25	10	0.3

QUESTION 5

Determine:

a) Weekly production rate; (5 marks)

b) Workload and (4 marks)

c) Average utilisation of this set of equipment. (3 marks)

[Total Marks 12]

QUESTION 6

DC Automation company has designed a stepper motor with a step angle = 1.8^0. The motor shaft is designed to rotate through 30 complete revolutions at an angular velocity of 10 rad/sec.

Determine:

a) The required number of pulses; (2 marks)

b) The pulse frequency to achieve the specified rotation and (3 marks)

c) How much time is required to complete the 30 revolutions? (3 marks)

[Total Marks 8]

QUESTION 7

The outline of the part in Figure 7.1, is to be profile milled using a 25 mm diameter end mill with two teeth. The part is 20 mm thick. Spindle speed is 1600 rev/ min and feed is 0.75 mm per tooth. Use the lower left corner X0 Y0, as the origin in the x-y axis system. Milling is to be done from point A to point B in an anti-clockwise direction. The three holes in the part have already been drilled and will be used for clamping the part during milling. Use D05 as your cutter offset register code.

Write the part program in the word address format (G-Code programming). Use absolute positioning. **(13 marks)**

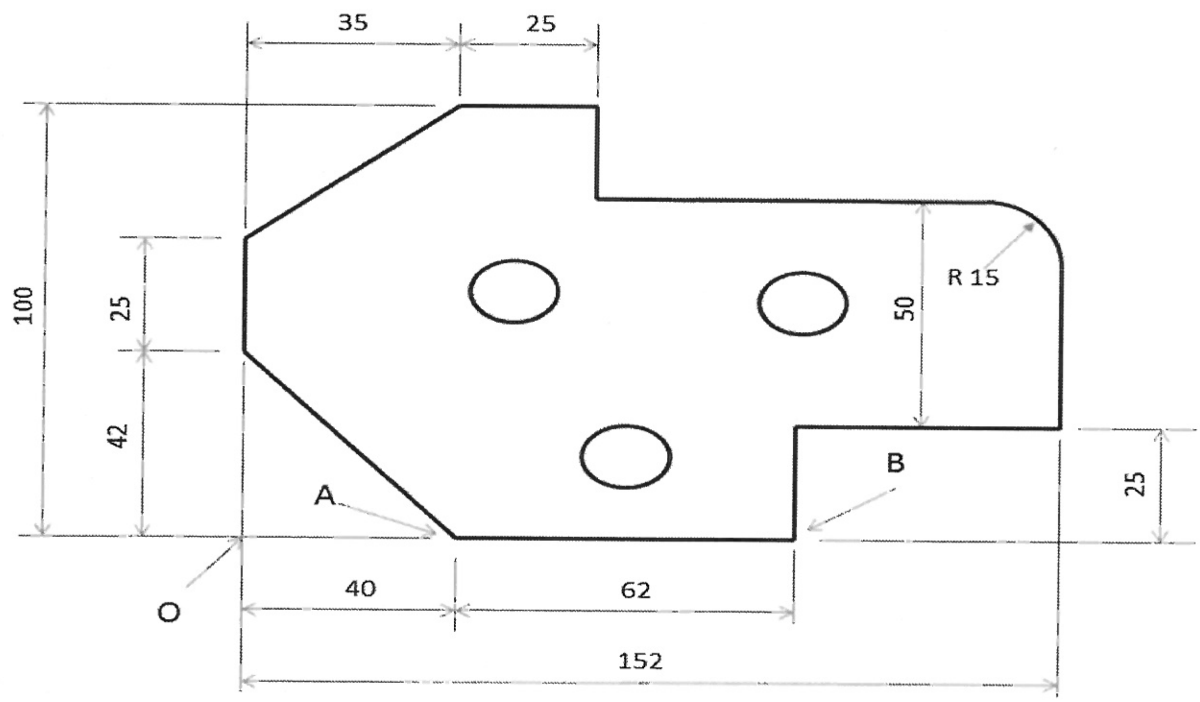

Figure 7.1 Diagram Not to Scale All Dimensions are in mm

QUESTION 8

Electricians working for Johannesburg City Power are designing a street lighting circuit. The lights (load Y) can be switched on from two different positions, which is either using switch X_1 or X_2.

a) Construct the Boolean Algebra for the lighting circuit; (2 marks)
b) Construct the ladder logic diagram for the lighting circuit; (2 marks)
c) Construct the logic network diagram for the lighting circuit; and (2 marks)
d) Write the low level language statements for the Boolean Algebra in (a) above. (2 marks)

An experienced Electrical Engineer has ordered the Electricians to make use of a photodetector that will determine whether the lights are working or not. If the lights fail to be on when either X_1 or X_2 is switched on, the photodetector causes a buzzer to sound.

e) Considering the buzzer, construct a new ladder logic diagram for the system and (4 marks)
f) Considering the buzzer, construct the truth table for this system. (4 marks)

[Total Marks 16]

QUESTION 9

DGG CONTROLS is an electronic company that designs and maintains analog-to-digital converters (ADC) that are used in processing industries. For a particular converter the maximum voltage range has been measured to be ± 32 V. The ADC has a 10-bit capacity.

Determine:

a) Number of quantization levels; (2 marks)
b) Resolution and (2 marks)
c) The quantization error for this ADC. (2 marks)

[Total Marks 6]

TOTAL = 100

FORMULAE SHEET

Production Relationship

$Q_f = \sum_{j=1}^{P} Q_j$ $\quad Q_f = PQ$

$P = \sum_{j=1}^{P} P_{2j}$

$n_{pf} = \sum_{j=1}^{P} Q_j n_{pj}$ $\quad n_{pf} = PQn_p$

$n_{of} = \sum_{j=1}^{P} Q_j n_{pj} \sum_{j=1}^{n_{Pj}} Q_j n_{ojk}$

$n_{of} = PQn_p n_o$

$S = C + ms \quad T = K_t I_a \quad E_b = K_v + \omega$

Automation and Process Control

$N = \frac{60\omega}{2\pi}$ $\quad I_a = \frac{V_{in}}{R} = \frac{V_{in} - E_b}{R_a}$

$T = K_t\left(\frac{V_{in} - K_v\omega}{R_a}\right)$ $\quad T_L = K_L\omega$

$HP = \frac{T\omega}{745{,}7}$ $\quad P = T\omega$

$745{,}7 = 1hp$ $\quad \alpha = \frac{360}{n_s}$

$A_m = n_p\alpha$ $\quad \omega = \frac{2\pi fp}{n_s}$

$N = \frac{60fp}{n_s}$ $\quad v = \frac{Q}{A}$

$F = pA \quad \omega = KQ \quad N_q = 2^n$

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

$\text{Quantization error} = \pm\frac{1}{2} R_{ADC}$

$E_o = E_{ref}\{0{,}5B_1 + 0{,}25B_2 + 0{,}125B_3 + \ldots + (2^n)^{-1}B_n\}$

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

Production Performance Metrics

$T_c = T_o + T_h + T_t$ $\quad T_c = \text{Max } T_o + T_r$

$T_b = T_{su} + QT_C$ $\quad A = \frac{MTBF - MTTI}{MTBF}$

$T_p = \frac{T_b}{Q}$ $\quad PC = \frac{nHpwRp}{n_o}$

$R_p = \frac{60}{T_p} = \frac{1}{T_p}$ $\quad PC = Hpc\sum_{i=1}^{n} R_{pi}$

$R_c = \frac{60}{Tc} = \frac{1}{Tc}$ $\quad R_{pph} = \frac{\sum_{j=1}^{n}\sum_j f_{ij}R_{pij}}{n_{oj}}$

$R_{ppw} = H_{pw}R_{pph}$ $\quad U_i = \sum_j f_{ij}$ $\quad U = \frac{\sum_j Ui}{n}$

$WL = \sum_i \sum_j Q_{ij}T_{pij}$ $\quad MLT = n_o(T_{su} + Q_{Tc} + T_{no})$

$MLT = n_o(\max T_o + T_r) + T_{no}$ $\quad TC = C_f + C_vQ$

$WIP = R_{pph}(MLT)$ $\quad UAC = IC(A/P,i,N))$

$FOHR = \frac{FOHC}{DLC}$ $\quad COHR = \frac{COHC}{DLC}$

$C_o = C_L(1 + FOHR_L) + C_m(1 + FOHR_m)$

$C_{pc} = C_m + \sum_{j=1}^{P}(CoiTp_i + Cti)$

$(A/,P,i,N) = \frac{i(1+i)^n}{(1+i)^n - 1}$

Open Loop System

$$N=\frac{v}{\pi D} \qquad f_r = Nn_t f \qquad \alpha=\frac{360}{n_s} \qquad A_m = n_p\alpha \qquad A_s=\frac{n_p\alpha}{r_g}=\frac{A_m}{r_g} \qquad r_g=\frac{A_m}{A_s}=\frac{N_m}{N_s}$$

$$x=\frac{pA_s}{360} \qquad n_p=\frac{360xrg}{p\alpha}=\frac{n_s x r_a}{p} \qquad N_s=\frac{60fp}{n_s r_g} \qquad v_t = fr = N_s p$$

$$f_p=\frac{vt n_s r_a}{60p}=\frac{fr n_s r_a}{60p}=\frac{N_m n_s}{60}=\frac{N_s n_s r_a}{60}$$

Closed Loop System $\alpha=\frac{360}{n_s}$ $\qquad n_p=\frac{A_s}{\alpha}=\frac{A_s n_s}{360}$ $\qquad \Delta X=\frac{pnp}{n_s}=\frac{pAs}{n_s\alpha}=\frac{pAs}{360}$

$$v_t = fr = N_s p = \frac{N_m p}{r_g} \qquad f_p=\frac{vtns}{60p}=\frac{fr n_s}{60p} \qquad CR_1=\frac{p}{n_s r_g} \qquad CR_2=\frac{L}{2^B-1}$$

$$CR = Max(CR_1, CR_2) \qquad Accuracy=\frac{CR}{2}+3\sigma \qquad Repeatability = \pm 3\sigma$$

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 the 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 cutters radius (nose radius in turning).
G41	Cutter offset compensation, left of part surface. Cutter radius (nose radius in turning) must be pecified in block
G42	Cutter offset compensation, right of part surface. Cutter radius (nose radius in turning) must be pecified 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 rate per minute in milling and drilling.
G95	Specify feed rate per revolution in milling and drilling.
G98	Specify feed rate per minute in turning.
G99	Specify feed rate per revolution in turning.

Common M-words Used in Word Address Format	
M-word	**Function**
M00	Program stop; used in the middle of program. Operator must restart machine.
M01	Optional program stop; active only when optional stop button on control panel has been
M02	End of program. Machine stop.
M03	Start spindle in clockwise direction for milling machine (reverse 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 the 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 (reverse 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 degits 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
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 90^0 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 the table A7.2. (Example specifies feed rate = 40mm/min in milling or drilling operation).