higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T410(E)(N19)T
NOVEMBER EXAMINATION

NATIONAL CERTIFICATE

DIGITAL ELECTRONICS N6

(8080376)

19 November 2014 (Y-Paper)
13:00–16:00

This question paper consists of 8 pages and 1 diagram sheet.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA
NATIONAL CERTIFICATE
DIGITAL ELECTRONICS N6
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.

2. Read ALL the questions carefully.

3. Number the answers according to the numbering system used in this question paper.

4. Write neatly and legibly.

NOTICE TO CANDIDATES

The lives and safety of people depend on Digital electronics. Digital electronics prevents lift doors from crushing people to death. Digital electronics signalling systems prevent trains from colliding. Digital electronics keeps people safe in aircraft and in hospital intensive-care units. Your work, your programming and designs, must be properly planned and presented in this diploma-level examination. Standards must be maintained for the safety of the public.

QUESTION 1

1.1   Refer to the DIAGRAM on the DIAGRAM SHEET (attached). Take the first design step in order to replace the human operator with an automatic, closed-loop, sense-and-control system.

        Draw a large neat fully-labelled block diagram showing the basic functions in that new closed-loop control system. Replace the human operator with function and process blocks which will duplicate the functions and processes performed by the human operator.

        You need not show the following:

        • Square-root extraction
        • Interfacing of high-power and low-power subsystems
        • Analogue-to-digital conversion (ADC)
        • Digital-to analogue conversion (DAC)

        Include, in your block diagram, ALL functions and processes performed by the human operator in the DIAGRAM.   (10)

Harvard Architecture is characterised by a memory (usually EPROM) which contains only the program and is distinct from the RAM. (The RAM in Harvard Architecture holds only the operands.) The questions that follow are based on the more familiar Von Neumann Architecture where a common RAM holds ALL data and program instructions. This necessitates a FETCH routine and an EXECUTE routine to obtain instructions and operands from the common RAM.

1.2   Draw a fully-labelled block diagram of a control unit integrated with a RAM (Random Access Memory). ALL the gates and the interconnections between the micro-instruction unit, program counter, RAM, instruction unit, decoder and arithmetic unit must be shown.   (10)
                                                                                      [20]

QUESTION 2

2.1 Write in the ANSWER BOOK the text (including spaces and line feeds) which is printed as a result of the following BASIC program. The numeric ASCII values are stored to construct English words. These cannot be changed or translated. Your answer MUST reflect the ASCII values which the program selects for printout.

```
10   REM   Dollar sign addresses ("variables") store ASCII characters. A
20   REM   string of ASCII characters can be described as "TEXT".
30   REM   Carefully analyse the conditional GOTO statements in this
40   REM   program. Then write in your answer book the text printed as a
50   REM   result of this program.
60   LET TEXTY01$ = "NEAT PRESENTATION"
70   LET TEXTY02$ = "COUNTS"
80   LET TEXTY03$ = "WHEN YOU WRITE"
90   LET TEXTY04$ = "NATIONAL DIPLOMA EXAMS"
100  LET TEXTY05$ = "MESSY UNPROFESSIONAL WORK"
110  LET TEXTY06$ = "SHOWS"
120  LET TEXTY07$ = "A"
130  LET TEXTY08$ = "DON'T CARE ATTITUDE"
140  LET TEXTY09$ = "ENGINEERS AND TECHNICIANS"
150  LET TEXTY10$ = "MUST"
160  LET TEXTY11$ = "CARE"
170  LET TEXTY12$ = "ABOUT"
180  LET TEXTY13$ = "THEIR WORK"
190  LET TEXTY14$ = "THE LIVES AND SAFETY OF PEOPLE"
200  LET TEXTY15$ = "IN"
210  LET TEXTY16$ = "CARS LIFTS JETS"
220  LET TEXTY17$ = "AND IN"
230  LET TEXTY18$ = "HOSPITAL"
240  LET TEXTY19$ ="AND IN"
250  LET TEXTY20$ = "THE WORKPLACE"
260  LET TEXTY21$ = "ARE"
270  LET TEXTY22$ = "IMPORTANT"
280  LET TEXTY23$ = "LIVES DEPEND ON"
285  LET TEXTY24$ = "THE WORK"
290  LET TEXTY25$ = "OF"
300  LET TEXTY26$ = "TECHNICIANS AND ENGINEERS"
320  LET TEXTY28$ = "WHEN"
330  LET TEXTY29$ = "THEY ARE PLANNING"
340  LET TEXTY30$ = "AND"
350  LET TEXTY31$ = "IMPLEMENTING"
360  LET TEXTY32$ = "HARDWARE AND SOFTWARE"
370  LET TEXTY33$ = "SOLUTIONS"
380  LET TEXTY34$ = "TO MAKE"
390  LET TEXTY35$ = "TRAFFIC LIGHTS"
400  LET TEXTY36$ = "LIFTS"
410  LET TEXTY37$ ="JETS"
420  LET TEXTY38$ = "AND"
430  LET TEXTY39$ = "INTENSIVE CARE UNITS"
```

Please turn over

```
440  LET TEXTY40$ = "WORK PROPERLY"
441  LET TEXTY41$ = " "
442  LET TEXTY42$ = "DEPEND ON"
443  LET TEXTY43$ = "THE NECESSITY TO PLAN AND PRESENT"
444  LET TEXTY44$ = "PROFESSIONAL WORK
445  LET TEXTY45$ = "IN DIPLOMA LEVEL EXAMINATIONS"
450  REM    Note carefully what ASCII has been entered into which
460  REM    SEQUENCER$ variables.  This will decide which of the
470  REM    conditional GOTO's are activated and what text is printed.
480  LET SEQUENCER11$ = "FIRST "
490  LET SEQUENCER11$ = "SECOND "
500  LET SEQUENCER11$ = "FIRST"
510  LET SEQUENCER22$ = "FIRST "
520  LET SEQUENCER22$ = "SECOND"
530  LET SEQUENCER25$ = "THIRD "
540  REM      Now here below are the conditional GOTO's.  They link up to
550  REM      the PRINT statements to select what text is printed and in
560  REM      what order that text is
561  REM      printed.
562  PRINT "BELOW IS THE FINAL PRINT-OUT FOR TODAY'S"
563  PRINT  "PROGRAM:"
564  CLS
565  PRINT    "ALL THE BEST FOR YOUR  EXAMINATIONS!"
570  IF SEQUENCER11$ = "FIRSTLY" THEN GOTO 670
580  IF SEQUENCER11$ = "SECONDLY" THEN GOTO 690
590  IF SEQUENCER11$ = "THIRDLY" THEN GOTO 710
600  IF SEQUENCER22$ = "FIRSTLY" THEN GOTO 730
610  IF SEQUENCER22$ = "SECOND" THEN GOTO 750
620  IF SEQUENCER22$ = "THIRD" THEN GOTO 770
630  REM      Here finally you find the PRINT statements.  These (if and
640  REM      when they are activated by the program above) will do the
650  REM      donkey work of printing out the text which is stored
660  REM      (in ASCII format) in the numbered TEXTY$ variables.
670  PRINT TEXTY01$, TEXTY 41$, TEXTY02$
680  GOTO 800
690  PRINT TEXTY04$, TEXTY 41$, TEXTY21$, TEXTY41$, TEXTY22$
700  GOTO 800
710  PRINT TEXTY23$, TEXTY 41$, TEXTY26$
720  GOTO 800
730  PRINT TEXTY35$, TEXTY 41$, TEXTY10$, TEXTY41$, TEXTY40$
740  GOTO 800
750  PRINT TEXTY42$, TEXTY 41$, TEXTY44$
760  GOTO 800
770  PRINT TEXTY29$, TEXTY 41$, TEXTY32$
780  GOTO 800
790  PRINT TEXTY33$, TEXTY 41$, TEXTY40$
800  END
```

(10)

2.2 Reactors (like the SYNTHOL reactors at SASOL Secunda) can be dangerous because reactions generate their own energy. This means that even if all inputs to a reactor are reduced to zero, the reaction can continue and perhaps cause an explosion. For this reason, the control of the temperature of a reactor is very important.

The temperature of a reaction in a reactor must be kept within the limits 1 150° to 1 200 °C. The temperature is measured by two thermocouples. The temperature of the reaction is controlled by varying the flow of chemicals through two valves. For reasons of safety the reactor is some distance from the control room and signals in both directions should be multiplexed.

Draw a fully-labelled block diagram of a digital process control system which will do the required tasks. Functions which are programmable on a micro-controller must be shown as blocks on the block diagram.

ALL the interfacing and peripheral equipment must be shown.

You must show ALL signal directions. (10)
[20]

QUESTION 3

ASCII (American Standard Code for Information Interchange) and PCM (Pulse Code Modulation) can both be used to transmit alphanumeric data. Interfacing and Code Conversion is necessary because PCM is used for long distance communication (for instance via satellite).

3.1 The following ASCII values must be transmitted using NRZ (Non-return to Zero) PCM (Pulse Code Modulation). Use THREE bits per packet and draw an NRZ-PCM graph to show how the values are represented in unipolar-binary PCM format.

NOTE: Do NOT make any adjustment to your graphical representation in order to change the sequence of transmission shown below.

PACKET	PACKET	PACKET	PACKET	PACKET	
0110111	0110111	0110111	0110111	0110111	(5)

3.2 Draw the block diagram of any INTEL microprocessor with which you are familiar. Clearly give the name and model number. (10)

3.3 The following program list is in machine code:

INSTRUCTION FIELD	ADDRESS FIELD	DESCRIPTION
0000	1001	Load Acc
0001	1010	Add
0010	1100	Add
0011	1011	Subtract
0100	1101	Subtract
0101	XXXX	Print
0110	XXXX	Stop

The data held at the above-mentioned store locations is as follows:

1001 = 30 000 decimal
1010 = 20 decimal
1011 = 24 decimal
1100 = 28 decimal
1101 = 32 decimal

Determine the output of this program segment. Before the program runs, the initial contents of the accumulator is 80 000 decimal. Represent the output in Binary Coded Decimal (BCD). (5)

[20]

QUESTION 4

4.1 Use the following assembler instruction set. You may NOT add instructions to the repertoire. Calculate the value of Y given that $Y = 2(2B + 3A - 2C)$ and that A, B and C are stored in consecutive memory locations beginning with hexadecimal address 300. Output Y to the computer screen (or alternatively to the printer). Use the correct programming fields. The first instruction location is address 001H. Close the program to limit memory use to the program lines used.

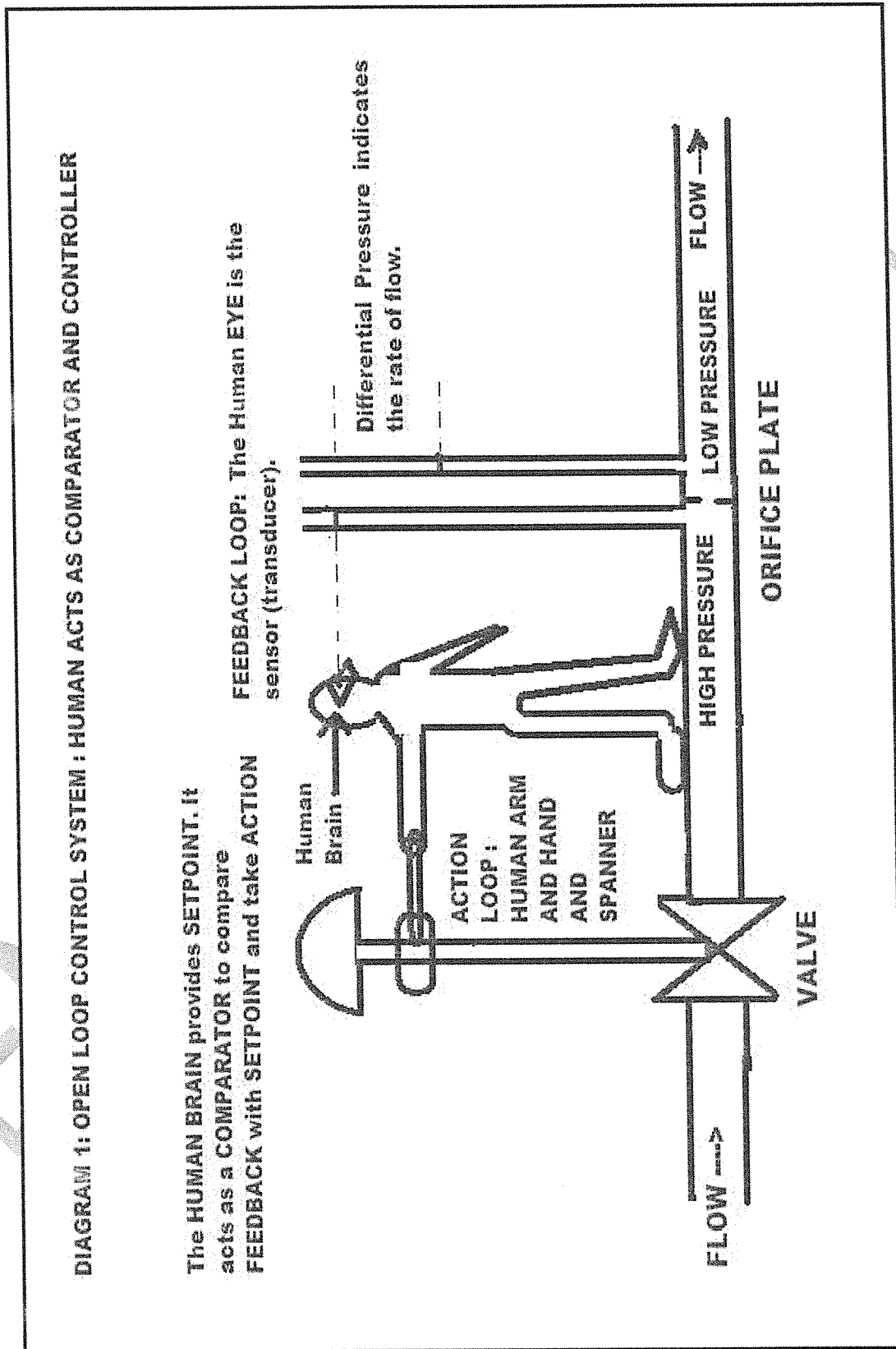| INSTRUCTION REPETOIRE	
MNEMONIC OP-CODE	DESCRIPTION
LDA	Load accumulator
ADD	Add
SUB	Subtract
STR	Store
OUT	Output
STP	Stop

(7)

4.2   A five-bit D/A converter produces an output voltage of 0,625 V for a digital input of 00001.

        Calculate the full-scale analogue output voltage. What is the digital input which corresponds to this output?   (4)

4.3   Use a sketch and explain what is meant by *quantising error*.   (3)

4.4   Draw a block diagram to show the most efficient manner of data acquisition.   (4)

4.5   What is the advantage of loading digitised data from sensors into RAM?   (2)
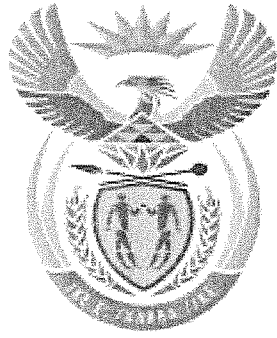   **[20]**

QUESTION 5

Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (5.1–5.10) in the ANSWER BOOK. Give a brief explanation to justify the answer.

5.1   Automatic Teller Machines ('ATM's') are analogue-controlled.

5.2   A feasibility study results in a highly technical and detailed report for management.

5.3   When you travel from one cell to another while using a cellular telephone, a computer will switch your communication to the cell with the transmitter which gives you the weakest signal.

5.4   Frequency Shift Keying (FSK) is used to transmit tones on telephone lines.

5.5   Pulse Code Modulation (PCM) can be used to transmit alpha-numeric data.

5.6   Hamming Code is an analogue correction code.

5.7   Computer Numerical Control (CNC) uses X and Y co-ordinates for very accurate machining of tempered steel dies for plastic injection moulding.

5.8   The field of digital electronics has expanded in recent years with developments like cellular telephone networks.

5.9   When a PLC (Programmable Logic Controller) is toggled so that the program displayed as a DIAGRAM is now displayed in STATEMENT LIST, a parallel network is displayed as 'AND'.

5.10   When a PLC (Programmable Logic Controller) is toggled so that the program displayed as a DIAGRAM is now displayed in STATEMENT LIST, a series network is displayed as 'OR'.

     (10 × 2)   **[20]**

     TOTAL: 100

DIAGRAM SHEET

DIAGRAM 1: OPEN LOOP CONTROL SYSTEM : HUMAN ACTS AS COMPARATOR AND CONTROLLER

The HUMAN BRAIN provides SETPOINT. It acts as a COMPARATOR to compare FEEDBACK with SETPOINT and take ACTION

FEEDBACK LOOP: The Human EYE is the sensor (transducer).

Differential Pressure indicates the rate of flow.

Human Brain

ACTION LOOP : HUMAN ARM AND HAND AND SPANNER

HIGH PRESSURE

LOW PRESSURE

ORIFICE PLATE

VALVE

FLOW —>

FLOW —>

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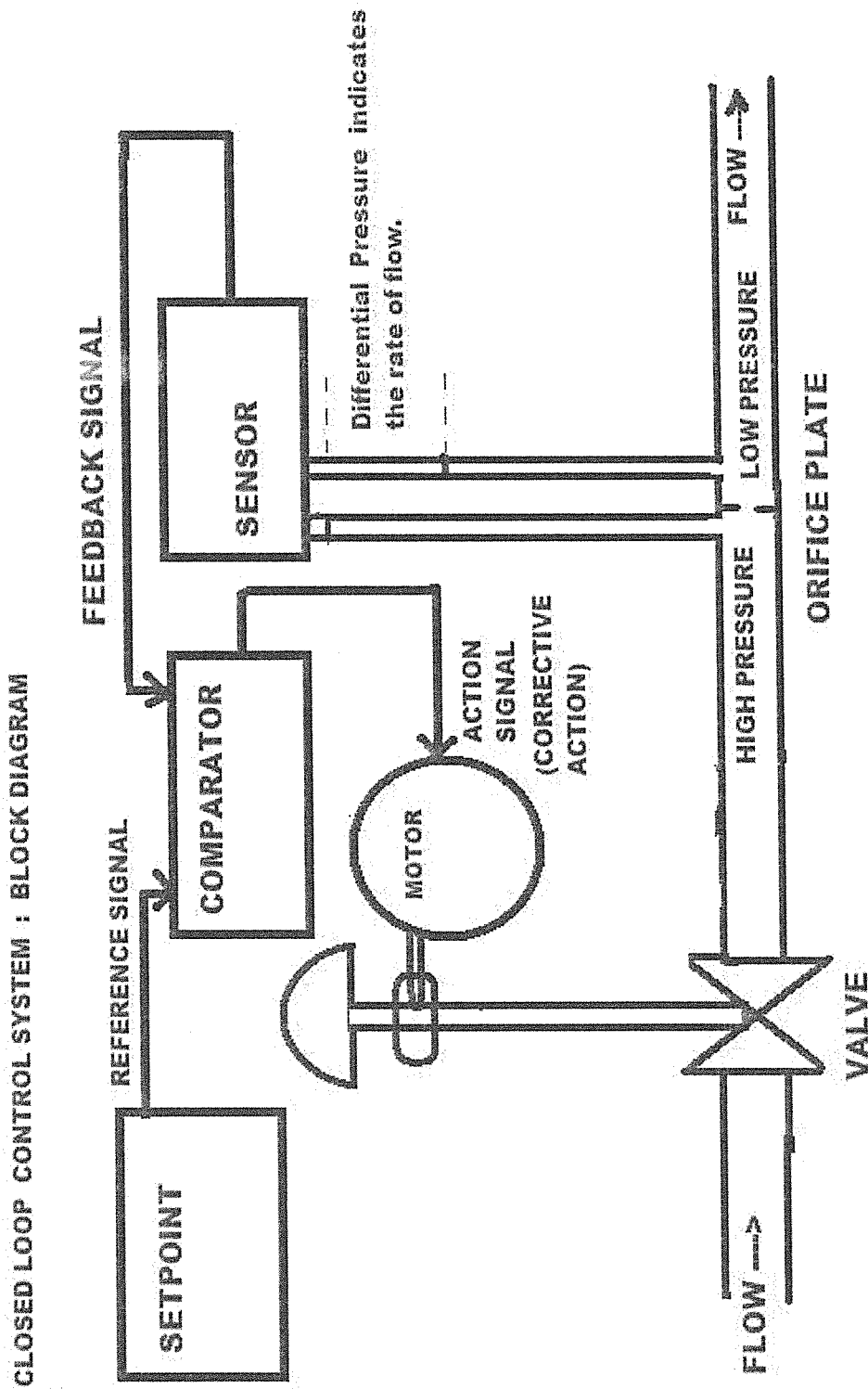
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This marking guideline consists of 9 pages.

QUESTION 1

1.1

CLOSED LOOP CONTROL SYSTEM : BLOCK DIAGRAM

SETPOINT

REFERENCE SIGNAL

COMPARATOR

FEEDBACK SIGNAL

SENSOR

MOTOR

ACTION SIGNAL (CORRECTIVE ACTION)

Differential Pressure indicates the rate of flow.

FLOW →

HIGH PRESSURE

LOW PRESSURE

ORIFICE PLATE

FLOW →

VALVE

(10)

1.2 CONTROL UNIT

MASTER CLOCK

PULSE COUNTER 1 2 3 4 5 6

$\&_1$

MAR

MEMORY

MBR

$\&_3$

PC

$\&_5$

$\&_6$

$\&_7$

$\&_2$

IR
OP CODE   ADDRESS

$\&_4$

CONDITIONAL JUMP

UNCONDITIONAL JUMP

DECODER

ARITHMETIC UNIT

(10)
[20]

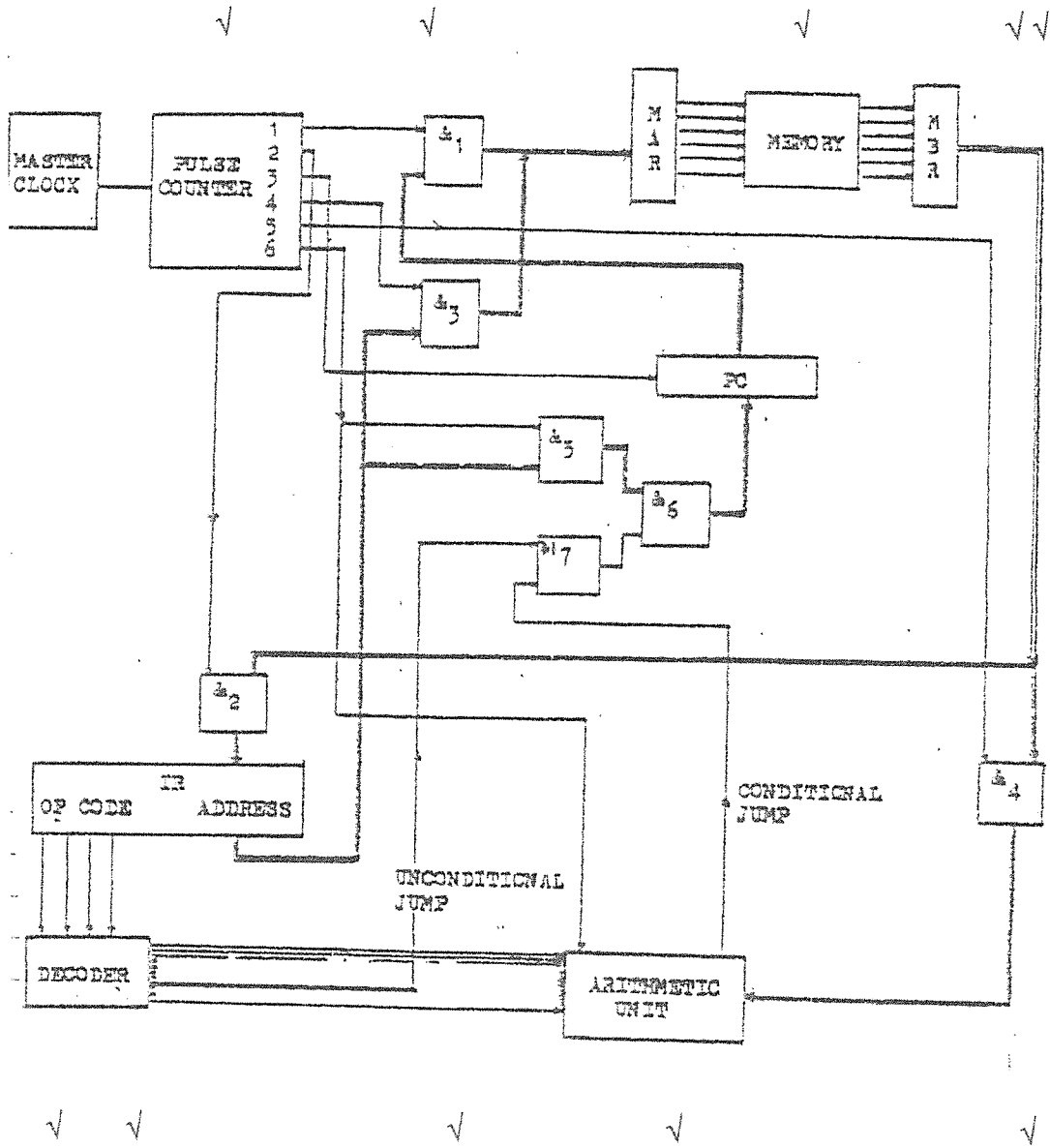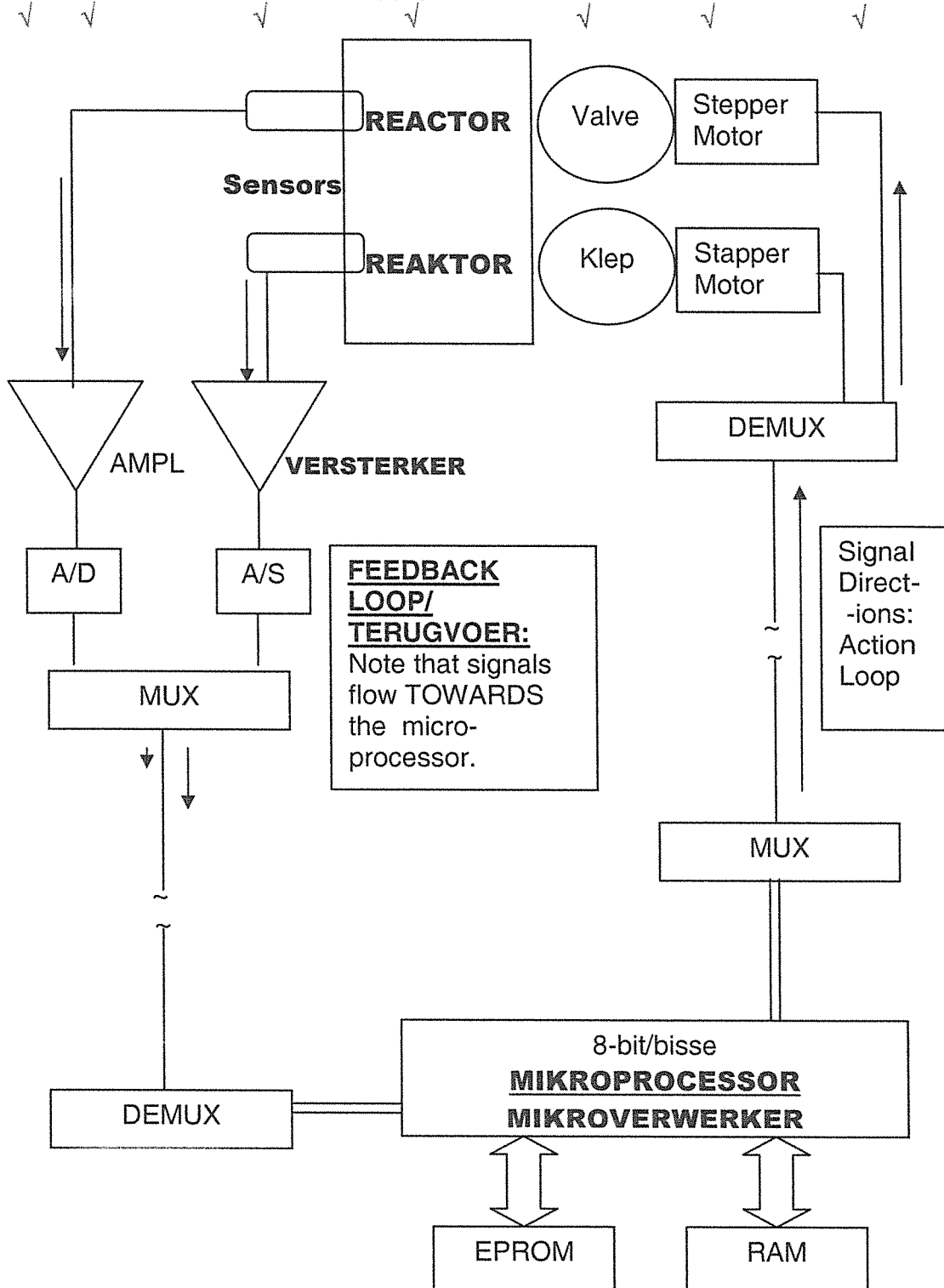## QUESTION 2

2.1   ALL THE BEST FOR YOUR EXAMINATIONS!
DEPEND ON PROFESSIONAL WORK   (10)

2.2   <u>**REACTOR PROCESS CONTROL**</u>

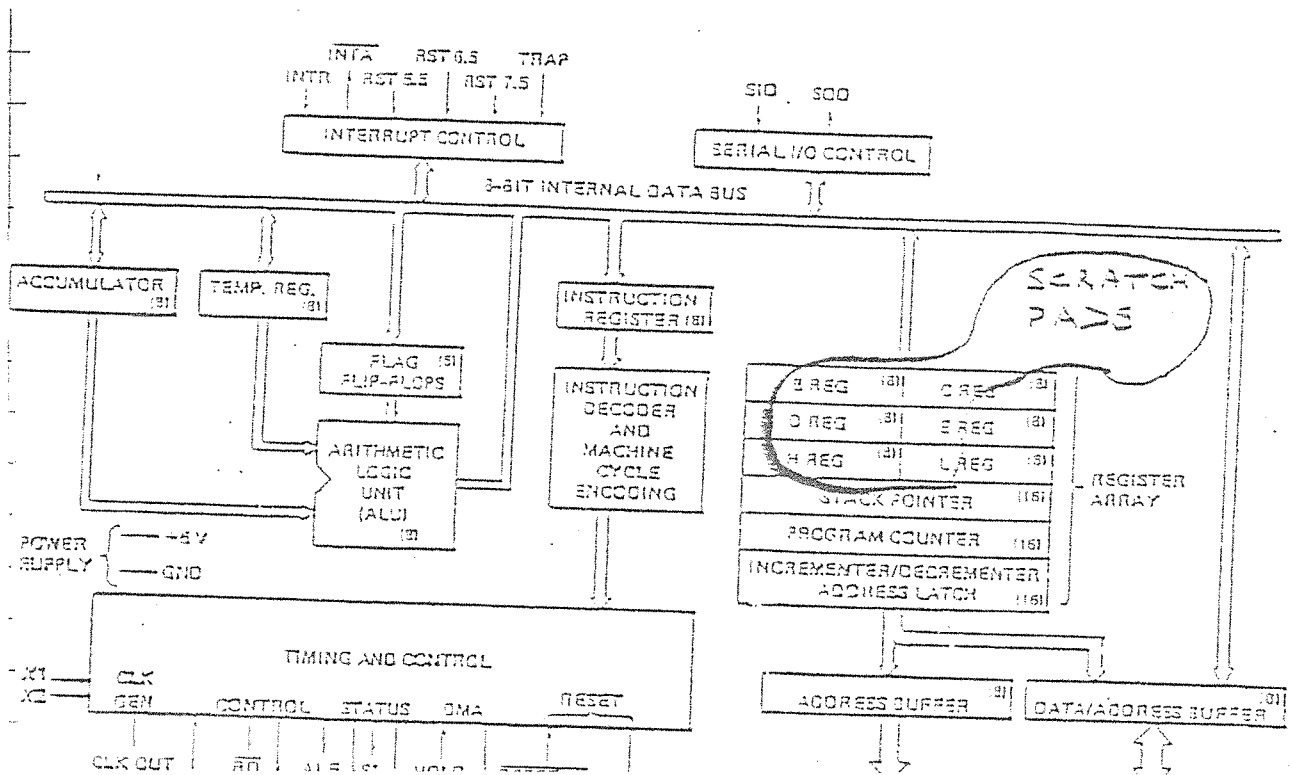   (10)
                                                                 [20]

QUESTION 3

3.1   GRAPHICAL FORMAT   :   NRZ PCM

	√	√	√	√	√	
ASCII	**PACKET** 0110001	**PACKET** 0110010	**PACKET** 0110011	**PACKET** 0110100	**PACKET** 0110101	**ASCII**
VALUES	7	7	7	7	7	**VALUES**
"1" ⟶						NRZ PCM UNIPOLAR BINARY FORMAT
"O" ⟶	1 1 1	1 1 1	1 1 1	1 1 1	1 1 1	

(5)

3.2   BLOCK DIAGRAM: MICROPROCESSOR: INTEL 8085A CPU

INTEL 8085A CPU: MANUFACTURER INTEL CORPORATION

Manufacturer: INTEL CORP.

(10)

      Please turn over

3.3 **Machine code computation:**

$$
\begin{array}{r}
30\ 000 \\
20\ + \\
28\ + \\
-\ 24 \\
\underline{-\ 32} \\
+\ 29\ 992
\end{array}
$$

Contents of accumulator (REPRESENTED in BCD: Binary Coded Decimal)
Akkumulatorinhoud: (VERTEENWOORDIG in BGD : Biner Gekodeerde   √
Desimaal):

√   √   √   √

0010 1001 1001 1001 0010   (5)
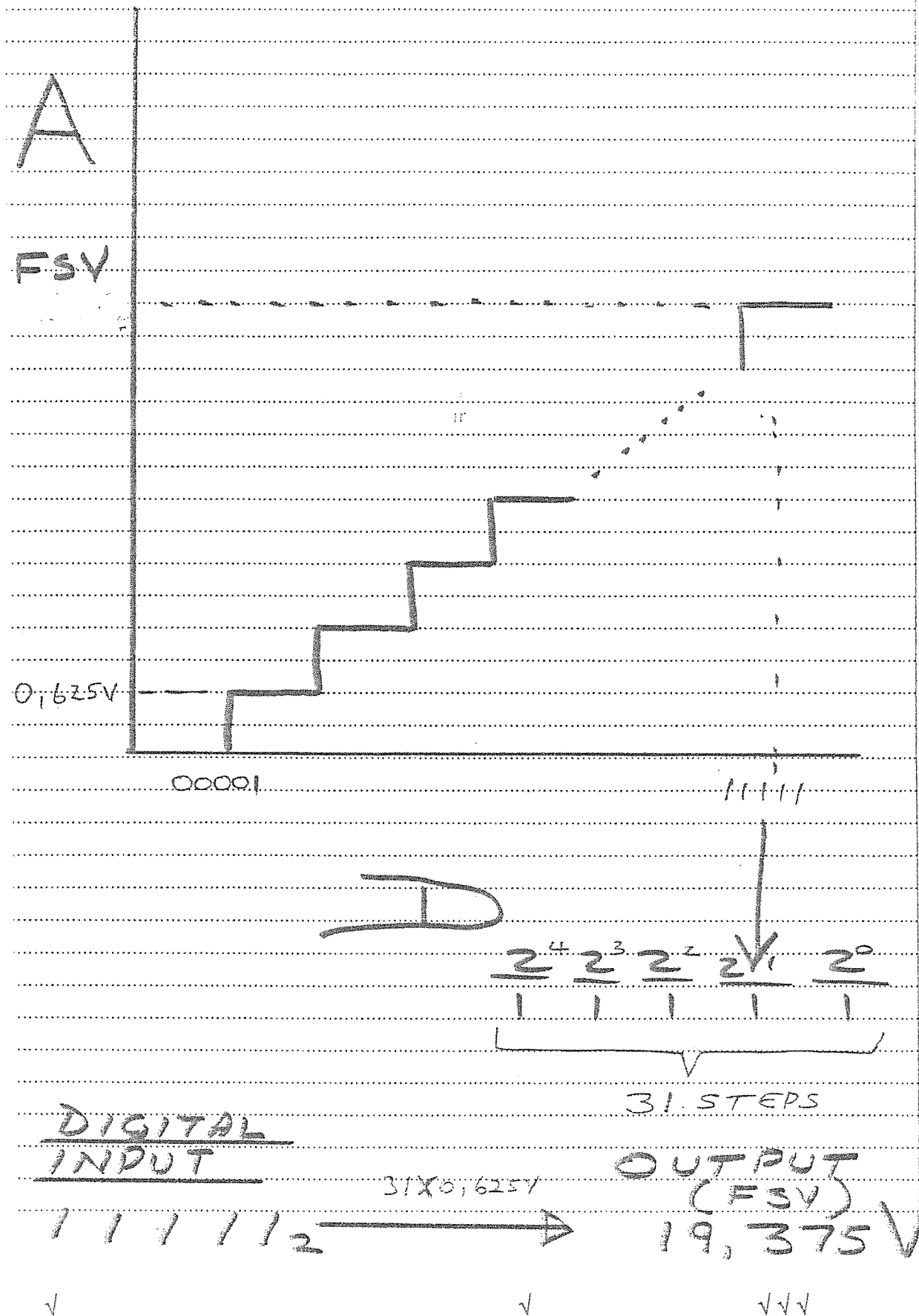   **[20]**

QUESTION 4

Calculate: Y= 2(2B +3A − 2C) = + 4B + 6A − 4C = B+B+B+B +A+A+A+A+A+A
                                                           -C-C-C-C

4.1

INSTRUCTION LOCATION	INSTRUCTION NWORD		DESCRIPTION
	OP-CODE	ADDRESS	
001	LDA	301	Load B
002	ADD	301	ADD B
003	ADD	301	ADD B
004	ADD	301	ADD B
005	ADD	300	ADD A
006	ADD	300	ADD A
007	ADD	300	ADD A
008	ADD	300	ADD A
009	ADD	300	ADD A
00A	ADD	300	ADD A
00B	SUB	302	SUB C
00C	SUB	302	SUB C
00D	SUB	302	SUB C
00E	SUB	302	SUB C
00F	OUT		Output
010	STP		Stop

√   √   √   √√

(7)

√ (next to DESCRIPTION header)

4.2   DIGITAL TO ANALOGUE CONVERSION

A

FSV

0,625V

00001

2^4 2^3 2^2 2^1 2^0

1   1   1   1   1

31 STEPS

DIGITAL
INPUT

11111_2 31 X 0,625V   →   OUTPUT (FSV)
                                          19,375V

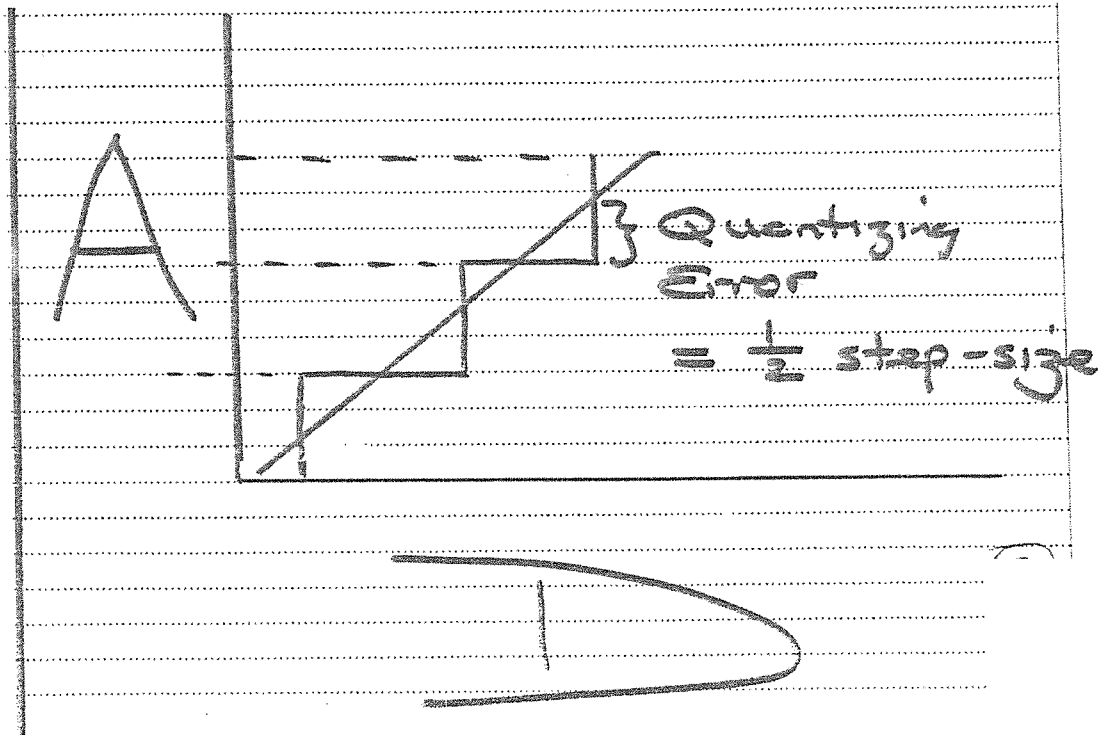√   √   √ √ √   (4)



4.3   <u>Quantizing error</u>: As shown on the sketch below the quantizing error of a D/A converter (an ideal D/A converter where other errors are assumed to be zero) <u>cannot</u> be less than half the resolution (i.e. half the step-size of the converter).

The reason is that the converter switches the output in discrete steps at the half-way mark on each step.   √

       √   √   (3)

4.4   **Most efficient manner of data acquisition: Autonomous load into RAM**

     √   √   √   √   (4)

           Please turn over
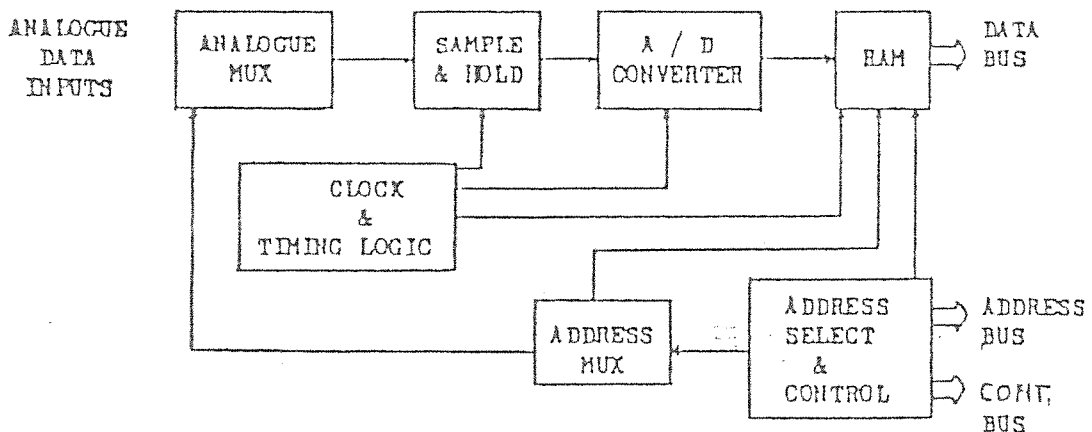
4.5   Once this is accomplished data can be accessed from RAM using a programming instruction for obtaining data from memory. This is obviously the simplest way to access the data: You just have to know how to program and to use instructions like **LOAD.** √ √

(2)
[20]

QUESTION 5

5.1   FALSE
A parallel network will be an "OR" in Statement List

5.2   FALSE
A series network will be described as an "AND" in Statement List.

5.3   FALSE
The computer switches you to the cell with the STRONGEST signal.

5.4   TRUE
These frequencies are the TONES on the modem.

5.5   TRUE
PCM can transmit alphanumeric data: LETTERS **AND** NUMBERS

5.6   FALSE
Hamming code is a DIGITAL code.

5.7   TRUE
Working on tempered steel is a great advantage of CNC spark erosion machining. The X and Y coordinates are accurate to within microns.

5.8   FALSE
ATM's are DIGITALLY controlled by a computer.

5.9   FALSE
A feasibility study should not be highly technical or very detailed: Accountants are not engineers and the report must be understandable to them and to other decision makers whose backgrounds are not technical.

5.10   TRUE
Cellular telephone networks are run by digital computers.

(10 × 2)   **[20]**

TOTAAL: 100