higher education & training

Department:
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REPUBLIC OF SOUTH AFRICA

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NOVEMBER EXAMINATION

NATIONAL CERTIFICATE

DIGITAL ELECTRONICS N6

(8080376)

29 November 2016 (X-Paper)
09:00–12:00

This question paper consists of 10 pages.

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. Subsections of each question must be answered in strict numerical order.
5. 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 Write a BASIC program to print every integer from 1 to 99. Use a loop to do this. Your program should be user friendly. Use PRINT (and possibly REM) statements to inform the user of your program what will be displayed on the screen when the program runs. The length of your program should not exceed 25 lines. (10)

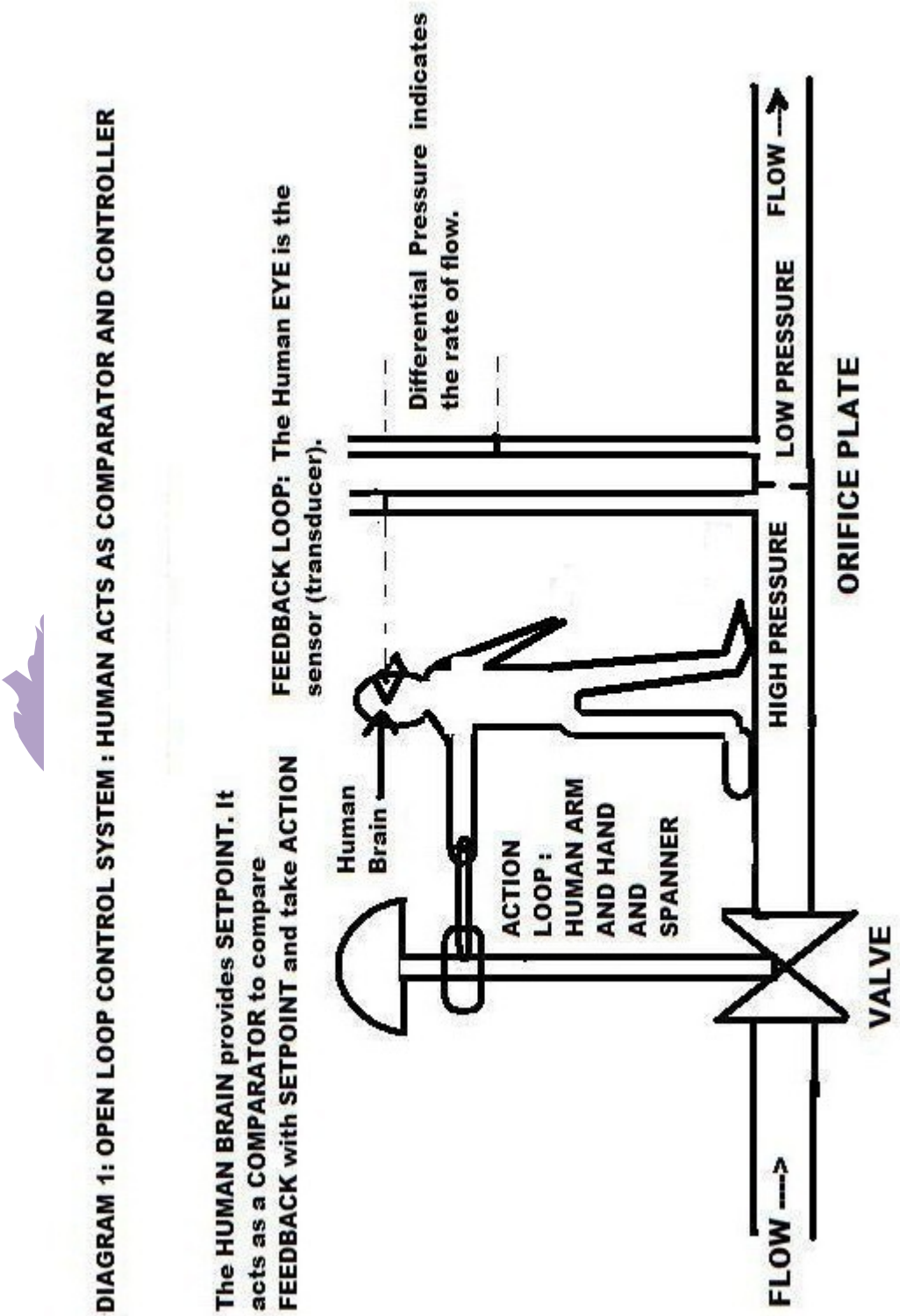
1.2 Refer to DIAGRAM 1 (below). Take the first design step in order to replace the human operator with an automatic, closed-loop, sense-and-control system. Draw a large neat fully-labelled block diagram showing the basic functions in that new closed loop control system. Replace the human operator with function and process blocks which will duplicate the functions and processes performed by the human operator.

You do NOT need to 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 DIAGRAM 1. (10)
[20]

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



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
50  REM  a 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'
```


2.1
```
420 LET TEXTY38$ = 'AND'
430 LET TEXTY39$ = 'INTENSIVE CARE UNITS'
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 GOTOs 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 GOTOs.  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 'THE FINAL PRINT-OUT FOR TODAY'S'
563 PRINT  'PROGRAM  IS AS FOLLOWS:'
564 PRINT 'FULL MARKS FOR CORRECT PRINT-OUT!'
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)

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 different addresses in the common RAM.

2.2 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 units, program counter, RAM, instruction unit, decoder and arithmetic unit must be shown. (10)

[20]

QUESTION 3

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

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).

3.2 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)

3.3 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	Halt

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

1001 = 2 000 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(B + A – C) 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

5.1 Reactors (like the SYNTHOL reactors at SASOL Secunda) can be dangerous. The reason for this is 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 1 000°C to 1 050 °C. The temperature is measured by two thermocouples. (Thermocouples are used to measure high temperatures. Thermistors are used to measure lower temperatures.) 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)

5.2 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write 'true' or 'false' next to the question number (5.2.1–5.2.5) in the ANSWER BOOK. Give a brief explanation to justify each answer.

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

5.2.2 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 strongest signal.

5.2.3 Frequency Shift Keying (FSK) is used to transmit analogue frequency signals on telephone lines.

5.2.4 Pulse code Modulation (PCM) can be used to transmit alpha-numeric data.

5.2.5 Hamming Code is an analogue correction code.

(5 × 2) (10)

TOTAL: 100