Student Name:
Student ID:

CS 2115 Midterm (100 marks)

1. Convert the decimal number 31.3125 to binary, octal and hexadecimal numbers. [10 marks]

The solution is: $(31.3125)_{10}=(11111.0101)_2=(37.24)_8=(1F.5)_{16}$;

2. Explain how the natural binary number system is used in the Russian Multiplication Method to multiply the two decimal numbers 85 x 18. [10 marks]

85	× 18	= 1530
85	18	18
42	36	
21	72	+ 72
10	144	
5	288	+ 288
2	576	
1	1152	+ 1152
		1530

18	× 85	= 1530
18	85	
9	170	170
4	340	
2	680	
1	1360	+ 1360
		1530

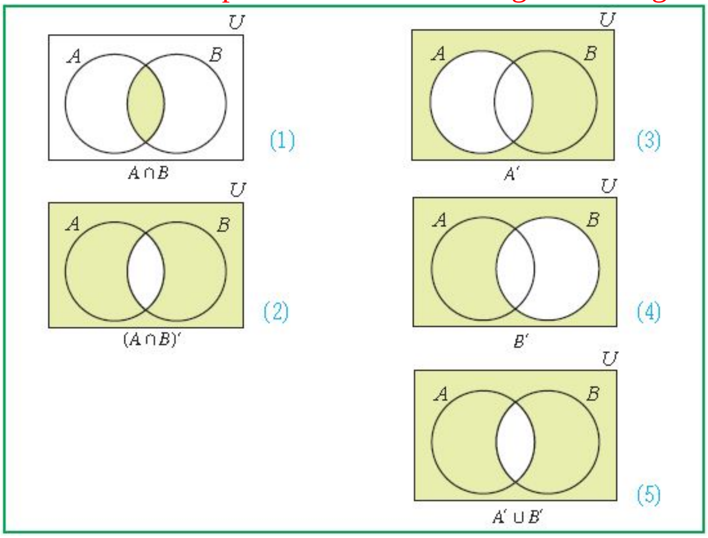
3. [CS2115 2015/2016 Final Exam Question]

(a) Prove the following two statements in *DeMorgan's Theorem*. [20 marks]

$$\overline{A\,B} = \overline{A} + \overline{B}$$

$$\overline{A + B} = \overline{A}\;\overline{B}$$

A proof of the second statement using Venn diagram is in the lecture slides, and the first statement can be proved as follows using Venn diagram:



(b) Hence, use the *DeMorgan's Theorem* to express the following Boolean logic expression into a Sum-of-Product (SOP) expression.

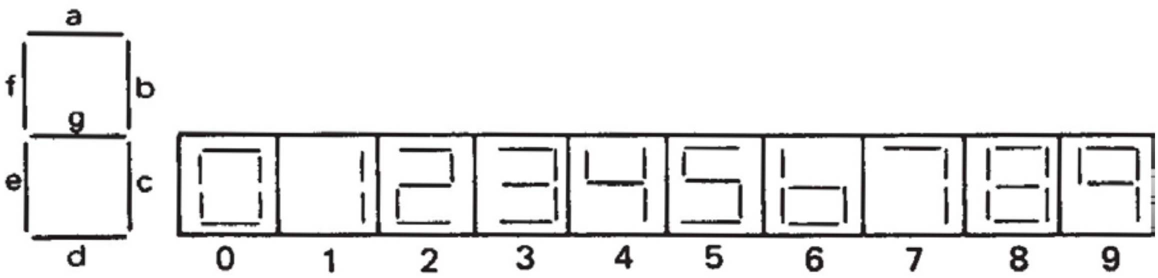
[20 marks]

$$\overline{(X \cdot \overline{\overline{Y}}) \cdot (\overline{Y} + Z)}$$

A correct application of De Morgan's theorem will lead to the following correct expression:

= x.y' + y.z'

4. [CS2115 2016/2017 Final Exam Question]
The seven-segment display contains seven individual Light Emitting Diode (LED) segments, arranged in the shape of the decimal digit 8 as shown in the figure below. In such a display, each segment can be individually enabled, allowing the display of decimal digits 0 through 9 depending on which segments are lit up at any point in time. The figure demonstrates the display of decimal digits 0 through 9 on a seven-segment display:



Design a digital circuit that takes as input a binary-coded-decimal (BCD) digit and decodes it into seven outputs which individually control the seven LED segments of a seven-segment display. Use Karnaugh Map to simplify the circuit whenever possible.

[40 marks]

Workings must be shown to write down the correct truth table and the simplification using K-map and the correct deduction of Boolean expressions.

Table 5.2 Seven-segment pattern and code

Decimal digit	BCD code x_1	x_2	x_3	x_4	Seven-segment code A	B	C	D	E	F	G
1	0	0	0	1	0	1	1	0	0	0	0
2	0	0	1	0	1	1	0	1	1	0	1
3	0	0	1	1	1	1	1	1	0	0	1
4	0	1	0	0	0	1	1	0	0	1	1
5	0	1	0	1	1	0	1	1	0	1	1
6	0	1	1	0	0	0	1	1	1	1	1
7	0	1	1	1	1	1	1	0	0	0	0
8	1	0	0	0	1	1	1	1	1	1	1
9	1	0	0	1	1	1	1	0	0	1	1
0	0	0	0	0	1	1	1	1	1	1	0

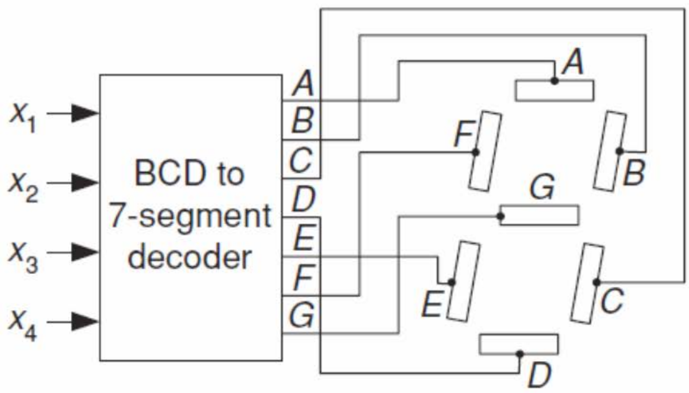


Table 5.2 can be viewed as the truth table for the output functions of the BCD-to-seven-segment decoder. The seven-segment code corresponding to each digit is directly obtained from the pattern. For example, to display the decimal digit 2, segments A, B, G, E, D are turned on while segments C and F remain off. In a similar manner, the rest of the seven-segment code is obtained. The expressions for the segment excitation functions are

$$
\begin{aligned}
A &= x_1 + x_2'x_4' + x_2x_4 + x_3x_4, \\
B &= x_2' + x_3'x_4' + x_3x_4, \\
C &= x_2 + x_3' + x_4, \\
D &= x_2'x_4' + x_2'x_3 + x_3x_4' + x_2x_3'x_4, \\
E &= x_2'x_4' + x_3x_4', \\
F &= x_1 + x_2x_3' + x_2x_4' + x_3'x_4', \\
G &= x_1 + x_2'x_3 + x_2x_3' + x_3x_4'.
\end{aligned}
$$

- END -