PART 1: DATA REPRESENTATION & SETS (INDIVIDUAL)

COS10023-Computer and Logic Essentials

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Data representation

1. *Convert the following unsigned binary numbers to decimal and then decimal to hexadecimal:

i. 0b 10111101

Binary to decimal:

0b	1	0	1	1	1	1	0	1
base$^{\text{position \#}}$	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	(128)	(64)	(32)	(16)	(8)	(4)	(2)	(1)

= 1 x 128 + 0 x 64 + 1 x 32 + 1 x 16 + 1 x 8 + 1 x 4 + 0 x 2 + 1 x 1 = 189

Decimal is 189

Decimal to hexadecimal:

189 : 16 = 11, remainder: 13 (it is D)

11 : 16 = 0, remainder: 11 (it is B)

0x	B	D
base$^{\text{position \#}}$	16^1	16^0
	(16)	(1)

Hexadecimal is 0x BD

ii. 0b 011011101

Binary to decimal:

0b	1	1	0	1	1	1	0	1
base$^{\text{position \#}}$	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	(128)	(64)	(32)	(16)	(8)	(4)	(2)	(1)

= 1 x 128 + 1 x 64 + 0 x 32 + 1 x 16 + 1 x 8 + 1 x 4 + 0 x 2 + 1 x 1 = 221

Binary is 221

Decimal to hexadecimal:

221 : 16 = 13, remainder: 13 (it is D)

13 : 16 = 0, remainder: 13 (it is D)

0x	D	D
base$^{\text{position \#}}$	16^1	16^0
	(16)	(1)

Hexadecimal is 0x DD

2. Convert the following 16-bit binary string below, determine its value as requested

0b 1011 1101 1001 1100

Convert 0b 10111101 10011100 to: 0b 1011 1101 and 0b 1001 1100

i. *Two 8-bit unsigned integers as decimal values.

- 0b 1011 1101
  From binary to decimal:

0b	1	0	1	1	1	1	0	1
base^position #	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	(128)	(64)	(32)	(16)	(8)	(4)	(2)	(1)

  = 1 x 128 + 0 x 64 + 1 x 32 + 1 x 16 + 1 x 8 + 1 x 4 + 0 x 2 + 1 x 1 = 189

- 0b 1001 1100
  From binary to decimal:

0b	1	0	0	1	1	1	0	0
base^position #	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	(128)	(64)	(32)	(16)	(8)	(4)	(2)	(1)

  = 1 x 128 + 0 x 64 + 0 x 32 + 1 x 16 + 1 x 8 + 1 x 4 + 0 x 2 + 0 x 1 = 156

Two 8-bit unsigned integers as decimal values are 189 and 156.

ii. **Two 8-bit signed integers (two's complement) as decimal values.

- 0b 1011 1101

  Two's complement, so we need to:

  Flip all the bits: 0b 0100 0010

  Add 1: 0b 0100 0011

  From binary to decimal:

0b	0	1	0	0	0	0	1	1
base^position #	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	(128)	(64)	(32)	(16)	(8)	(4)	(2)	(1)

  = 0 x 128 + 1 x 64 + 0 x 32 + 0 x 16 + 0 x 8 + 0 x 4 + 1 x 2 + 1 x 1 = 67

Because the first number in the original binary is 1, so it is a negative number: -67

- 0b 1001 1100

  Two's complement, so we need to:

  Flip all the bits: 0b 0110 0011

  Add 1: 0b 0110 0100

  From binary to decimal:

0b	0	1	1	0	0	1	0	0
base$^{\text{position \#}}$	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	(128)	(64)	(32)	(16)	(8)	(4)	(2)	(1)

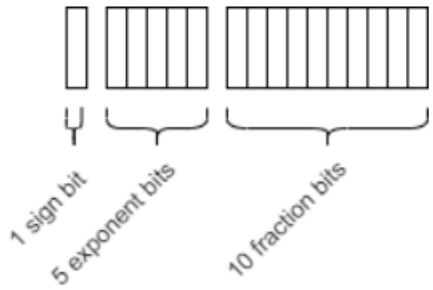
  = 0 x 128 + 1 x 64 + 1 x 32 + 0 x 16 + 0 x 8 + 1 x 4 + 0 x 2 + 0 x 1 = 100

Because the first number of the original binary is 1, so it is a negative number: 100

The given 16-bit binary string can be represented as two 8-bit signed integers (-67 and -100) in decimal.

iii. ***One half-precision (16 bit) floating point value as a decimal value.

The half-precision floating-point format is a 16-bit word divided into a 1-bit sign indicator, a 5-bit biased exponent, and a 10-bit fraction, that's why we will split the binary bit into:



0b 1011 1101 1001 1100 -> 0b 1 01111 0110011100

Sign = 1, therefore negative number

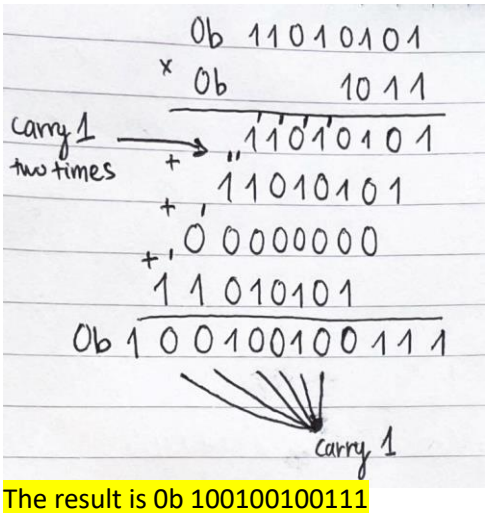
Exp = Exponent – 15 = 0b01111 – 15 = 0

M = 1 . 0110011100 = $2^0 + 2^{-2} + 2^{-3} + 2^{-6} + 2^{-7} + 2^{-8} = 1.40234375$

Number = $(-1)^s$ x M x $2^{Exp} = (-1)^1$ x 1.40234375 x 2^0 = -1.40234375 **Check again**

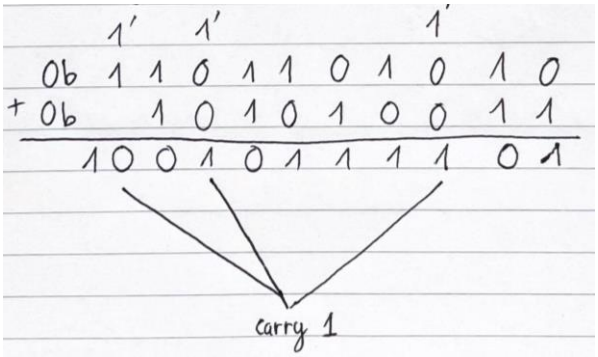
3. Perform the following binary operations. Please write down the steps to get the answer. Correct answer only will be awarded a zero.

i. 0b 11010101 multiply by 0b 1011



The result is 0b 100100100111

ii. 0b 1101101010 added to 0b 101010011



The result is: 0b 10010111101

4. **Represent the decimal value of-195.85 as an IEEE 754 single precision floating point. Please write your final answer with spaces between the sign, exponent, and mantissa.

We have: -195.85, that means:

Integer is -195

Fraction is 0.85

Step 1: Convert 195 from decimal to binary (using Sign-Magnitude Representation)

195 : 2 = 97, remainder: 1

97 : 2 = 48, remainder: 1

48 : 2 = 24, remainder: 0

24 : 2 = 12, remainder: 0

12 : 2 = 6, remainder: 0

6 : 2 = 3, remainder: 0

3 : 2 = 1, remainder: 1

1 : 2 = 0, remainder: 1

The result for 195 is 0b 11000011

Step 2: Convert 0.85 from decimal to binary

0.85 x 2 = **1**.7

0.7 x 2 = **1**.4

0.4 x 2 = **0**.8

0.8 x 2 = **1**.6

0.6 x 2 = **1**.2

0.2 x 2 = **0**.4

0.4 x 2 = **0**.8

0.8 x 2 = **1**.6

The loop 11011001 will be repeated, so we will stop at 24 bits

Combine them together, we have: 195.85 -> 11000011.1101100111011001

Step 3: Convert the binary number into base 2 scientific notation.

From: 11000011.1101100111011001

To: 1.10000111101100111011001x 2^7

Step 4: Determine the sign of the number and display in binary format.

Because -195.85 Is negative, so the sign will be 1.

Step 5: Get the exponent based on precision.

The exponent bias for single precision is 127, so we have to add the base 2 exponent to it. So the exponent will be used is 127+7=134

134 : 2 = 67, remainder: 0

67 : 2 = 33, remainder: 1

33 : 2 =16, remainder: 1

16 : 2 = 8, remainder: 0

8 : 2 = 4, remainder: 0

4 : 2 =2, remainder: 0

2 : 2 = 1, remainder: 0

1 : 2 = 0, remainder: 1

So the exponent will become 10000110.

Step 6: Determine the mantissa

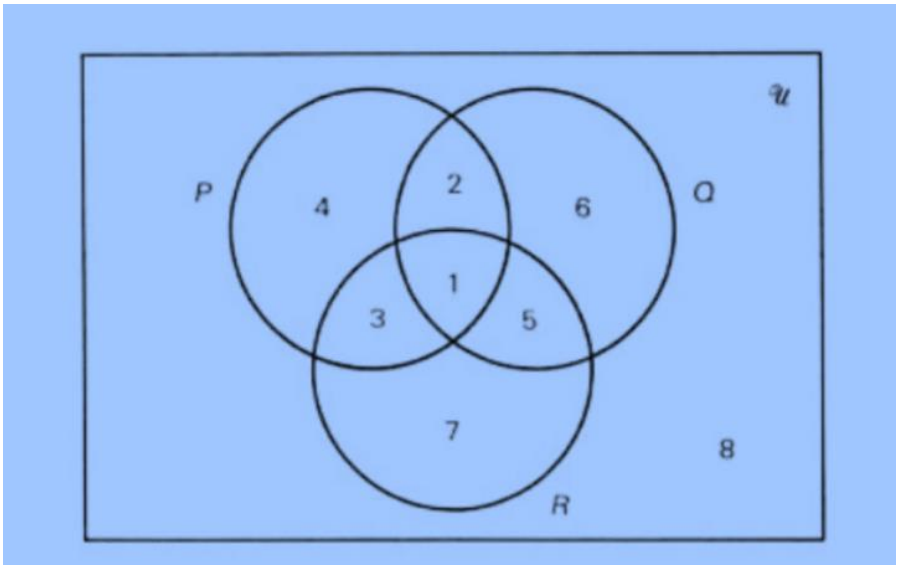
The mantissa aspect, or the third part of the IEEE 754 conversion, is the rest of the number after the decimal of the base 2 scientific notation. (1. 10000111101100111011001 x 2^7)

So it is 10000111101100111011001

So the result which represents the decimal value of -195.85 as an IEEE 754 single precision floating point is: 0b 1 10000110 10000111101100111011001 (-195.850967407)

Sets

5. *Consider the following Venn diagram, which depicts the relationship between three sets, P, Q and R. This diagram has 8 regions (1 to 8).



Identify the regions representing the sets

Sets	Regions
$P \cup Q \cup R$	{1,2,3,4,5,6,7}
$P \cap (Q \cup R)$	{1,2,3}
$P^c \cup Q^c$	{3,4,5,6,7,8}
$(P \cup R)^c$	{6,8}
$R \cap (P \cup Q^c)$	{1,3,7}
$P^c \cap (Q \cup R)$	{5,6,7}
$(P^c \cap Q) \setminus R$	{6}

6. In Clubs Week, students get the opportunity to join clubs based on their interests. We are interested in exploring patterns around which clubs students are joining. The following data has been calculated for a cohort of 440 students:

* 211 joined the esports club
* 120 joined the aquatics club
* 186 joined the trivia club
* 55 joined the esports and trivia clubs
* 33 joined the aquatics and trivia clubs
* 6 joined the esports, aquatics and trivia clubs
* 46 joined no club

a) * Show how the inclusion/exclusion formula for finite sets can be used to determine the missing value for joining the esports and aquatics clubs.

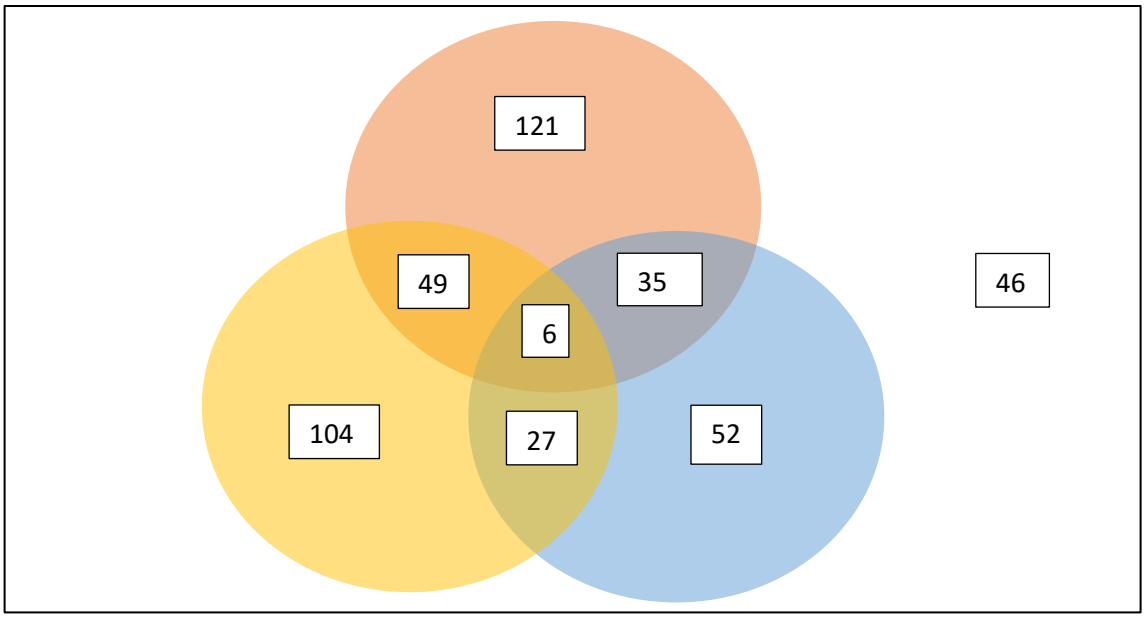
We have:
$|E| = 211$
$|A| = 120$
$|T| = 186$
$|E \cap T| = 55$
$|A \cap T| = 33$
$|E \cap A \cap T| = 6$
$|A \cup E \cup T|^C = 46$
$|A \cup E \cup T| = 440$
We call number of students who join both esport and aquatics club is $(E \cap A)$.
We have :
$| A \cup E \cup T| = |E| + |A| + |T| - |E \cap T| - |A \cap T| - |E \cap A| + |E \cap A \cap T| + |A \cup E \cup T|^C$
$440 = 211 + 120 + 186 - 55 - 33 - |E \cap A| + 6 + 46$
➔ $E \cap A = 41$

There are 41 students who join both esport and aquatics club

Therefore: (calculate for part b)
33 – 6 = 27 (T ∩ A)\E: students who join trivia and aquatics but not esport
55 – 6 = 49 (T ∩ E)\A: students who join trivia and esport but not aquatics
41 – 6 = 35 (E ∩ A)\T: students who join esport and aquatics club but not trivia

211 – 49 – 6 – 35 = 121 E(A ∩ T): students who join esport club only
120 – 35 – 6 – 27 = 52 A(E ∩ T): students who join aquatics club only
186 – 6 – 27 – 49 = 104 T(A ∩ E): students who join trivia club only

b) * Draw a Venn diagram with each club as a set and label each part of the diagram with the correct values.



c) * Provide counts for the following. **Show the numerical expression** using the values from the Venn diagram you used to find your answer: correct answers without expressions will be awarded 0 marks.

i. Joined exactly two clubs (not none, not one, not three).
We have:
33 – 6 = 27 (T ∩ A)\E: students who join trivia and aquatics but not esport
55 – 6 = 49 (T ∩ E)\A: students who join trivia and esport but not aquatics
41 – 6 = 35 (E ∩ A)\T: students who join esport and aquatics club but not trivia
(I use the same caculation in part b)

So the total will be: 27 + 49 + 35 = 111

i. Joined aquatics but not esports.
27 + 52 = 79

ii. Did not join the trivia club. (Which means it also includes students that don't participate in any club)
I take the data from the venn: 121 + 35 + 52 + 46 = 254

d) ** Using each club as a set, represent the following using set operators (U, ∩, C or '):
i. Joined both aquatics and esports clubs. A ∩ E

ii. Did not join aquatics nor trivia. $(\mathrm{A} \cup \mathrm{T})^{C}$

iii. Joined trivia and esports but not aquatics. (T ∪ E)\A