**Question 1**

Q1 a)

1x27 + 1x26 + 0x25 + 0x24 + 1x23 + 1x22 + 0x21 + 0x20

= 128 + 64 + 8 + 4

= **20410**

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Q1 b)

1x37 + 1x36 + 1x33 + 1x32

= 2187 + 729 + 27 + 9

= **295210**

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Q1 c)

1x47 + 1x46 + 1x43 + 1x42

= 16384 + 4096 + 64 + 16

= **2056010**

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**Question 2**

Q2 a)

10000/2 = 5000 remainder 0

5000/2 = 2500 remainder 0

2500/2 = 1250 remainder 0

1250/2 = 625 remainder 0

625/2 = 312 remainder 1

312/2 = 156 remainder 0

156/2 = 78 remainder 0

78/2 = 39 remainder 0

39/2 = 19 remainder 1

19/2 = 9 remainder 1

9/2 = 4 remainder 1

4/2 = 2 remainder 0

2/2 = 1 remainder 0

1/2 = 0 remainder 1

Thus the answer is **100111000100002**

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Q2 b)

First convert hex to binary:

= 1111 1110 1101 1100 . 1011 1010 2

= 1111111011011100.101110102

Now convert binary to octal by grouping and adding zeroes:

= **00**1 111 111 011 011 100 . 101 110 10**0**2

Thus the answer is: **177334.5648**

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Q2 c)

First convert octal to binary:

= 001 010 011 100 101 . 110 111 2

= 001010011100101.1101112

Now convert binary to hex by grouping and adding zeroes:

= **0**001 0100 1110 0101 . 1101 11**002**

Thus the answer is **14E5.DC16**

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**Question 3**

Q3 a)

We can expand the left side:

1xS3 + 0xS2 + 0xS1 + 1xS0 = 1968410

We know that 1xS0 is = 1 so:

1xS3 + 1 = 19683 + 1

Now take the cubic root of each term to find S:

**S= 27**

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Q3 b)

We can expand the left side:

1xT3 + 0xT2 + 1xT1 + 1xT0 = 493110

We know that 1xT0 is = 1 so:

1xT3 + 1xT1 + 1 = 4930 + 1

Through factoring, trial and error and rounding:

**T = 17**

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**Question 4**

Q4 a)

Convert to binary:

9876/2 = 4938 remainder 0

4938/2 = 2469 remainder 0

2469/2 = 1234 remainder 1

1234/2 = 617 remainder 0

617/2 = 308 remainder 1

308/2 = 154 remainder 0

154/2 = 77 remainder 0

77/2 = 38 remainder 1

38/2 = 19 remainder 0

19/2 = 9 remainder 1

9/2 = 4 remainder 1

4/2 = 2 remainder 0

2/2 = 1 remainder 0

1/2 = 0 remainder 1

We get 987610 = 100110100101002 and since it’s unsigned, add a sign:

+987610 = **0**100110100101002

Now two’s complement

-987610 = **1**011001011011002

So the answer is **1011001011011002**

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Q4 b)

First convert the number to binary (ignore the negative, we will consider the sign when we do the two’s complement):

98/2 = 49 remainder 0

49/2 = 24 remainder 1

24/2 = 12 remainder 0

12/6 = 6 remainder 0

6/2 = 3 remainder 0

3/2 = 1 remainder 1

1/2 = 0 remainder 1

Convert the decimal part to binary (using multiplication method!)

0.7654310x2 = 1.530862

0.530862x2 = 1.061724

0.061724x2 = 0.123448

0.123448x2 = 0.246896

0.246896x2 = 0.493792

0.493792x2 = 0.987584

0.987584x2 = 1.975168

0.975168x2 = 1.950336

0.950336x2 = 1.900672

0.900672x2 = 1.801344

0.801344x2 = 1.602688

0.602688x2 = 1.205376

0.205376x2 = 0.410752

0.410752x2 = 0.821504

Round to 10 decimal digits (10 digits after the decimal)

01100010.11000011112

Take two’s complement of the number since it’s negative

Thus the final answer is **10011101.00111100012**

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**Question 5**

Q5 a)

1010.10102 = 1x23 + 0x22 + 1x21 + 0x20 + 1x2-1 + 1x2-3

= 8 + 2 + 0.5 + 0.125

= **10.62510**

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Q5 b)

If it is a sign and magnitude number, then the first bit will represent the sign, which is negative. Taking the work shown from above, we can see that the 8 is omitted (as the sign takes its place).  
  
So the answer is **-2.62510**

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Q5 c)

The two’s complement is -101.01102

= 1x22 + 1x2-2 + 1x2-3

= **-5.37510**

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**Question 6**

Q6 a)

**1111111**

10101010

+ 11111111

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101010012

The answer is: **101010012**

No overflow because last two carries are the same.

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Q6 b)

**1111111**

01011111

+ 01110101

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110101002

The answer is: **110101002**

Overflow because adding two positives and getting a negative!

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Q6 c)

**1111 1 1**

11110101

+ 01010101

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010010102

The answer is:  **010010102**

No overflow because we are adding numbers of different signs. And last two carries are the same.

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**Question 7**

Q7 a)

First convert to binary:

1234/2 = 617 remainder 0

617/2 = 308 remainder 1

308/2 = 154 remainder 0

154/2 = 77 remainder 0

77/2 = 38 remainder 1

38/2 = 19 remainder 0

19/2 = 9 remainder 1

9/2 = 4 remainder 1

4/2 = 2 remainder 0

2/2 = 1 remainder 0

1/2 = 0 remainder 1

Converting the decimal (via multiplication):

0.875x2 = 1.75

0.75x2 = 1.5

0.5x2 = 1.0

The number in binary is 10011010010.1112 so now normalize it:

1.00110100101112 x 210 This is the real exponent

1.00110100101112 x 2136 This is adding the bias 127

Now convert the exponent 137 to binary:

137/2 = 68 remainder 1

68/2 = 34 remainder 0

34/2 = 17 remainder 0

17/2 = 8 remainder 1

8/2 = 4 remainder 0

4/2 = 2 remainder 0

2/2 = 1 remainder 0

1/2 = 0 remainder 1

Now convert to 32-bit IEEE format (and add zeros at the end so that it’s 32 bits). Also recall that the original number is negative, so the first bit is a 1:

1 10001001 0011010010111 0000000000 2

Now convert to hex via grouping:

1100 0100 1001 1010 0101 1100 0000 0000 2

Therefore the answer is **C49A5C0016**

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Q7 b)

First convert to binary:

7654/2 = 3827 remainder 0

3827/2 = 1913 remainder 1

1913/2 = 956 remainder 1

956/2 = 478 remainder 0

478/2 = 239 remainder 0

239/2 = 119 remainder 1

119/2 = 59 remainder 1

59/2 = 29 remainder 1

29/2 = 14 remainder 1

14/2 = 7 remainder 0

7/2 = 3 remainder 1

3/2 = 1 remainder 1

1/2 = 0 remainder 1

Converting the decimal (via multiplication):

0.3x2 = 0.6

0.6x2 = 1.2

0.2x2 = 0.4

0.4x2 = 0.8

0.8x2 = 1.6

0.6x2 = 1.2

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As you can see, the numbers follow a pattern (we get 01**0011**, where the bolded numbers repeat). Since it is repeating, we must truncate to round.

The number in binary is 1110111100110.010011…2 so now normalize it:

1.1101111001100100112 x 212 This is the real exponent

1.1101111001100100112 x 2139 This is adding the bias 127

Now convert the exponent 139 to binary:

139/2 = 69 remainder 1

69/2 = 34 remainder 1

34/2 = 17 remainder 0

17/2 = 8 remainder 1

8/2 = 4 remainder 0

4/2 = 2 remainder 0

2/2 = 1 remainder 0

1/2 = 0 remainder 1

Now convert to 32-bit IEEE format (and add the repeating digits at the end so that it’s 32 bits). Also recall that the original number is positive, so the first bit is a 0:

0 10001011 110111100110010011 00110 2

Now convert to hex via grouping:

0100 0101 1110 1111 0011 0010 0110 0110 2

Therefore the answer is **45EF326616**

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**Question 8**

Q8 a)

Convert FEDCBA9816 to binary: 1111 1110 1101 1100 1011 1010 1001 10002

Rewrite into significand form and normalize:

1 11111101 101110010111010100110002

- 1.101110010111010100110002 x2253  We must subtract the bias 127

- 1.101110010111010100110002 x2126  This is the true exponent

Convert -1.101110010111010100110002 to decimal

= - 1x20 + 1x2-1 +1x2-3 + 1x2-4+ 1x2-5 + 1x2-8 + 1x2-10 + 1x2-11 + 1x2-12 +

1x2-14 + 1x2-16+ 1x2-19+ 1x2-20

= - 1.72444438934

Now to make the exponent more readable

2126 = 10z

Log10(2126) = z

z = 37.9297794537

2126 = 1037.9297794537

2126 = 1037 x 100.9297794537

= 1037 x 8.50705917378

Now to make simplify the whole number

-1.72444438934 x 2126

= -1.72444438934 x 8.50705917378 x 1037

= - 14.669950462 x 1037

Therefore the answer is: **- 1.466995046210 x 1038**

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Q8 b)

Convert 89ABCDEF16 to binary: 1000 1001 1010 1011 1100 1101 1110 11112

Rewrite into significand form and normalize:

1 00010011 010101111001101111011112

- 1.010101111001101111011112 x219  We must subtract the bias 127

- 1.010101111001101111011112 x2-108 This is the true exponent

Convert -1.010101111001101111011112 to decimal

= - 1x20 + 1x2-2 +1x2-4 + 1x2-6+ 1x2-7 + 1x2-8 + 1x2-9 + 1x2-12 + 1x2-13 +

1x2-15 + 1x2-16+ 1x2-17 + 1x2-18 + 1x2-20 + 1x2-21 + 1x2-22 + 1x2-23

= - 1. 34222209453

Now to make the exponent more readable

2-108 = 10z

Log10(2-108) = z

z = -32.5112395317

2-108 = 10-32.5112395317

2-108 = 10-32 x 10-0.5112395317

= 10-32 x 8.50705917378

Now to make simplify the whole number

-1. 34222209453 x 2-108

= -1. 34222209453 x 0.3081487911 x 10-32

= -0.41360411582 x 10-32

Therefore the answer is: **-4.136041158210 x 10-31**

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**Question 9**

Q9 a)

First convert each to binary:

FEDCBA9816: 1 11111101 101110010111010100110002

89ABCDEF16: 1 00010011 010101111001101111011112

Now rewrite into 32 bit IEEE format (work shown in previous question):

FEDCBA9816: - 1.101110010111010100110002 x2126

89ABCDEF16: - 1.010101111001101111011112 x2-108

Now to make the number with the smaller exponent equal to the larger one. However, since the difference between the two exponents is larger than the number of significant bits+1, the result will just equal the larger number (FEDCBA9816)

Therefore the answer is **FEDCBA9816**

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Q9 b)

First convert each number to binary:

00FCD6EB16: 0000 0000 1111 1100 1101 0110 1110 10112

80FCD6EA16: 1000 0000 1111 1100 1101 0110 1110 10102

Rewrite into 32bit IEEE format (don’t forget to subtract the bias 127)

00FCD6EB16: + 1.111110011010110111010112 x2-126

80FCD6EA16: - 1.111110011010110111010102 x2-126

The numbers are the same exponent. If we were to sum them, we can see that they differ by 0.000000000000000000000012 x2-126,which is 0.0000000000000000000000102 x2-127.

Convert to proper IEEE. (Remember to consider the bias. Note that this is a case of underflow as the smallest exponent we can have is -127)

We can now convert this to hex via grouping.

0000 0000 0000 0000 0000 0000 0000 0010

Therefore the answer is: **0000000216**

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Q9 c)

First convert each number to binary:

00FCD6EB16: 0000 0000 1111 1100 1101 0110 1110 10112

09ABCDEF16: 0000 1001 1010 1011 1100 1101 1110 11112

Rewrite into 32bit IEEE format (don’t forget to subtract the bias 127)

00FCD6EB16: + 1.111110011010110111010112 x2-126

09ABCDEF16: + 1.010101111001101111011112 x2-108

Now to make the number with the smaller exponent equal to the larger one via division.

00FCD6EB16: + 1.111110011010110111010112 x2-126

00FCD6EB16: + 0.000000000000000001111112 x2-108

Now to sum:

**111111111**

1.010101111001101111011112 x2-108

+ 0.000000000000000001111112 x2-108

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1.010101111001110001011102 x2-108

Now convert to binary (remember to add the bias 127 to the exponent and then convert to binary):

0 0001 1001 010101111001110001011102

Now convert to hex. Therefore the answer is: **09ABCE2E16**

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