QUESTION : Perform AES and give output of round 2 by using following data ?

R_0 = 54 68 61 74 73 20 6D 79
20 4B 75 6E 67 20 46 75

R_1 = E2 32 FC F1 91 12 91 88 B1
59 E4 E6 D6 79 A2 93

R_2 = 56 08 20 07 C7 1A B1 8F 76
43 55 69 A0 3A F7

State Matrix =

$$\begin{bmatrix} 54 & 4F & 4E & 20 \\ 77 & 6E & 69 & 54 \\ 6F & 65 & 6E & 77 \\ 20 & 20 & 65 & 6F \end{bmatrix}$$

Sol:-

Step 1
Add Round Key

$$= \begin{bmatrix} 54 & 4F & 4E & 20 \\ 77 & 6E & 69 & 54 \\ 6F & 65 & 6E & 77 \\ 20 & 20 & 65 & 6F \end{bmatrix} \oplus \begin{bmatrix} 54 & 73 & 20 & 67 \\ 68 & 20 & 4B & 90 \\ 61 & 6D & 75 & 46 \\ 74 & 79 & 6E & 75 \end{bmatrix}$$

54 = 0101 0100 4F = 0100 1111

54 = 0101 0100 73 = 0111 0011

0000 0000 = **00** 0011 1100 = **3C**

4E = 0100 1110 20 = 0010 0000

20 = 0010 0000 67 = 0110 0111

0110 1110 = **6E** 0100 0111 = **47**

77 = 0111 0111 6E = 0110 1110

68 = 0110 1000 20 = 0010 0000

0001 1111 = **1F** 0100 1110 = **4E**

69 = 0110 1001 54 = 0101 0100

4B = 0100 1011 20 = 0010 0000

0010 0010 = **22** 0111 0100 = **74**

6F = 0110 1111 65 = 0110 0101

61 = 0110 0001 6D = 0110 1101

0000 1110 = **0E** 0000 1000 = **08**

6E = 0110 1110 77 = 0111 0111

75 = 0111 0101 46 = 0100 0110

0001 1011 = **1B** 0011 0001 = **31**

20 = 0010 0000 20 = 0010 0000

74 = 0111 0100 79 = 0111 1001

0101 0100 = **54** 0101 1001 = **59**

65 = 0110 0101 6F = 0110 1111

6E = 0110 1110 75 = 0111 0101

0000 1011 = **0B** 0001 1010 = **1A**

$$= \begin{bmatrix} 00 & 3C & 6E & 47 \\ 1F & 4E & 22 & 74 \\ 0E & 08 & 1B & 31 \\ 54 & 59 & 0B & 1A \end{bmatrix}$$

Step 2:-

Substitution Method

$$= \begin{bmatrix} 63 & EB & 9F & A0 \\ C0 & 2F & 93 & 92 \\ AB & 30 & AF & C7 \\ 20 & CB & 2B & A2 \end{bmatrix}$$

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Step 3:-

Shifting Rows

$$= \begin{bmatrix} 63 & EB & 9F & A0 \\ 2F & 93 & 92 & C0 \\ AF & C7 & AB & 30 \\ A2 & 20 & CB & 2B \end{bmatrix}$$

Step 4:-

Mixed Columns

$$= \begin{bmatrix} 02 & 03 & 01 & 01 \\ 01 & 02 & 03 & 01 \\ 01 & 01 & 02 & 03 \\ 03 & 01 & 01 & 02 \end{bmatrix} \begin{bmatrix} 63 & EB & 9F & A0 \\ 2F & 93 & 92 & C0 \\ AF & C7 & AB & 30 \\ A2 & 20 & CB & 2B \end{bmatrix}$$

$= 02 \cdot 63 \oplus 03 \cdot 2F \oplus 01 \cdot AF \oplus 01 \cdot A2$

$= (x)(01100011) \oplus (x+1)(00101111) \oplus 01$

$(10101111) \oplus 01 \cdot (10100010)$

$= (x)(x^6+x^5+x^1+1) \oplus (x+1)(x^5+x^3+x^2+x^1+1)$

$= (x^7+x^6+x^2+x) \oplus (x^6+x^4+x^3+x^2+x+x^5+x^3+x^2+x+1)$

$= (11000110) \oplus (01110001)$

11000110
01111001
10101111
+ 10100010
10111010 = BA

$= 02 \cdot EB \oplus 03 \cdot 93 \oplus 01 \cdot C7 \oplus 01 \cdot 20$

$= x(11101011) \oplus (x+1)(10010011) \oplus 01(11000111) \oplus 01(00100000)$

$= x(x^7+x^6+x^5+x^3+x^1+1) \oplus (x+1)(x^7+x^4+x^1+1)$

$= (x^8+x^7+x^6+x^4+x^2+x) \oplus (x^8+x^5+x^3+x^2+x^7+x^4+x^1+1)$

$= (x^4+x^3+1+x^7+x^6+x^4+x^2+x^1) \oplus (x^4+x^3+1+x^5+x^2+x^1+x^7+x^4+x^1+1)$

$= (11001111) \oplus (10101100) \oplus (11000111) \oplus (00100000)$

11001111
10101100
11000111
+ 00100000
10000100 = 84

$= 02 \cdot 9F \oplus 03 \cdot 92 \oplus 01 \cdot AB \oplus 01 \cdot CB$

$= (x)(10011111) \oplus (x+1)(10010010) \oplus 01(10101011) \oplus 01 \cdot (11001011)$

$= (x)(x^7+x^4+x^3+x^2+x+1) \oplus (x+1)$
(x^7+x^4+x)

$= (x^8+x^5+x^4+x^3+x^2+x) \oplus (x^8+x^5+x^4+$
$x^7+x^4+x)$

$= (x^8+x^5+1+x^5+x^4+x^3+x^2+x) \oplus$
$(x^8+x^3+1+x^5+x^4+x^7+x^4+x)$

$= (00100111) \oplus (10101111) \oplus (10101011) \oplus$
(11001011)

$$\begin{array}{r} 00100111 \\ 10101111 \\ 10101011 \\ +\ 11001011 \\ \hline 11101000 = \mathbf{E8} \end{array}$$

$= 02 \cdot A0 \oplus 03 \cdot C0 \oplus 01 \cdot 30 \oplus 01 \cdot 2B$

$= (x)(10100000) \oplus (x+1)(11000000) \oplus$
$01(00110000) \oplus 01(00101011)$

$= x(x^7+x^5) \oplus (x+1)(x^7+x^6)$

$= (x^8+x^6) \oplus (x^8+x^7+x^7+x^6)$

$= (x^4+x^3+1+x^6) \oplus (x^4+x^3+1+x^6)$

$= (01011001) \oplus (01011001) \oplus (00110000) \oplus$
(00101011)

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01011001
01011001
00110000
+ 00101011
00011011 = 1B

= 01·63 ⊕ 02·2F ⊕ 03·AF ⊕ 01 A2
= 01(01100011) ⊕ (x)(00101111) ⊕ (x+1)
(10101111) ⊕ 01(10100010)
= x(00101111) ⊕ (x+1)(10101111)
= x(x^5+x^3+x^2+x^1+1) ⊕ (x+1)(x^7+x^5+x^3+x^2+x^1+
= (x^6+x^4+x^3+x^2+x^1) ⊕ (x^8+x^6+x^4+x^3+x^2+x^1+1)
x^7+x^5+x^3+x^2+x^1+1)
= (x^6+x^4+x^3+x^2+x^1) ⊕ (x^7+x^5+x^4+x^3+x^2+x^1+
x^2+x^1+x^7+x^5+x^3+x^2+x+1)
= (01011110) ⊕ (11b010b0) ⊕ (01100011) ⊕
(10100010)

01100011
01011110
11b010b0
+ 10100010
01bb0101 = 575

= 01·EB ⊕ 02·93 ⊕ 03·C7 ⊕ 01·20
= 01(11101011) ⊕ (x)(10010011) ⊕ (x+1)(11000111) ⊕
01(00100000)

$= x(x^7+x^6+x^5+1) \oplus (x+1)(x^6+x^5+x^4+x^3+1)$

$= (x^8+x^7+x^6+x^5) + (x^7+x^6+x^5+x^4) \oplus (x^7+x^6+x^5+x^4+x^3+x^2+x^7+x^6+x^5+x^4+x^3+x^2+x+1)$

$= (x^8+x^7+x^6+x^5+x^7+x^6+x^5+x^4) + (x^8+x^7+x^6+x^5+x^4+x^3+x^2+x+1)$

$= (x^8+x^4) + (x^8+x^7+x^6+x^5+x^4+x^3+x^2+x+1)$

$= x^7+x^6+x^5+x^3+x^2+x+1$

$= (11101011) \oplus (00111111) \oplus (01010000) \oplus (00100000)$

11101011

00111111

01010000

00100000

$10100100 = A4$

$= 01 \cdot 9E \oplus 02 \cdot 92 \oplus 03 \cdot AB \oplus 01 \cdot CB$

$= 01(10011111) \oplus (x)(10010010) \oplus (x+1)(10101011) \oplus 01(11001011)$

$= (x)(x^7+x^4+x^1) \oplus (x+1)(x^7+x^5+x^3+x^1+1)$

$= (x^8+x^5+x^2) \oplus (x^7+x^5+x^4+x^3+x^2+x^7+x^5+x^3+x^2+1)$

$= (x^7+x^5+1+x^4+x^2) \oplus (x^7+x^5+x^4+x^3+x^2+x^7+x^5+x^3+x^2+x+1)$

$= (x^7+x^5+x^4+x^2+1) \oplus (x^7+x^5+x^4+x^3+x^2+x^7+x^5+x^3+x^2+x+1)$

$= (10011111) \oplus (01011101) \oplus (11100100) \oplus (11001011)$

$= x(x^7+x^5+x^3+x^1+1) \oplus (x+1)(x^7+x^4+x^3+x^1+1)$

$= (x^8+x^6+x^4+x^2+x^1) \oplus (x^8+x^7+x^6+x^5+x^4+x^3+x^2+x^1+1)$

$= (x^8+x^7+x^6+x^5+x^4+x^3+x^2+x^1) \oplus (x^8+x^7+x^6+x^5+x^4+x^3+x^2+x^1+1)$

$= (1001\,1111) \oplus (1001\,0010) \oplus (0100\,1101) \oplus (0100\,0110)$

$$\begin{array}{r} 1001\,1111 \\ 1001\,0010 \\ 0100\,1101 \\ +\,0100\,0110 \\ \hline 0000\,0110 = 06 \end{array}$$

$= 01.A0 \oplus 01.C0 \oplus 02.30 \oplus 03.2B$

$= 1(10100000) \oplus 1(11000000) \oplus (x)(00110000) \oplus (x+1)(00101011)$

$= x(x^5+x^4) \oplus (x+1)(x^5+x^3+x^1+1)$

$= (x^6+x^5) \oplus (x^6+x^4+x^2+x^1+x^5+x^3+x^1+1)$

$= (1010\,0000) \oplus (1100\,0000) \oplus (0110\,0000) \oplus (0111\,1101)$

$$\begin{array}{r} 1010\,0000 \\ 1100\,0000 \\ 0110\,0000 \\ +\,0111\,1101 \\ \hline 0111\,1101 = 7D \end{array}$$

00100110
10010011
11000111
+01000000
01110010 = 32

= 03·9F ⊕ 01·92 ⊕ 01·AB ⊕ 02·CB
= (x+1)(10011111) ⊕ 1(10010010) ⊕ 1(10101011) ⊕ (x)(11001011)
= (x+1)(x^7+x^4+x^3+x^2+x^1+1) ⊕ x(x^7+x^6+x^3+x^1+1)
= (x^8+x^5+x^4+x^3+x^2+x^1+x^7+x^6+x^3+x^2+x^1+1) ⊕ (x^8+x^7+x^4+x^2+x^1)
= (x^4+x^3+1+x^7+x^5+1) ⊕ (x^4+x^3+1+x^7+x^6+x^2+x^1)
= (10111000) ⊕ (10001111)
= (10111000) ⊕ (10010010) ⊕ (10101011) ⊕ (10001111)

10111000
10010010
10101011
+10001111
00001110 = 0E

= 03·A0 ⊕ 01·C0 ⊕ 01·30 ⊕ 02·2B
= (x+1)(10100000) ⊕ 1(11000000) ⊕ 1(00110000) ⊕ (x)(00101011)
= (x+1)(x^7+x^5) ⊕ (x)(x^5+x^3+x^1+1)

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$= 03 \cdot 63 \oplus 01 \cdot 2F \oplus 01 \cdot AF \oplus 02 \cdot A2$

$= (x+1)(01100011) \oplus 1(00101111) \oplus 1(10101111) \oplus x(10100010)$

$= (x+1)(x^6+x^5+x^1+1) \oplus x(x^7+x^5+x^1)$

$= (x^7+x^6+x^2+x^1+x^6+x^5+x^1+1) \oplus (x^8+x^6+x^2)$

$= (x^7+x^5+x^2+1) \oplus (x^7+x^5+x^1+x^6+x^2)$

$= (10100101) \oplus (00101111) \oplus (10101111) \oplus (01011101)$

$\begin{array}{r} 10100101 \\ 00101111 \\ 10101111 \\ +\ 01011101 \\ \hline 01111010 = 7A \end{array}$

$= 03 \cdot EB \oplus 01 \cdot 93 \oplus 01 \cdot C7 \oplus 02 \cdot 20$

$= (x+1)(11101011) \oplus 1(10010011) \oplus 1(11000111) \oplus x(00100000)$

$= (x+1)(x^7+x^6+x^5+x^3+x^1+1) \oplus x(x^5)$

$= (x^8+x^7+x^6+x^5+x^3+x^2+x^1+x^6+x^5+x^3+x^1+1) \oplus (x^6)$

$= (x^7+x^6+x^5+x^4+x^3+x^2+x) \oplus (x^6)$

$= (01001010) \oplus (10010011) \oplus (11000111) \oplus (01000000)$

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$= (x^7 + x^3 + 1 + x^6 + x^4 + x^3 + x^2 + x^1) \oplus (x^4 + x^3 + 1 + x^7 + x^6 + x^5 + x^2 + x^1)$

$= (01100011) \oplus (00101111) \oplus (01000101) \oplus (11111101)$

01100011
00101111
01000101
$+ 11111101$
$\overline{11110000} = F4$

$= 01 \cdot EB \oplus 01 \cdot 93 \oplus 02 \cdot C7 \oplus 03 \cdot 20$

$= 1((11101011) \oplus (10010011) \oplus (x)(11000111) \oplus (x+1)(00100000)$

$= x(x^7 + x^6 + x^2 + x^1 + 1) \oplus (x+1)(x^5)$

$= (x^8 + x^7 + x^3 + x^2 + x^1) \oplus (x^6 + x^5)$

$= (x^4 + x^3 + 1 + x^7 + x^6 + x^2 + x^1) \oplus (x^6 + x^5)$

$= (11101011) \oplus (10010011) \oplus (10010101) \oplus (01100000)$

11101011
10010011
10010101
$+ 01100000$
$\overline{10001101} = 8D$

$= 01 \cdot 9F \oplus 01 \cdot 92 \oplus 02 \cdot AB \oplus 03 \cdot CB$

$= 01(10011111) \oplus 1(10010010) \oplus x(10101011) \oplus (x+1)$

1 0 0 1 1 1 1 1

0 0 1 1 1 1 0 1

1 1 1 0 0 1 0 0

+ 1 1 0 0 1 0 1 1

1 0 0 0 1 1 0 1 = 8D

= 01·A0 ⊕ 02·C0 ⊕ 03·30 ⊕ 01·2B

= 01(10100000) ⊕ (x)(11000000) ⊕ (x+1)(00110000) ⊕ 01(00101011)

= x(x^7 + x^6) ⊕ (x+1)(x^5 + x^4)

= (x^8 + x^7) ⊕ (x^6 + x^5 + x^5 + x^4)

= (x^4 + x^3 + 1 + x^7) ⊕ (x^6 + x^4)

= (10100000) ⊕ (10011001) ⊕ (01010000) ⊕ (00101011)

1 0 1 0 0 0 0 0

1 0 0 1 1 0 0 1

0 1 0 1 0 0 0 0

+ 0 0 1 0 1 0 1 1

0 1 0 0 0 0 0 0 = 40

= 01·63 ⊕ 01·2F ⊕ 02·AF ⊕ 03·A2

= 1(01100011) ⊕ 1(00101111) ⊕ (x)(10100011) ⊕ (x+1)(10100010)

= x(x^7 + x^5 + x^3 + x^2 + x^1 + 1) + (x+1)(x^7 + x^5 + x^1)

= (x^8 + x^6 + x^4 + x^3 + x^2 + x^1) + (x^8 + x^6 + x^2 + x^1 + x^5 + x^1)

$= (x^6 + x^5 + x^3 + x^2) \oplus (x^5 + x^4 + x^3 + x^1)$

$= (x^{11} + x^8 + x^7 + x^6 + x^5) \oplus (x^8 + x^4 + x^2 + 1)$

$= (11111011) \oplus (11000000) \oplus (00110000) \oplus (01010100)$

11111011

11000000

00110000

$+ 01010100$

$01011100 = 5D$

$= 03 \cdot A0 \oplus 01 \cdot C0 \oplus 01 \cdot 30 \oplus 02 \cdot 2B$

$= (x+1)(10100000) \oplus 1(11000000) \oplus 1(00110000) \oplus$

$$= \begin{bmatrix} BA & 84 & E8 & 1B \\ 75 & A4 & 8D & 40 \\ F4 & 8D & 06 & 7D \\ 7A & 32 & 0E & 5D \end{bmatrix}$$

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$$\begin{bmatrix} BA & 84 & E8 & 1B \\ 75 & A4 & 8D & 40 \\ F4 & 8D & 06 & 7D \\ 7A & 32 & 0E & 5D \end{bmatrix} \oplus \begin{bmatrix} E2 & 91 & B1 & D6 \\ 32 & 12 & 59 & 79 \\ FC & 91 & E4 & A2 \\ F1 & 88 & E6 & 93 \end{bmatrix}$$

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$$= \begin{bmatrix} 58 & 159 & 59 & CD \\ 47 & B6 & D4 & 39 \\ 08 & 1C & E2 & DF \\ 8B & BA & E8 & CE \end{bmatrix}$$

Substitution Method

$$= \begin{bmatrix} 6A & 59 & CB & BD \\ A0 & 4E & 48 & 12 \\ 30 & 9C & 98 & 9E \\ 3D & F4 & 9B & 8B \end{bmatrix}$$

Shifting Rows

$$= \begin{bmatrix} 6A & 59 & CB & BD \\ 4E & 48 & 12 & A0 \\ 98 & 9E & 30 & 9C \\ 8B & 3D & F4 & 9B \end{bmatrix}$$

Mixed Columns:-

$$\begin{bmatrix} 02 & 03 & 01 & 01 \\ 01 & 02 & 03 & 01 \\ 01 & 01 & 02 & 03 \\ 03 & 01 & 01 & 02 \end{bmatrix} \begin{bmatrix} 6A & 59 & CB & BD \\ 4E & 48 & 12 & A0 \\ 98 & 9E & 30 & 9C \\ 8B & 3D & F4 & 9B \end{bmatrix}$$

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$= 01 \cdot 6A \oplus 02 \cdot 4E \oplus 03 \cdot 98 \oplus 01 \cdot 8B$

$= (01101010) \oplus x(01002110) \oplus (x+1)(10011000) \oplus (10001011)$

$= x(x^6 + x^3 + x^2 + x^1) \oplus (x+1)(x^7 + x^4 + x^3)$

$= (x^7 + x^4 + x^3 + x^2) \oplus (x^4 + x^3 + x^1 + 1 + x^5 + x^4 + x^7 + x^4 + x^3)$

$= (01101010) \oplus (10011100) \oplus (10110011) \oplus (10001011)$

$$\begin{array}{r} 01101010 \\ 10011100 \\ 10110011 \\ +\ 10001011 \\ \hline 11001110 = CE \end{array}$$

$= 01 \cdot 59 \oplus 02 \cdot 48 \oplus 03 \cdot 9E \oplus 01 \cdot 3D$

$= (01011001) \oplus (x)(01001000) \oplus (x+1)(10011110) \oplus (00111101)$

$= x(x^6 + x^3) \oplus (x+1)(x^7 + x^4 + x^3 + x^2 + x^1)$

$= (x^7 + x^4) \oplus (x^4 + x^3 + x^1 + 1 + x^5 + x^4 + x^3 + x^4 + x^7 + x^4 + x^3 + x^2 + x)$

$= (01011001) \oplus (10010000) \oplus (10111001) \oplus (00111101)$

$$\begin{array}{r} 01011001 \\ 10010000 \\ 10111001 \\ +\ 00111101 \\ \hline 01001101 = 4D \end{array}$$

$= 01.6A \oplus 01.4E \oplus 02.98 \oplus 03.8B$

$= (01101010) \oplus (01001110) \oplus x(10011000) \oplus (x+1)(10001011)$

$= x(x^7+x^4+x^3) \oplus (x+1)(x^7+x^3+x^1+1)$

$= (x^8+x^5+x^4+x^3+x^5+x^4) \oplus (x^8+x^4+x^2+x+x^7+x^3+x^1+x^7+x^4+x^3+x+1)$

$= (01101010) \oplus (01001110) \oplus (10001011) \oplus (10000110)$

$$\begin{array}{r} 01101010 \\ 01001110 \\ 10001011 \\ +\ 10000110 \\ \hline 10001001 = 89 \end{array}$$

$= 01.59 \oplus 01.48 \oplus 02.9E \oplus 03.3D$

$= (01011001) \oplus (01001000) \oplus x(10011110) \oplus (x+1)(00111101)$

$= x(x^7+x^4+x^3+x^2+x^1) \oplus (x+1)(x^5+x^4+x^3+x^2+1)$

$= (x^8+x^5+x^4+x^3+x^5+x^4+x^3+x^2) \oplus (x^6+x^5+x^4+x^3+x+x^5+x^4+x^3+x^2+1)$

$= (01011001) \oplus (01001000) \oplus (00100111) \oplus (01000111)$

$$\begin{array}{r} 01011001 \\ 01001000 \\ 00100111 \\ +\ 01000111 \\ \hline 01110001 = 71 \end{array}$$

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$= 01 \cdot CB \oplus 02 \cdot 12 \oplus 03 \cdot 3b \oplus 01 \cdot F4$

$= (11001011) \oplus (x)(00010010) \oplus (x+1)(00110000) \oplus (11110100)$

$= x(x^4+x^1) \oplus (x+1)(x^5+x^4)$

$= (x^5+x^2) \oplus (x^6+x^5+x^4+x^1)$

$= (11001011) \oplus (00100100) \oplus (01010000) \oplus (11110100)$

$$\begin{array}{r} 11001011 \\ 00100100 \\ 01010000 \\ +\ 11110100 \\ \hline 01001011 = 4B \end{array}$$

$= 01 \cdot BD \oplus 02 \cdot A0 \oplus 03 \cdot 9C \oplus 01 \cdot 9B$

$= (10111101) \oplus x(10100000) \oplus (x+1)(10011100) \oplus (10011011)$

$= x(x^7+x^5) \oplus (x+1)(x^7+x^4+x^3+x^2)$

$= (x^4+x^3+x^1+1+x^6) \oplus (x^8+x^5+x^2+x+x^5+x^2+x^3+x^1+x^4+x^3+x^2)$

$= (10111101) \oplus (01011011) \oplus (10111111) \oplus (10011011)$

$$\begin{array}{r} 10111101 \\ 01011011 \\ 10111111 \\ +\ 10011011 \\ \hline 11000010 = C2 \end{array}$$

$= 02 \cdot CB \oplus 03 \cdot 12 \oplus 01 \cdot 30 \oplus 01 \cdot F4$

$= x(11001011) \oplus (x+1)(00010010) \oplus (00110000) \oplus (11110100)$

$= x(x^7+x^6+x^3+x^1+1) \oplus (x+1)(x^4+x^1)$

$= (x^8+x^7+x^4+x^2+x^1) \oplus (x^5+x^2+x^4+x^1)$

$= (x^4+x^3+x^1+1+x^7+x^4+x^2+x^1) \oplus (x^5+x^2+x^4+x^1)$

$= (10001101) \oplus (00110110) \oplus (00110000) \oplus (11110100)$

$$\begin{array}{r} 10001101 \\ 00110110 \\ 00110000 \\ +\ 11110100 \\ \hline 01111111 = 7F \end{array}$$

$= 02 \cdot BD \oplus 03 \cdot A0 \oplus 01 \cdot 9C \oplus 01 \cdot 9B$

$= x(10111101) \oplus (x+1)(10100000) \oplus (10011100) \oplus (10011011)$

$= x(x^7+x^5+x^4+x^3+x^2+1) \oplus (x+1)(x^7+x^5)$

$= (x^8+x^6+x^5+x+x^6+x^5+x^4+x^2+x^1) \oplus (x^4+x^3+x^1+1+x^6+x^7+x^5)$

$= (01100001) \oplus (11111011) \oplus (10011100) \oplus (10011011)$

$$\begin{array}{r} 01100001 \\ 11111011 \\ 10011100 \\ +\ 10011011 \\ \hline 10011101 = 9D \end{array}$$

$= 02.6A \oplus 03.4E \oplus 01.98 \oplus 01.8B$

$= x(01101010) \oplus (x+1)(01001110) \oplus (10011000) \oplus (10001011)$

$= x(x^6+x^5+x^3+x^1) \oplus (x+1)(x^6+x^3+x^2+x^1)$

$= (x^7+x^6+x^4+x^2) \oplus (x^7+x^4+x^3+x^2+x^3+x^2+x^1+x^1)$

$= (11010100) \oplus (11010010) \oplus (10011000) \oplus (10001011)$

$$\begin{array}{r} 11010100 \\ 11010010 \\ 10011000 \\ +\ 10001011 \\ \hline 00010101 \end{array} = 15$$

$= 02.59 \oplus 03.48 \oplus 01.9E \oplus 01.3D$

$= x(01011001) \oplus (x+1)(01001000) \oplus (10011110) \oplus (00111101)$

$= x(x^6+x^4+x^3+1) \oplus (x+1)(x^6+x^3) \oplus$

$= (x^7+x^5+x^4+x^1) \oplus (x^7+x^4+x^6+x^3)$

$= (10110010) \oplus (11011000) \oplus (10011110) \oplus (00111101)$

$$\begin{array}{r} 10110010 \\ 11011000 \\ 10011110 \\ +\ 00111101 \\ \hline 11001001 \end{array} = C9$$

BA = 10111010

E2 = 11100010

01011000 = 58

E8 = 11101000

B1 = 10110001

01011001 = 59

75 = 01110101

32 = 00110010

01000111 = 47

8D = 10001101

59 = 01011001

11010100 = D4

F4 = 11110100

FC = 11111100

00001000 = 08

06 = 00000110

E4 = 11100100

11100010 = E2

7A = 01111010

F1 = 11110001

10001011 = 8B

0E = 00001110

E6 = 11100110

11101000 = E8

84 = 10000100

91 = 10010001

00010101 = 15

1B = 00011011

D6 = 11010110

11001101 = CD

A4 = 10100100

12 = 00010010

10110110 = B6

40 = 01000000

79 = 01111001

00111001 = 39

8D = 10001101

91 = 10010001

00011100 = 1C

7D = 01111101

A2 = 10100010

11011111 = DF

32 = 00110010

88 = 10001000

10111010 = BA

5D = 01011101

93 = 10010011

11001110 = CE

M T W T F S

Date: __/__/20__

= 03.6A ⊕ 01.4E ⊕ 01.98 ⊕ 02.8B

= (x+1)(01101010) ⊕ (01001110) ⊕ (10011000) ⊕ (10001011)

= (x+1)(x^6 + x^5 + x^3 + x) ⊕ (x^7 + x^3 + x + 1)

= (x^7 + x^6 + x^5 + x^4 + x^3 + x^2 + x) ⊕ (x^7 + x^3 + x + 1 + x^6 + x^4 + x^2)

= (10111110) ⊕ (01001110) ⊕ (10011000) ⊕ (10001011)

10111110
01001110
10011000
+ 10001011

01100101 = 65

= 03.59 ⊕ 01.48 ⊕ 01.9E ⊕ 02.3D

= (x+1)(01011001) ⊕ (01001000) ⊕ (10011110) ⊕ x(00111101)

= (x+1)(x^6 + x^4 + x^3 + 1) ⊕ (x)(x^5 + x^4 + x^3 + x^2 + 1)

= (x^7 + x^5 + x^4 + x + x^6 + x^4 + x^3 + 1) ⊕ (x^6 + x^5 + x^4 + x^3 + x)

= (11101011) ⊕ (01001000) ⊕ (10011110) ⊕ (01111010)

11101011
01001000
10011110
+ 01111010

01000111 = 47

M T W T F S

Date: / /20

= 03 76 ⊕ 01 43 ⊕ 01 55 ⊕ 02 69

= (x+1)(01110110) ⊕ (01000011) ⊕ (01010101) ⊕ x(01101001)

= (x+1)($x^6+x^5+x^4+x^2+x^1$) ⊕ (x)($x^6+x^5+x^3+1$)

= ($x^7+x^6+x^5+x^4+x^6+x^5+x^4+x^2+x^7+x^6+x^1$) ⊕ ($x^7+x^6+x^4+x^1$)

= (10011010) ⊕ (01000011) ⊕ (01010101) ⊕ (11010010)

10011010
01000011
01010101
+ 11010010
01011110 = 5E

= 03 · BD ⊕ 01 · A0 ⊕ 01 · 9C ⊕ 02 · 93

= (x+1)(10111101) ⊕ (10100000) ⊕ (10011100) ⊕ x(10011011)

= (x+1)($x^7+x^5+x^4+x^3+x^2+1$) ⊕ x($x^7+x^6+x^5+x^4+1$)

= ($x^8+x^7+x^6+x^5+x^7+x^6+x^5+x^4+x^6+x^5+x^4+x^3+x^5+x^4+x^3+x^2+x^2+x+1$) ⊕ ($x^8+x^7+x^6+x^5+x$)

= (11011100) ⊕ (10100000) ⊕ (10011100) ⊕ (00101101)

11011100
10100000
10011100
+ 00101101
11001101 = CD

M T W T F S

Date: __/__/20__

$= 01 \cdot CB \oplus 01 \cdot 12 \oplus 02 \cdot 30 \oplus 03 \cdot F4$

$= (11001011) \oplus (00010010) \oplus x(x)(00110000) \oplus$
$(x+1)(11110100)$

$= x(x^5+x^4) \oplus (x+1)(x^7+x^6+x^5+x^4+x^2)$

$= (x^6+x^5) \oplus (x^8+x^7+x^6+1+x^5+x^4+x^3+x^2+x^7+x^6+x^5+x^4+x^3+x^2)$

$= (11001011) \oplus (00010010) \oplus (01100000) \oplus$
(00000111)

$$\begin{array}{r} 11001011 \\ 00010010 \\ 01100000 \\ +\ 00000111 \\ \hline 10111110 = BE \end{array}$$

$= 01 \cdot BD \oplus 01 \cdot A0 \oplus 02 \cdot 9C \oplus 03 \cdot 9B$

$= (10111101) \oplus (10100000) \oplus x(10011100) \oplus$
$(x+1)(10011011)$

$= x(x^7+x^4+x^3+x^2) \oplus (x+1)(x^7+x^4+x^3+x^1+1)$

$= (x^8+x^5+x^4+x^3+x^2) \oplus (x^8+x^7+x^4+x^3+x^2+x^1+x^7+x^4+x^3+x^2+x^1+1)$

$= (10111101) \oplus (10100000) \oplus (00100011) \oplus (10110110)$

$$\begin{array}{r} 10111101 \\ 10100000 \\ 00100011 \\ +\ 10110110 \\ \hline 10001000 = 88 \end{array}$$