

Lab - 7  
CT-216

## HUFFMAN CODING

Rakshit Pandhi-202201426



### % Question 1

```
PS1 = [1/2 1/4 1/8 1/16 1/32 1/32];  
PS2 = [1/6 1/6 1/6 1/6 1/6 1/6];  
H_S_1 = -sum(PS1.*log2(PS1));  
H_S_2 = -sum(PS2.*log2(PS2));  
disp(['Entropy for Source 1=',num2str(H_S_1)]);
```

Entropy for Source 1=1.9375

```
disp(['Entropy for Source 2=',num2str(H_S_2)]);
```

Entropy for Source 2=2.585

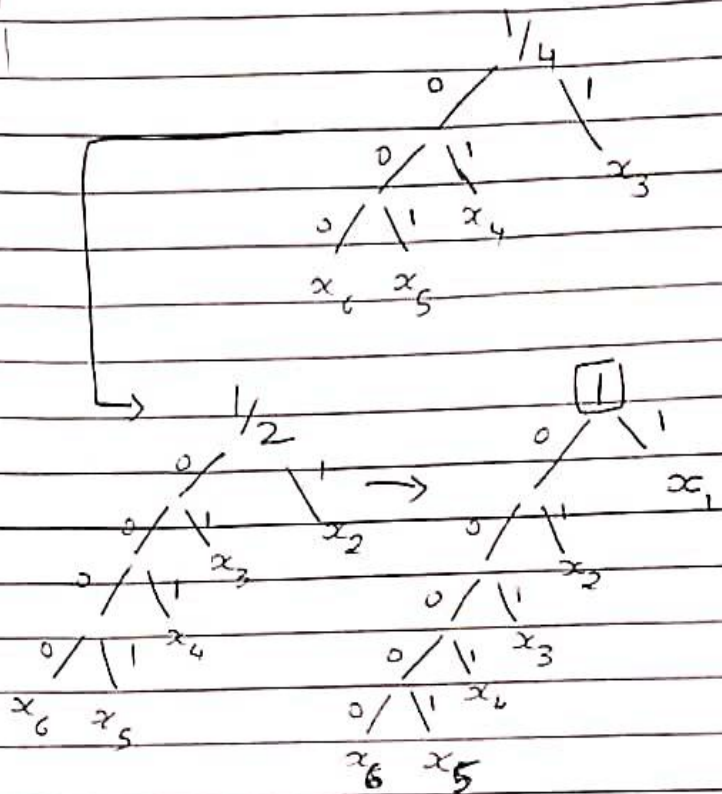
```
disp('Source-2 will be having a greater entropy.The graph of entropy which we know  
(downward parabola) is the reason why at equal probable case entropy is the largest  
here(1/6 equally likely)')
```

Source-2 will be having a greater entropy.The graph of entropy which we know (downward parabola) is the reason why a

### % Question 2

#### % Part (a)

$x_1$	$1/2$			$1/16$		$1/8$	
$x_2$	$1/4$			0	1	0	1
$x_3$	$1/8$			$x_6$	$x_5$	0	1
$x_4$	$1/16$		$1/8$			$x_6$	$x_5$
$x_5$	$1/32$		$1/16$				
$x_6$	$1/32$						

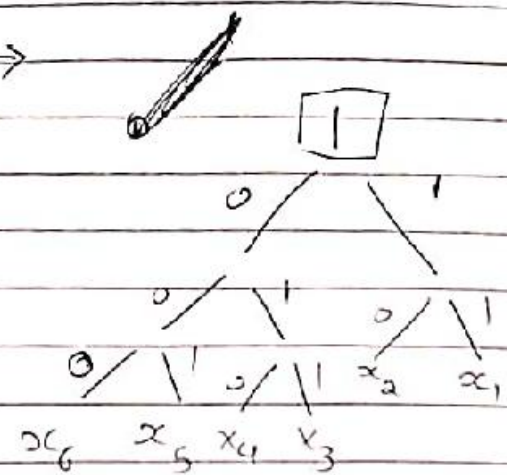
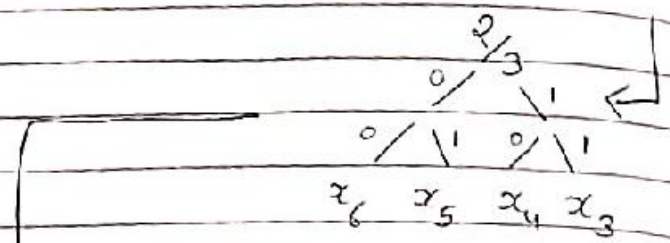
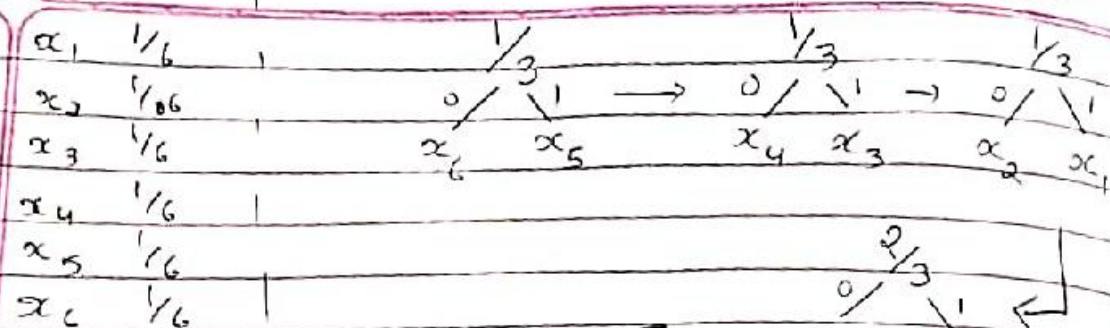


$x_1 = 1 \ (1/2)$   
 $x_2 = 01 \ (1/4)$   
 $x_3 = 001 \ (1/8)$   
 $x_4 = 0001 \ (1/16)$   
 $x_5 = 00001 \ (1/32)$   
 $x_6 = 00000 \ (1/32)$

$$R = \sum_{i=1}^L p_i \cdot n_i$$

$$= \left(\frac{1}{2} \times 1\right) + \left(\frac{1}{4} \times 2\right) + \left(\frac{1}{8} \times 3\right) + \left(\frac{1}{16} \times 4\right) + \left(\frac{1}{32} \times 5\right) + \left(\frac{1}{32} \times 5\right)$$

$R = \frac{31}{16}$  (Source - 1)  
 2



$\therefore x_1 = 11 (1/6)$   
 $x_2 = 10 (1/6)$   
 $x_3 = 011 (1/6)$   
 $x_4 = 010 (1/6)$   
 $x_5 = 001 (1/6)$   
 $x_6 = 000 (1/6)$

$R = \sum_{i=1}^L p_i q_i$   
 $= \left( \frac{1}{6} \times 2 \right) + \left( \frac{1}{6} \times 2 \right) + \left( \frac{1}{6} \times 3 \right)$   
 $+ \left( \frac{1}{6} \times 3 \right) + \left( \frac{1}{6} \times 3 \right) + \left( \frac{1}{6} \times 3 \right)$

$R = \frac{8}{3}$  (Source-2)

```
% Part (b)
load('discreteSources.mat')
S1_arr = ["0" "10" "110" "1110" "11110" "11111"];
S1
```

```
S1 = 1×1000000
    1    1    3    1    1    4    2    1    1    1    3    1    1...
```

```
bit_str_1 = join(S1_arr(S1), '');
bit_str_1
```

```
bit_str_1 =
"001100011101000011000100110100000111100000010011001111010111101110001001111010100011010100001000110111010010011001"
```

```
S2_arr = ["11" "10" "011" "010" "001" "000"];
S2
```

```
S2 = 1×1000000
    2    5    5    2    4    5    3    5    3    1    5    5    6...
```

```
bit_str_2 = join(S2_arr(S2), '');
bit_str_2
```

```
bit_str_2 =
"100010011001000101100101111001001000100110110101101110010011001011000011011000100110010010110010111011110111100100"
```

```
% Part (c)
disp('Calculating Menc/M and R for both the sources -> ');
```

Calculating Menc/M and R for both the sources ->

```
disp('Source-1');
```

Source-1

```
M_enc_1 = strlen(bit_str_1);
disp(['Menc_1:', num2str(M_enc_1)]);
```

Menc\_1:1935764

```
M_1 = 1e6;
disp(['M_1 :', num2str(M_1)]);
```

M\_1 :1000000

```
R_S1_1 = M_enc_1/M_1;
disp(['Menc/M :', num2str(R_S1_1)]);
```

Menc/M :1.9358

```
R_1 = 31/16;
disp(['R_1(sum(pk*nk)) :', num2str(R_1)]);
```

```
R_1(sum(pk*nk)) :1.9375
```

```
disp('Source-2');
```

```
Source-2
```

```
M_enc_2 = strlen(bit_str_2);  
disp(['Menc_2:',num2str(M_enc_2)]);
```

```
Menc_2:2666551
```

```
M_2 = 1e6;  
disp(['M_2 :',num2str(M_2)]);
```

```
M_2 :1000000
```

```
R_S2_2 = M_enc_2/M_2;  
disp(['Menc/M :',num2str(R_S2_2)]);
```

```
Menc/M :2.6666
```

```
R_2 = 8/3;  
disp(['R_2(sum(pk*nk)) :',num2str(R_2)]);
```

```
R_2(sum(pk*nk)) :2.6667
```

```
% Part (d)
```

```
disp('Source-1');
```

```
Source-1
```

```
eta_S1_1 = H_S_1/R_S1_1;  
disp(['Efficiency(Simulated):',num2str(eta_S1_1)]);
```

```
Efficiency(Simulated):1.0009
```

```
eta_S1_2 = H_S_1/R_1;  
disp(['Efficiency(Theoretical):',num2str(eta_S1_2)]);
```

```
Efficiency(Theoretical):1
```

```
disp('Source-2');
```

```
Source-2
```

```
eta_S2_1= H_S_2/R_S2_2;  
disp(['Efficiency(Simulated):',num2str(eta_S2_1)]);
```

```
Efficiency(Simulated):0.9694
```

```
eta_S2_2 = H_S_2/R_2;  
disp(['Efficiency(Theoretical):',num2str(eta_S2_2)]);
```

Efficiency(Theoretical):0.96936

```
% Part (e)
% Now randomizing the codeword attached to random probability
disp('Now attaching random codeword with random probability');
```

Now attaching random codeword with random probability

```
S1_arr = ["10" "11110" "1110" "0" "11111" "110"];
S1
```

S1 = 1×1000000

1	1	3	1	1	4	2	1	1	1	3	1	1...
---	---	---	---	---	---	---	---	---	---	---	---	------

```
bit_str_1 = join(S1_arr(S1), '')
```

```
bit_str_1 = "1010111010100111101010101110101011110101110101010101111101010101011110101110101111111011111010101111010111."
```

```
S2_arr = ["001" "011" "10" "11" "000" "010"];
S2
```

S2 = 1x1000000

2	5	5	2	4	5	3	5	3	1	5	5	6...
---	---	---	---	---	---	---	---	---	---	---	---	------

```
bit_str_2 = join(S2_arr(S2), '')
```

```
bit_str_2 =
"0110000000111110001000010001000000010011101011001100111110000100101010010011100000001000010001100011001111010000101
```

```
disp( 'Source-1' );
```

Source-1

```
M_enc_1 = strlen(bit_str_1);  
disp(['Menc_1:', num2str(M_enc_1)]);
```

Menc\_1:3062207

```
R_S1_1 = M_enc_1/M_1;  
disp(['Menc/M(S1) :',num2str(R_S1_1)]);
```

Menc/M(S1) :3.0622

```
R_S1_2=98/32;  
disp(['R_1(sum(pk*nk)) :', num2str(R_S1_2)]);
```

```
R_1(sum(pk*nk)) :3.0625
```

```
disp( 'Source-2' );
```

Source-2

```
M_enc_2 = strlen(bit_str_2);  
disp(['Menc_2:', num2str(M_enc_2)]);
```



Menc\_2:2666945

```
R_S2_1 = M_enc_2/M_2;  
disp(['Menc/M(S2) :',num2str(R_S2_1)]);
```

Menc/M(S2) :2.6669

```
R_S2_2=8/3;  
disp(['R_2(sum(pk*nk)) :',num2str(R_S2_2)]);
```

R\_2(sum(pk\*nk)) :2.6667

```
disp('Source-1');
```

Source-1

```
eta_S1_1 = H_S_1/R_S1_1;  
disp(['Efficiency(Simulated):',num2str(eta_S1_1)]);
```

Efficiency(Simulated):0.63271

```
eta_S1_2 = H_S_1/R_S1_2;  
disp(['Efficiency(Theoretical):',num2str(eta_S1_2)]);
```

Efficiency(Theoretical):0.63265

```
disp('Source-2');
```

Source-2

```
eta_S2_1 = H_S_2/R_S2_1;  
disp(['Efficiency(Simulated):',num2str(eta_S2_1)]);
```

Efficiency(Simulated):0.96926

```
eta_S2_2 = H_S_2/R_S2_2;  
disp(['Efficiency(Theoretical):',num2str(eta_S2_2)]);
```

Efficiency(Theoretical):0.96936