- Let the source symbols in the order of decreasing probabilities
  - **S=**$\{s_{1,}s_{2,}s_3 \dots \dots . s_q$**)**
  - **P=**$\{p_{1,}p_{2,}p_3 \dots \dots . p_q$**).**
  - $p_1 \geq p_2 \geq p_3 \dots \dots . \geq p_q$
- Compute the sequence
  - α_1**=0**
  - α_2**=**$p_1 = p_{1+}\alpha_1$
  - $\alpha_3 = p_2 + p_1 = p_2 + \alpha_2$
  - $\alpha_4 = p_3 + p_2 + p_1 = p_3 + \alpha_3$
  - $\alpha_{q+1} = p_q + \alpha_q = 1$

- Determine the smallest integer for l_i (length of code word) using the inequality
  - $2^{l^i} \geq \frac{1}{p_i}$ **for all i=1 to q**
- Expand the decimal numbers α_i in binary form up to l_i places neglecting the expansion beyond l_i places.
- Remove the decimal point to get the desired code.

- **Code efficiency:** The average length 'L' of any code is given by $\boldsymbol{L = \sum_{i=1}^{q} p_i L_i}$ where $L_i = l_1 l_2 l_3 l_4 \ldots \ldots . l_q$
- Code efficiency, $\boldsymbol{\eta_c = \frac{H(S)}{L} * 100}$

- **Ex: 1**. Construct the Shannon's binary code for the following message symbols S=(s_1, s_2, s_3, s_4) with probabilities P=(0.4, 0.3,0.2,0.1).
- Solution:
- ***0.4 > 0.3 > 0.2 > 0.1***

$$\alpha_0 = 0,$$
$$\alpha_1 = 0.4$$
$$\alpha_2 = 0.4+0.3=0.7$$
$$\alpha_3 = 0.7+0.2=0.9$$
$$\alpha_4 = 0.9 + 0.1 = 1.0$$

$$2^{-l_1} \le 0.4 \rightarrow l_1 = 2$$
$$2^{-l_2} \le 0.3 \rightarrow l_2 = 2$$
$$2^{-l_3} \le 0.2 \rightarrow l_3 = 3$$
$$2^{-l_4} \le 0.1 \rightarrow l_4 = 4$$

$$\alpha_0 = 0 = 0.00\,|\underline{0}$$
$$\alpha_1 = 0.4 = 0.01\,|\underline{10}$$
$$\alpha_2 = 0.7 = 0.101\,|\underline{10}$$
$$\alpha_3 = 0.9 = 0.1110\,|\underline{01}$$

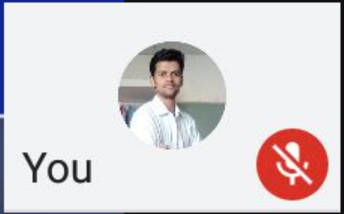
0.4×2
0.8×2 → 0
1.6 → 1
0.6×2
1.2 → 1
0.2×2
0.4 → 0
$\Rightarrow$ 0.0110....

0.7×2
1.4 → 1
0.4×2
0.8×2 → 0
1.6 → 1
0.6×2
1.2 → 1
0.2×2
0.4×2 → 0
0.8 → 0
$\Rightarrow$ 0.101100...

0.9×2
1.8 → 1
0.8×2
1.6 → 1
0.6×2
1.2 → 1
0.2×2 → 0
0.4×2
0.8×2 → 0
$\Rightarrow$ 0.11100...

S_i	P_i	α_i	l_i	binary	Code.
S_1	0.4	0	2	$(0.00000\cdots)_2$	00
S_2	0.3	0.4	2	$(0.01100\cdots)_2$	01
S_3	0.2	0.7	3	$(0.101100\cdots)_2$	101
S_4	0.1	0.9	4.	$(0.11100\cdots)_2$	1110

- The codes are
- ***S1*: *00, s2*: *01, s3*: *101, s4*: *1110***



- Apply Shannon’s binary encoding procedure to the following set of messages and obtain code efficiency and redundancy. 1/8, 1/16, 3/16, 1/4, 3/8
- Solution:
- 3/8>1/4>3/16>1/8>1/8