

1. a)  $p = [0.25, 0.2, 0.1, 0.1, 0.1, 0.1, 0.05, 0.05, 0.05]$

$$\text{Entropy} = \sum_i p_i \log_2 \frac{1}{p_i} \approx 2.941$$

b) p	0.25	0.2	0.1	0.1	0.1	0.1	0.05	0.05	0.05
Code1	10	00	010	011	1100	1101	11100	11101	1111
Code2	11	101	011	010	001	1001	1000	0001	0000

c) rate of code1 & code2 = 3

$\beta \approx 2.941$  so the rate and entropy are almost same

2. a) A, B, C, E

$p$  is not uniquely decodable ( $'10110' \rightarrow '10', '110'$ )  
 $\searrow$   
 $\rightarrow '1011', '0'$ )

Is not uniquely decodable ('00100'  $\rightarrow$  '0', '0', '100')  
 $\searrow$  '001', '0', '0')

b) A, C, E

c) average length of  $A \rightarrow 3$ ,  $B \rightarrow 2.125$ ,  $C \rightarrow 2.125$ ,  $E \rightarrow 2$

3.	symbol	2	3	4	5	6
	prob	1/11	4/11	3/11	1/11	2/11
	code	100	00	01	101	11

Thus the sequence  $\{2, 3, 3, 3, 4, 4, 4, 5, 6, 6\} \rightarrow 1000000000$  (2, 3, 3, 3)

010101101111 (4.4.4.5.6.6)

4,  $\begin{matrix} (00) & (110) & (100) & (010) & (011) & (1010) & (11100) & (11101) & (10110) & (10111) & (11110) & (11111) \\ S1 & S2 & S3 & S4 & S5 & S6 & S7 & S8 & S9 & S10 & S11 & S12 \end{matrix}$

0.20 0.18 0.10 0.10 0.10 0.66 0.06 0.04 0.04 0.04 0.04 0.04

Diagram illustrating the relationship between reciprocal lattice points and real space planes. The points are labeled with their coordinates in reciprocal space (h, k, l) and their corresponding real space plane indices (h, k, l):

- $0.20$  (01)
- $0.10$  (110)
- $0.08$  (101)
- $0.08$  (111)
- $0.14$  (101)
- $0.40$  (0)
- $0.24$  (10)
- $0.18$  (111)
- $0.36$  (11)
- $1.00$
- $0.66$  (1)

4. symbol	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s12
code	00	10	100	010	011	1010	1100	1110	1011	1011	1111	1111

5. a) symbol	0	50	20	99
prob	1/2	1/4	1/8	1/8

Entropy = 1.75

b)	(0)	(10)	(110)	(111)	symbol	0	50	20	99
	0	50	20	99	code	0	10	110	111
	1/2	1/4	1/8	1/8					

Diagram showing binary tree structure for Huffman coding:

- Root node splits into (0) with probability 1/2 and a subtree with probability 1/2.
- The subtree splits into (10) with probability 1/4 and a subtree with probability 1/4.
- The subtree splits into (110) with probability 1/8 and (111) with probability 1/8.
- Intermediate nodes are labeled: 1/2 (1) and 1/4 (11).

c) average bit rate = 1.75 = Entropy

Q. 1125 horizontal lines with 16:9 aspect ratio

→ width =  $1125 \times (16/9) = 2000$

Bits needed for 2 hour = interlacing

$(2000 \times 1125 / 2)$  pixel/frame ×

$(30 \text{ frame/sec} \times 24 \text{ bits/pixel} \times (2 \times 60 \times 60) \text{ sec})$

=  $1.1664 \times 10^{13}$  bits