Question 1

(a) Explain what is meant by the term *lossless* as applied to a data compression scheme and give an example of an image compression application which requires lossless encoding.

[4 vidmarks]

(b) Explain what is meant by the terms *spatial redundancy, temporal redundancy* and *perceptual redundancy* in the context of still images and video sequences.

[8 vidmarks]

(c) Give an example of an international standard for lossless compression of still images. Describe its operation, outlining how it exploits spatial redundancy.

[8 vidmarks]

***(d) "Source coding is in itself a lossless process but it is an integral part of any lossy compression scheme."* Explain what is meant by this statement.**

[5 vidmarks]

Question 2

(a) Consider the 8×8 block of pixels in Figure 1. This can be considered to be an information source in which the symbols are the grey level values which occur in the block. Give the formula for calculating the entropy of an information source and calculate the entropy of the pixel block in Figure 1.

255	100	100	127	170	250	250	255
255	100	100	127	170	250	250	255
255	100	100	127	170	250	250	255
255	100	100	127	170	250	250	255
255	100	100	100	170	250	250	255
255	100	100	100	170	250	250	255
255	255	255	255	255	255	255	255
255	255	255	255	255	255	255	255

Figure 1: An 8×8 block of pixel values

[4 vidmarks]

(b) Construct a Huffman tree for the grey levels which occur in the 8×8 block of pixels in Figure 1. Using the tree calculate the Huffman codewords for this information source and comment on their efficiency.

[7 vidmarks]

(c) Using example information sources, explain why Huffman coding is not 100% efficient in general. Explain using another example information source how symbols can be grouped in Huffman coding in order to produce more efficient coding. Explain how this leads to a statement of Shannon's Noiseless Coding Theorem and outline the implications for an encoding process.

[12 vidmarks]

(d) List two different mechanisms for parsing and decoding variable length codewords (VLCs). Note: you do NOT have to describe either approach.

[2 vidmarks]

Question 3

(a) Briefly describe how the following transformations or properties affect the coefficients of the Fourier Series representation of a periodic function with period L:

1. **Spatial shift of waveform**
2. **Amplitude shift of waveform**
3. **Waveform even/odd symmetry**
4. **Waveform translational symmetry**
5. **Waveform discontinuities or discontinuities of its derivatives**

[8 vidmarks]

(b) Explain how the previously mentioned properties of the Fourier Series expansion of periodic functions can be used to develop the 1-D discrete cosine transform (DCT) of a 1-D block of data samples taken from a non-periodic sampled signal. Explain why discrete cosine transforms are in general preferred to discrete sine transforms.

[9 vidmarks]

(c) Compare and contrast the DCT with the discrete Hadamard transform. Also comment on the possibilities for "fast" versions of the respective transforms.

[8 vidmarks]

Question 4

(a) Discuss how properties of the human visual system can be relevant to the design of transform-based video coding schemes. Support your response by reference to particular video coding schemes if possible.

[8 vidmarks]

(b) Distinguish between the design of a scalar quantization process using the Lloyd-Max approach, the companding approach and the optimum uniform quantizer approach. Discuss the issues surrounding algorithms for allocating bits to quantized transform coefficients.

[9 vidmarks]

(c) Outline the structure of the video compression layer of the ISO MPEG-1 digital audio/video coding standard, explaining the role played by each component process. You should specifically mention in your response the relationships between I, P and B frames and how their presence can affect subsequent editing of compressed video.

[8 vidmarks]

Question 5

(a) Describe three advantages of coding arbitrarily-shaped video objects as oppose to rectangular frames of video.

[6 vidmarks]

(b) Explain the method used for encoding Binary Alpha Blocks (BABs) in MPEG-4. Your answer should describe how a pixel's neighbourhood is used in the process and should list and describe the different coding modes possible for a BAB. Use diagrams in order to illustrate your explanation.

[12 vidmarks]

(c) Explain what is meant by *a scalable bitstream*. Describe *temporal scalability* in the context of the MPEG-4 coding standard. Illustrate your answer with a diagram indicating one of the two types of temporal scalability possible and the types of Video Object Planes (VOPs) used in each layer.

[7 vidmarks]

Question 6

(a) Using a block diagram, sketch the structure of a typical video encoder and briefly explain its operation.

[6 vidmarks]

(b) Describe two different search strategies which could be used in a motion estimation process. Use diagrams to illustrate your description.

[8 vidmarks]

(c) Specify a set of operational parameters for each strategy you listed in part (b) above and compare the computational complexity of each approach for an $N \times M$ block of pixels under the following conditions:

- **you should assume that for each pixel location there are three operations;**
- **you should ignore the computational cost of accessing pixel data.**

[8 vidmarks]

(d) Must a particular motion estimation search strategy be specified in a video compression standard? Why?

[3 vidmarks]