THE UNIVERSITY OF AUCKLAND

SECOND SEMESTER, 2009
Campus: Tamaki

COMPUTER SCIENCE

Data Communications Fundamentals

(Time allowed: 45 minutes)

NOTE:

- Attempt *all* questions in the space provided.
  Extra space for answers is available on page 6.
- This mid-semester test will contribute 15% to your overall course mark.
  Indicated marks are out of a total of 100 marks.
- *If you require additional information in order to answer a question, you should make a reasonable assumption as required for your answer, and you should explain your assumption on your script.*

Surname: .... Forenames: ....

Student ID: ....

Question	*Possible marks*	*Awarded marks*
Codes	45	
Signal-to-noise ratio	20	
Compression	35	
Total	100	

Student ID: ....

Codes a) What is a code? [5 marks]

A code is the assignment of a unique string of characters (a codeword) to each character in an alphabet.

b) What is a prefix code? What is a uniquely decodable code? [10 marks]

A prefix code (or prefix-free code) is a code in which no codeword is a proper prefix of another codeword.
A code is uniquely decodable if the encoding of every possible cleartext using that code is unique.

c) Give an example of a uniquely decodable code which is not a prefix code.
Justify your answer. [10 marks]

The code $\{10, 1011\}$ is uniquely decodable because any finite sequence of codewords can be uniquely split into 10 and 1011. It is not a prefix code (10 is a proper prefix of 1011).

d) Is ASCII a prefix code? Justify your answer. [5 marks]

ASCII is a prefix code because each codeword has a fixed length.

e) State Kraft's theorem. [5 marks]

A prefix code exists for codewords lengths $l_1, l_2, \ldots, l_N$ if and only if

$$2^{-l_1} + 2^{-l_2} + \cdots + 2^{-l_N} \leq 1.$$

Student ID: ....

f) Does there exist a prefix binary code whose codewords lengths are exactly: 100, 2, 1, 2? Justify your answer. [10 marks]

$2^{-100} + 2^{-2} + 2^{-1} + 2^{-2} = 2^{-100} + \frac{1}{4} + \frac{1}{2} + \frac{1}{4} = 2^{-100} + 1 > 1$, so the numbers 100, 2, 1, 2 do not satisfy the inequality in Kraft's theorem, hence there is no prefix binary code whose codewords lengths are exactly: 100, 2, 1, 2.

Signal-to-noise ratio a) What is the signal-to-noise ratio? [5 marks]

The signal-to-noise ratio is the ratio S/N, where S is the signal power and N is the noise power.

b) Define the bit rate and the bandwidth. [5 marks]

The bit rate describes a medium's capacity. The range of frequencies a medium can pass is called bandwidth.

c) In a noisy transmission, what is the relation between bite rate and signal-to-noise ratio? [10 marks]

In a noisy transmission, bit rate $=$ bandwidth $\times \log_2(1 + S/N)$.

Student ID: . . . .

Compression Assume that you wish to compress a large file consisting entirely of strings of lower-case letters (26), the digits 0,1,2,3,4,5,6,7,8,9 and the symbols \$, #.

a) What is a fix-length code? [5 marks]

A fix-length code is a code using codewords of a given fixed length.

b) How many bits do you need to store a file with n characters using an 8-bit (fix-length) code? [5 marks]

The code uses 8 bits to code each character, so if the file has n characters each stored as an 8-bit code you need $8n$ bits.

c) Can you reduce the size of the fix-length code for the file assumed above? Present your solution and calculate the size of the compressed file. How much size reduction (percentage) have you obtained? [10 marks]

The file uses 26 + 10 + 2 = 38 characters, so with a 6-bit code one can code $2^6 = 64 > 38$ characters. A file with n characters will be coded by $6n$ bits, so the size reduction is (from $8n$ to $6n$) 25%.

d) Can you compress the file with the Baudot code? Justify your answer. [10 marks]

Yes, it is possible because $38 < 64 = 2^5 \times 2$ which is the maximal number of characters we can code with a 5-bit code using the extra information 11111 (shift down) and 11011 (shift up).

Student ID: . . . .

e) The Baudot code is a 5-bit code. How can you compress the file with only a 5-bit code?

[5 marks]

The Baudot code is a 5-bit code using the special extra information 11111 (shift down) and 11011 (shift up).

Student ID: . . . .

Student ID: . . . .