Student ID: ……..

EXAMINATIONS — 2009

MID-YEAR

ENGR101

ENGINEERING TECHNOLOGY

Time allowed:

3 Hours

Instructions:

1. You must answer **ALL** questions.
   Answer in the appropriate boxes if possible — if you write your answer elsewhere, make it clear where your answer can be found.
   The exam will be marked out of 150 marks.
2. Non-programmable calculators without a full alphabetic key pad are permitted.
3. Non-electronic foreign language dictionaries are permitted.
4. There is an appendix containing Assembly Language instructions at the end of the paper, which you may tear off.
5. There are spare pages for your working and your answers in this exam.

Questions

	Marks
1. Binary Numbers	[9]
2. Logic	[10]
3. Adders & ALU	[16]
4. Software	[20]
5. Operating systems	[12]
6. The Internet	[13]
7. Product and System Design	[6]
8. Waves and Sound	[14]
9. ADC and DAC	[9]
10. Image Technology	[9]
11. Data Compression	[9]
12. Data Encoding	[8]
13. Engineering practice	[15]

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Specify the question number for work that you do want marked.

Question 1. Binary Numbers **[9 marks]**

(a) [2 marks] Write -74 as a 12-bit two's complement number. Show your working or explain your method as appropriate.

(b) [7 marks] Calculate 29-74 using 12-bit 2's complement arithmetic.

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Question 2. Logic **[10 marks]**

(a) [5 marks] Draw a circuit to implement the operation $Y = (A + B)(\overline{A} + AC)B$

(b) [5 marks] Simplify the expression for Y in question 2(a) using the rules of Boolean algebra.

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Question 3. Adders and ALU's **[16 marks]**

(a) [5 marks] A full adder takes two input signals A and B, as well as a carry-in signal from the previous stage of the adder. Draw a truth table for the sum and carry-out signals generated by a full adder.

(b) [3 marks] Write a Boolean expression for the carry out signal of the full adder.

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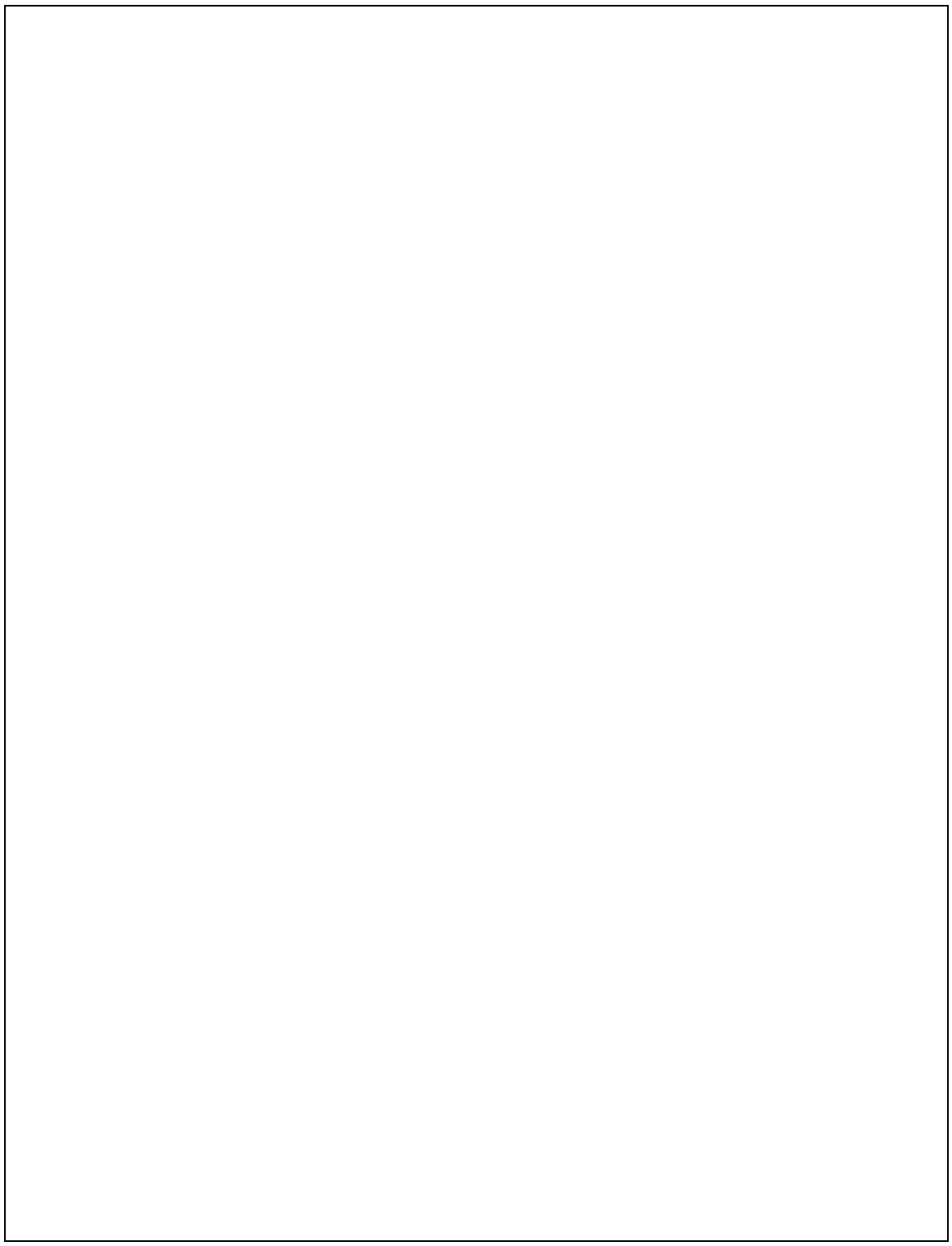
(c) [2 marks] Draw a circuit to implement the expression that you derived in part b.



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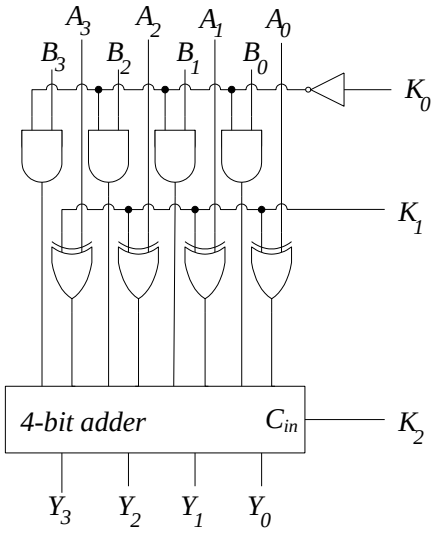
(d) [6 marks] A simplified circuit of an ALU is shown. What values for K_0, K_1 and K_2 would you set if you wanted the circuit to implement Y = -A? Note that both Y and A are 4-bit numbers.

Explain your reasoning.



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Question 4. Software. **[20 marks]**

(a) [2 marks] Does every machine language instruction have a microcode equivalent? Can you give an example of one from the Knob and Switch computer machine language set.

(b) [2 marks] What are the advantages of mixing code and data in the same memory area rather than having them in separate areas?

(c) [4 marks] Briefly explain the purpose of an assembler and discuss whether there is always a one-to-one mapping between each assembly instruction and machine instruction.

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(d) [4 marks] Consider the assembly language program below. Compute the final value of R0. What is the final value as a function of the initial values of R0 and R2.

Assume that R0 initially contains the value 5, R1 initially contains the value 1, R2 contains the value 4 and R3 contains the value 2.

0: ADD R0 R0 R3
1: SUB R2 R2 R1
2: BZERO 4
3: BRANCH 0
4: HALT

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(e) [5 marks] Write an assembly language program that computes the larger of two values. The first value is stored in memory location 20, the second value is stored in memory location 21 and the larger value should be stored in memory location 22. Either value is okay is they are equal.

(f) [3 marks] Construct the symbol table for the following assembly language program. Assume that code starts at memory location **15** and data at memory location **110**.

```
0: LOAD R0 a
1: LOAD R1 b
loop:
2: ADD R0 b R0
2: STORE a R0
3: BRANCH loop
4: HALT
```

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Question 5. Operating Systems. **[12 marks]**

(a) [2 marks] List four main functions of an operating system.

(b) [3 marks] Consider the HACK computer architecture. Remember that this is a simple computer that uses memory mapped IO to communicate with the keyboard and the screen. What Briefly describe the steps involved in reading a character from the keyboard? Consider the role of the CPU, the I/O controller, display memory and the display itself.

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(c) [2 marks] Briefly explain how it can appear that multiple programs are running simultaneously although a computer may only have a single core CPU?

(d) [5 marks] Why are device drivers separate from the operating system kernel in modern operating systems?

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Question 6. The Internet. **[13 marks]**

(a) [5 marks] Consider two computers on the same network that begin transmitting an Ethernet frame at the same time. Briefly explain what happens and how further collisions are avoided.

(b) [3 marks] Explain why adding more computers connected by a switch will **not** cause as much of as a drop in the number of successfully transmitted frames as connecting them with a hub.

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(c) [5 marks] Why would you choose to transmit a movie as interleaved video and audio packets as opposed to sending all the video followed by all the audio? Are there any downsides of interleaving?

(d) [3 marks] When sending packets, computers do not use human readable addresses like www.victoria.ac.nz. Describe the type of address computers use and briefly explain how the computer translates between the human readable address and the address that it uses.

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Question 7. Product and System design **[6 marks]**

(a) [2 marks] List at least 4 issues that you would need to deal with when designing a product.

What is the real need?
Who is it for?
What is the benefit?
Is it legal or ethical?
What implementation steps are required?
What key technologies are required?

(b) [2 marks] Briefly describe one product on the market with reference to a technical specification that was important to the success of the product.

One example referring to a spec such as:

•Physical (size, weight, materials)
•Technical (electrical, electronic, mechanical, software)

(c) [2 marks] Give one example of a product on the market that was designed with regard to human sensory systems and briefly describe the technical aspect and how it relates to our senses.

Printers, displays, audio systems etc

Vision and audio perception.

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Question 8. Waves and Sound **[14 marks]**

(a) [3 marks] A wave is described by the equation below. Find the wavelength, frequency and speed of the wave, $y = 12\sin(0.25x - 2t + \pi)$, where t is in seconds and x is in metres.

$y = A\cos\left(\frac{2\pi x}{\lambda} \pm \frac{2\pi t}{T} + \phi\right)$ $0.25 = \frac{2\pi}{\lambda}$ $\lambda = 8\pi$ metres

$2 = \frac{2\pi}{T}$ $T = \pi$ seconds $F = \frac{1}{T} = \frac{1}{\pi}$ Hz

Speed is $\frac{\lambda}{T} = 8$ ms^{-1}

(b) [1 mark] Write the function of a wave that would cancel this wave.

$y = 12\sin(0.25x - 2t)$

(c) [2 marks] Describe what you would hear if two sound waves of equal amplitude at 1000Hz and 1010Hz were combined together.

A 10Hz beat

(d) [2 marks] Sketch what the combined wave would look like as a function of time.

A 1kHz wave with 10Hz amplitude modulation

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(e) [2 marks] Sketch the power spectrum of the combined waves.

Two equal peaks, 1000Hz and 1010Hz

(f) [2 marks] Explain briefly why, for the same note played, a clarinet sounds different to a flute.

Different harmonic content.

(g) [2 marks] Calculate the wavelength of the FM radio station at 90.6MHz. Note that the speed of light is 3 x 10^8 ms^{-1}.

$\lambda = \frac{3\times10^8}{90.6\times10^6}$=3.3m

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Question 9. ADC and DAC **[9 marks]**

(a) [2 marks] 16-bit digital data will be converted to analogue data by a DAC. If the range of the signal is to be -1 to +1 volts, what will be the voltage resolution?

V = 2Volts divided by $(2^{16} -1) = 30.5 \times 10^{-6}$ Volts

or

V = 2Volts divided by $(2^{16}) = 30.5 \times 10^{-6}$ Volts

(b) [2 marks] What sample rate would be required to adequately digitize the sound of a musical instrument that has a frequency range from 500Hz to 6kHz?

12kHz

(c) [5 marks] What type of filters are often used in the A-D and D-A conversion processes? Explain briefly what the filters do.

Lowpass.

One is used as an anti-aliasing filter in the A-D process and the other is used as a reconstruction filter in the D-A process.

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Question 10. Image technology **[9 marks]**

(a) [3 marks] Explain how RGB displays can fool the eye into seeing colours that are not present.

The 3 emitters (RGB) stimulate the corresponding cones in the eye. If the pixel size is small enough the eye can't resolve the individual colours and will perceive just a single colour.

(b) [3 marks] How many different colours could be represented if the amounts of red, green, and blue data are each represented by 6 bits?

2^{18}

(c) [3 marks] The resolution of the human eye is $3x10^{-4}$ radians, design a screen size (width and height) that can be viewed from half a metre and still give an image that appears continuous. The image is 1024 x 768 pixels.

$H/D = 3x10^{-4}$

D = 0.5m therefore H the pixel size can be 150um max

1024 x 150um = 154mm wide and 768 x 150um = 115mm high

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Question 11. Data Compression **[9 marks]**

(a) [3 marks] Describe briefly the principle behind data compression.

Data compression works by reducing the redundancy in the data that is used to encode information and sometimes the information itself can be reduced without a significant reduction in quality.

(b) [3 marks] Compress the following data stream by using pairs of bits.
10000100100000101100010

10 00 01 00 10 00 01 01 10 00 10 =22bits

00:0, 10:10, 01:110, 11:111

10 0 110 0 10 0 110 110 10 0 10 =21bits

(c) [3 marks] Explain what lossy data compression means. Under what circumstances can lossy compression be used? Give an example of a file type that uses lossy compression.

Lossy data compression refers to a reduction in the information content. Lossy compression can be used when any loss in information won't result in adverse effects. Very good with images and audio.

JPEG

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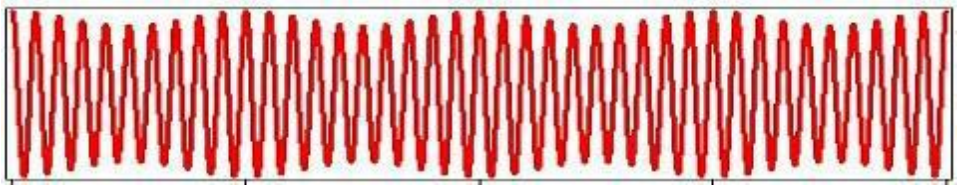
Question 12. Data Encoding **[8 marks]**

(a) [3 marks] Briefly describe with the aid of a diagram, how information can be encoded on a wave using Amplitude Modulation (AM).

The amplitude of the carrier wave is made to have an envelope that follows the signal wave.



(b) [2 marks] What is the main advantage of Frequency Modulation (FM) over Amplitude Modulation (AM)?

FM is less susceptible to interference

(c) [3 marks] Briefly describe the relationship between data transmission bit rate and the bandwidth of the signal.

Switching on and off a carrier results in the spreading of the spectral line in the frequency spectrum. For high data rates we need to switch the carrier more rapidly. The faster the switching rate the broader the spectral line and hence greater use of the spectrum.

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Question 13. Engineering Practice **[15 marks]**

(a) [5 marks] You are a professional engineer working in industry. One of your friends asks you to help her put an extra power point in her house. You have some knowledge about wiring, but you think that adding a single power point would be pretty straightforward. What should you think about before replying to your friends request for help?

What are the legal issues regarding electrical work. In other words, what am I allowed to do. Even if I am allowed to do it, am I competent and can I guarantee the safety of the house occupiers. If you are not sure then you should advise your friend to contract a licensed electrician.

(b) [5 marks] Briefly discuss the ramifications of engineering being a self-regulating profession

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