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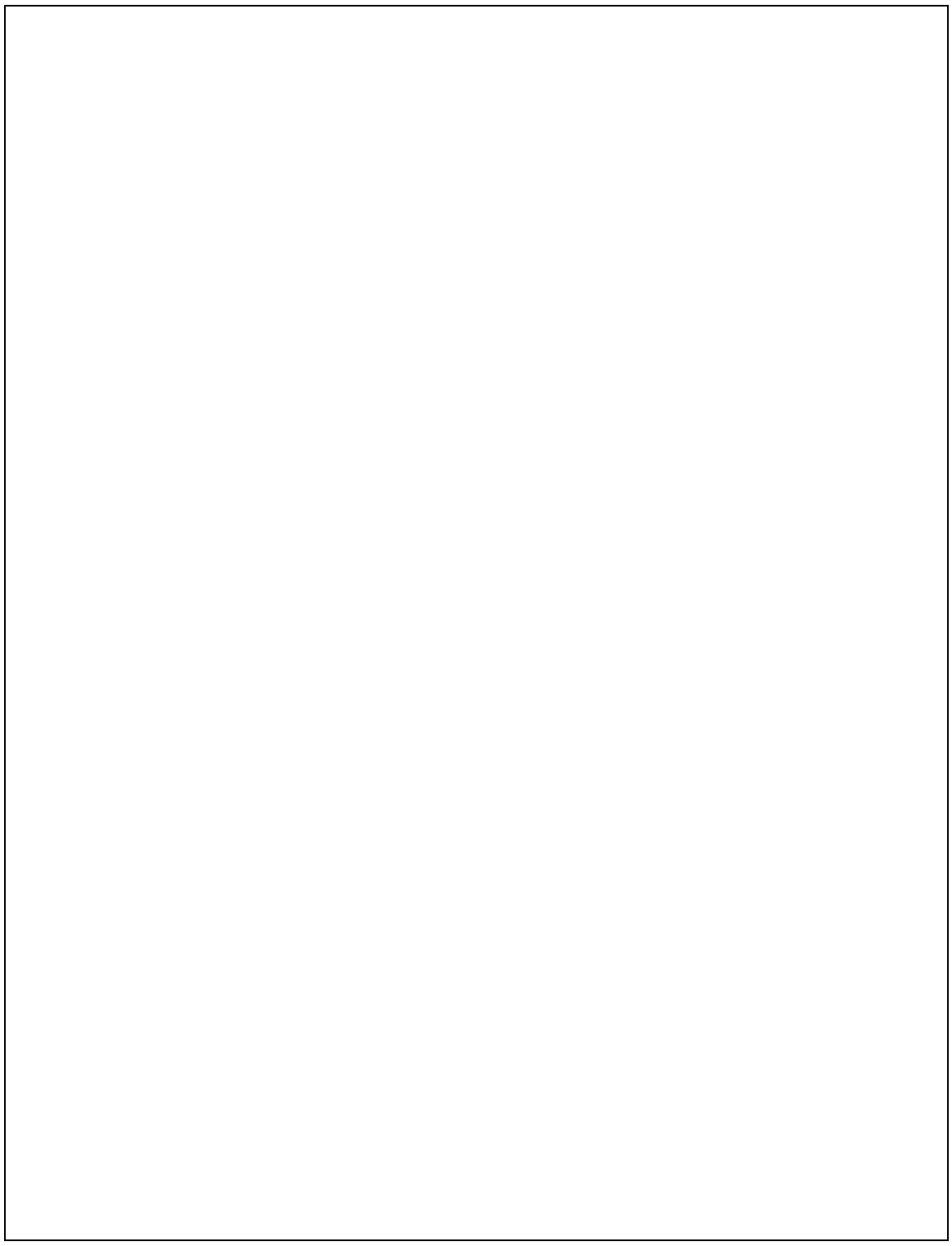
(c) [2 marks] Draw a circuit to implement the expression that you derived in part b.



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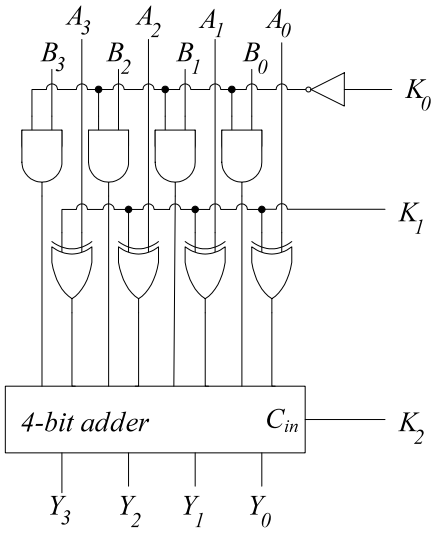
(d) [6 marks] A simplified circuit of an ALU is shown. What values for K_0, K_1 and K_2 would you set if you wanted the circuit to implement Y = -A? Note that both Y and A are 4-bit numbers.

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.

(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.

(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.

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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.

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

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

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

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

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

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

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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?

(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?

(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.

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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.

(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?

(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.

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

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

(b) [3 marks] Compress the following data stream by using pairs of bits.
10000100100001011000 1

(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.

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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).

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

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

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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?

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

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(c) [5 marks] You work for a company that builds network switches. Your analysis suggests that the switches might catch fire when a rare set of conditions are met. You have raised the potential problem, but the chief technical officer of the company has assured you that everything will be fine and asks you to sign off on the design so that manufacturing of the switches can begin. What might you do?

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APPENDIX: ASSEMBLY LANGUAGE INSTRUCTIONS

Data Movement Instructions:	**Example:**	**Meaning:**
LOAD [REG] [MEM]	LOAD R2 13	R2 = M[13]
STORE [MEM] [REG]	STORE 8 R3	M[8] = R3
MOVE [REG1] [REG2]	MOVE R2 R0	R2 = R0
Arithmetic and Logic Instructions:	**Example:**	**Meaning:**
ADD [REG1] [REG2] [REG3]	ADD R3 R2 R1	R3 = R2 + R1
SUB [REG1] [REG2] [REG3]	SUB R3 R1 R0	R3 = R1 - R0
AND [REG1] [REG2] [REG3]	AND R0 R3 R1	R0 = R3 & R1
OR [REG1] [REG2] [REG3]	OR R2 R2 R3	R2 = R2 | R3
Branching Instructions:	**Example:**	**Meaning:**
BRANCH [MEM]	BRANCH 10	PC = 10
BZERO [MEM]	BZERO 2	PC = 2 IF ALU RESULT IS ZERO
BNEG [MEM]	BNEG 7	PC = 7 IF ALU RESULT IS NEGATIVE
Other Instructions:	**Example:**	**Meaning:**
NOP	NOP	Do nothing.
HALT	HALT	Halt the machine.