



## EXAMINATIONS - 2007

### MID YEAR

**ENGR 101**  
**ENGINEERING TECHNOLOGY**

Time allowed: **THREE** hours

Instructions: Answer **ALL** questions. Total marks 150.

Non-programmable, non-alphanumeric calculators are permitted.

**1. Binary numbers**

(a) Convert 39 to 7-bit binary plus a sign bit.

[2 marks]

(b) Convert the binary number (7-bits plus a sign bit) 10011011 to base-10.

[2 marks]

(c) Using 7-bit binary plus a sign bit, use 1's complement addition to perform the calculation  $39 - 27$ .

[6 marks]

**2. Thermal Images**

(a) Above what temperature do objects begin to emit blackbody radiation?

[2 marks]

(b) Why do objects around us not appear to glow?

[2 marks]

(c) Temperature data (temperatures at various spots) is to be displayed as a grey scale image. The temperatures will vary from 0 C to 100 C, and a resolution of 0.1 C is required for the data. Will standard 8-bit (256 level) grey scale images be good enough? If not, how many bits of grey scale level will be needed?

[2 marks]

(d) If you use a grey scale image with more than 256 levels to represent the above temperature data, will differences between two levels (say 100 and 101) be visible to the eye?

[2 marks]

(e) How could the temperature data be converted to 8-bit for display on a monitor?

[2 marks]

(f) State an application of infrared imaging.

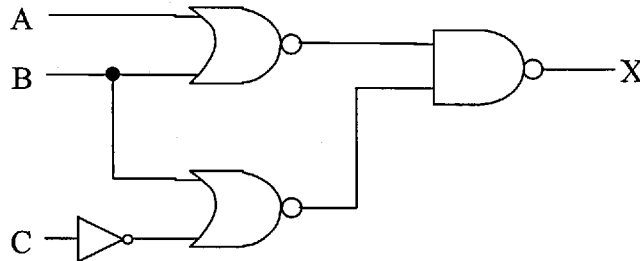
[2 marks]

3. **Logic circuits**

(a) Write down the truth tables for (i) a NAND gate; (ii) a NOR gate.

[4 marks]

(b) Determine the expression for the output X from the logic circuit shown below.



[3 marks]

(c) The logic circuit in (b) represents a digital combination lock which generates a LOW unlock signal for only one combination of inputs. Determine the combination of A, B and C that gives the unlock signal.

[4 marks]

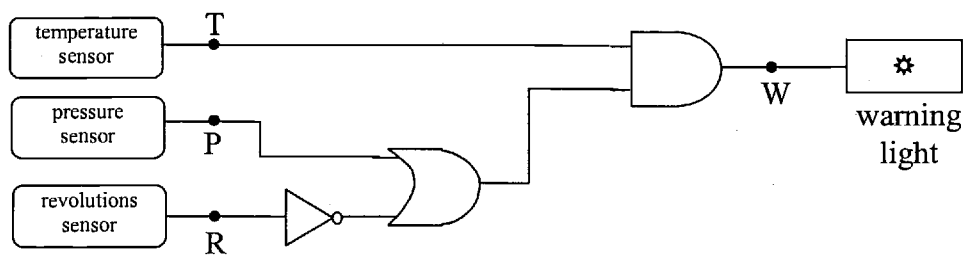
(d) A jet aircraft employs a system for monitoring the engine revolutions, pressure and temperature of each of its engines using sensors which operate as follows:

engine revolutions sensor (R) = 0 only when speed < 4800 rpm

pressure sensor (P) = 0 only when pressure < 1540 kPa

temperature sensor (T) = 0 only when temperature < 95 °C

The logic circuit which controls a cockpit warning light is shown below. Assume that W = 1 activates the warning light.



Determine the combination of engine conditions which activates the warning light.

[6 marks]

**4. Vision and Image Technology**

- (a) What are the key elements of the human retina that make colour vision possible? [2 marks]
- (b) How does RGB image technology simulate colours for the human eye? [2 marks]
- (c) The resolution of the human eye is approximately  $3 \times 10^{-4}$  radians. At a distance of 25 cm what are the smallest pixels that can be seen separately? [3 marks]
- (d) How many pixels would be required to make a 10 cm by 10 cm image appear approximately continuous at a distance of 25 cm? [3 marks]

**5. Data Compression**

We have learned that data compression is important in a bandwidth hungry world. Although there are many sophisticated data compression techniques, they can be classified as either lossless or lossy.

- (a) Explain what lossless data compression means. Under what circumstances is it likely to result in significant reduction in file size? Give an example of a file type that uses lossless compression. [3 marks]
- (b) Explain what lossy data compression means. Give an example of a file type that uses lossy compression. Under what circumstances can lossy compression be used? [3 marks]
- (c) Compress the following data stream by reporting pairs rather than individual bits as we have done in the homework.  
10001001000010110001 [3 marks]

**6. Wave maths**

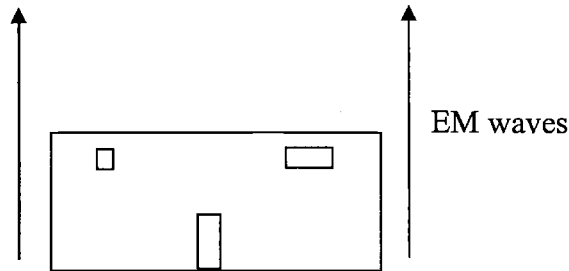
Consider the wave  $y = 9 \sin(?x + 0.3t - 1)$ , where  $x$  and  $y$  are in metres and  $t$  is in seconds. The ? is not a typo. The wave has speed  $10 \text{ ms}^{-1}$ . Find:

- (i) the amplitude of the wave,  
(ii) the period of the wave,  
(iii) the frequency of the wave,  
(iv) the wavelength of the wave,  
(v) the formula for the wave (replace the ? with a number).  
(vi) What is the displacement of the medium at  $x = 0$  and  $t = 0$ ?

[12 marks]

7. **Cell Phones**

(a) As a technology expert at the New Zealand High Tech Consortium you receive a proposal from an inventor that he claims will block cell phone signals in a building. The inventor proposes to produce large amplitude EM waves at a high frequency and use directional antennas surrounding the building to aim the EM waves mostly upward, producing a “wall” around the building (see the diagram below). He claims the high frequency, high amplitude EM waves will collide with the EM waves from the cell phones and stop them. Will this work? Explain.



[4 marks]

(b) Describe briefly how the cell phone system is constructed to allow cell phones to be small, low power devices rather than the large, high power car phones of previous years.

[4 marks]

8. **Spectrum of signals**

(a) Suppose we have the signal  $y = 8 \sin(9t)$  that has infinite duration (started at  $t =$  negative infinity, ends at  $t = +$  infinity). Sketch its power spectrum.

[3 marks]

(b) Suppose we have the signal  $y = 8 \sin(9t)$  that turns on for a short time  $t_{on}$  and then turns off. Sketch its power spectrum.

[3 marks]

(c) Describe how modulation is used to encode information on analogue and digital FM signals. Do these signals contain a range of frequencies? Explain.

[3 marks]

(d) Describe how modulation is used to encode information on analogue and digital AM signals. Do these signals contain a range of frequencies? Explain.

[3 marks]

**9. Hardware and system performance.**

(a) Describe the main differences between RAM, ROM and flash memory.

[5 marks]

(b) Why were sockets introduced for mounting CPUs? Does this mean that you may be able to use a different processor with your motherboard? Assuming that you can, would you be able to run programs written for one processor using a different processor?

[5 marks]

(c) A friend has bought a new computer and you want to compare its performance with the performance of your own computer. She suggests using benchmarking to compare the performance of the two computers. Critique her suggestion.

[5 marks]

**10. Operating Systems.**

(a) What functions does an operating system kernel perform in an operating system?

[5 marks]

(b) List three different types of user interfaces commonly found in operating systems and briefly describe the main characteristics of each of them.

[5 marks]

(c) Explain why the "X" windows system is a good example of modular versus monolithic design.

[5 marks]

**11. Networking.**

(a) What role do IP addresses play in routing packets across the Internet?

[5 marks]

(b) A friend wants to measure how long it takes for a packet to travel from New Zealand to the United Kingdom one way. To do this he times the delay between a request packet leaving his computer and a reply packet returning to his computer. He does this several thousand times, calculates the average round trip time and divides by two. This he announces as the average time for a one-way trip. Critique his approach.

[5 marks]

(c) You plan to buy some software from a company over the Internet by filling in their credit card details on a web page. What security threats do you face and how could you reduce them?

[5 marks]

**12. Open Source Software.**

(a) Explain the difference between free software and open source software.

[5 marks]

(b) You are asked to participate in a software development project for a research company working in partnership with a University. The software involves controlling manufacturing machinery to make parts for an underwater exploration robot. Would you choose open source or closed source approach to developing and releasing your software? Why or why not?

[5 marks]

(c) You are asked to participate in a software development project for a startup (located in Creative HQ downtown). The software involves managing assets for small businesses online. Would you choose open source or closed source approach to developing and releasing your software? Why or why not?

[5 marks]

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## Formula Sheet for ENGR 101 and TECH 102

**This sheet may be detached from the exam paper**

$$y = A \sin\left(\frac{2\pi x}{\lambda} \pm \frac{2\pi t}{T} + \phi\right) \quad v = \frac{\lambda}{T} = \lambda f$$

$c$  = speed of light =  $3 \times 10^8$  m/s

$M = \epsilon \sigma T^4$  where  $\epsilon$  is the emissivity, we will take it to be 1.

$$\text{and } \sigma = 5.7 \times 10^{-8} \frac{W}{m^2 K^4}$$

$$\lambda_{\text{max int}} T = 2.88 \times 10^{-3} \text{ mK}$$

Human eye resolution =  $3 \times 10^{-4}$  radians

$\theta = H/D$  with the angle in radians

