OLLSCOIL NA hÉIREANN, CORCAIGH
THE NATIONAL UNIVERSITY OF IRELAND, CORK

COLÁISTE NA hOLLSCOILE, CORCAIGH
UNIVERSITY COLLEGE, CORK

SUMMER EXAMINATIONS, 2006

B.E. (ELECTRICAL)
B.E. (MICROELECTRONICS)
M.ENG.SC. (MICROELECTRONICS)
H.DIP. (MICROELECTRONICS)
VISITING EUROPEANS

Medical Electronic Systems
EE4012

Professor Dr. U. Schwalke
Professor P. J. Murphy
Dr. R. Salerno-Kennedy
Dr. K. McCarthy
Dr. W.P. Marnane
Dr. W. Wright
Dr. G. Lightbody

Time Allowed: *3 hours*

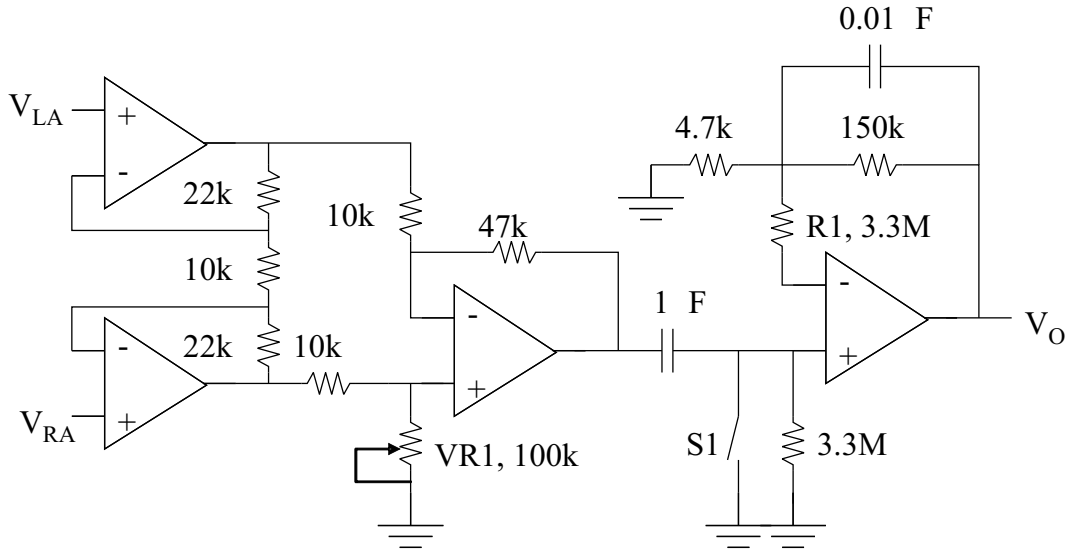
Answer *five* questions.

All questions carry equal marks.
The use of a Casio fx570w or fx570ms calculator is permitted.

1. (a) Define and briefly describe how neurons communicate. [*10 marks*]

   (b) Define and briefly describe the chemical synapse [*10 marks*]

2. (a) The circuit diagram shows a simple ECG amplifier using ideal op-amps and with inputs from the left and right arms. If the variable resistor, VR1, is set to 47k and switch S1 is open, determine and illustrate the frequency response of the circuit in the range 0.01Hz to 10kHz. [*16 marks*]



(b) i. What is the purpose of VR1? [*2 marks*]

ii. What is the purpose of S1? [*2 marks*]

3. (a) If mains current is applied to a human adult subject by means of copper wire grasped in the hands, briefly describe and outline the threshold current levels for the following:

i. Threshold of perception [*2 marks*]
ii. Let go current [*2 marks*]
iii. Ventricular fibrillation [*2 marks*]

(b) Describe the make-up and operation of a typical residual current circuit breaker and indicate which type of shock this protects against. [*6 marks*]

(c) Discuss briefly the following concepts including simple diagrams as appropriate:

i. Electrical Shielding [*4 marks*]
ii. The use of driven guards [*4 marks*]

4. (a) Give three examples of each of the following biomedical signals:

i. Endogenous
ii. Exogenous [*6 marks*]

(b) Define the following properties of a Discrete time random process:

i. Wide Sense Stationary
ii. Ergodic Process [*4 marks*]

(c) Using Diagrams and Text explain how the cross correlation function can be used to determine the heart rate from an ECG signal. [*5 marks*]

(d) $x(n)$ is the transmitted signal and it is received after a delay n_d corrupted by noise $v(n)$ such that

$$y(n) = x(n - n_d) + v(n)$$

Show how the cross correlation function can be used to determine the delay n_d. [*5 marks*]

5. (a) Using diagrams and text explain how the spectral analysis of a pulsed doppler ultrasound bloodflow meter can be used to for disease detection in the carotid artery. [*10 marks*]

   (b) i. State the main steps required to reconstruct a tomographic image from a Radon transform using the Fourier slice technique.

   [*5 marks*]

   ii. Explain why the basic Ram-Lak kernel function is normally windowed in the frequency domain.

   [*5 marks*]

6. Describe the physical principles behind MRI signal generation, stating clearly how the excess magnetic moment is produced and why a secondary 90° RF field is required. Hence, explain in detail tip angle, T1 recovery, T2 decay and dephasing mechanisms.

   [*20 marks*]

7. (a) i. Demonstrate using a sketch how a usable torque/force could be developed in electrically stimulated muscle, by using a train of pulses. Suggest a model for electrically stimulated muscle torque/force, and propose a method to identify it from data. Comment on the need for a detailed nonlinear model, and whether a simple linear model would suffice for control purposes.

   ii. Show how functional electrical stimulation can be used for controlled standing. As part of your answer give a detailed block diagram. Discuss the major issues that limit the application of functional electrical stimulation for controlled standing. [*10 marks*]

   (b) i. Give a possible block diagram for the control of blood Glucose in a Type I Diabetic.

   ii. Highlight the various types of sensor available for blood Glucose measurement.
   What are the main drawbacks with the use of a subcutaneous blood Glucose measurement. Propose a technique that has been demonstrated to improve the quality of this measurement.

   iii. Describe in some detail the models that describe Insulin and Glucose dynamics and how they could possibly be used in a blood-Glucose control scheme.

   [*10 marks*]