

## National Exams December 2013

### 04-Bio-B8, Rehabilitation Engineering

3 hours duration

The following exam includes 7 questions of which you must answer 5. Use diagrams if necessary to aid in your explanations. Each question is worth 20 marks, with marks allocated for each subsection indicated.

#### **NOTES:**

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is an OPEN BOOK EXAM.  
Any non-communicating calculator is permitted.
3. FIVE (5) questions constitute a complete exam paper.  
The first five questions as they appear in the answer book will be marked.
4. Each question is of equal value.
5. Most questions require an answer in essay format. Clarity and organization of the answer are important.

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1. For the following two neuromuscular conditions describe the functional impairments and the possible rehabilitation engineering interventions, including the broad underlying pathology, the time course of the resulting disability, and the rehabilitation technologies appropriate for mild, moderate and severe conditions:
  - (i) MS (multiple sclerosis) 10 marks
  - (ii) cerebral palsy 10 marks
  
2. A current technology used to treat profound deafness resulting from destruction or disease of the inner ear is the artificial cochlea.
  - (i) Describe the functional components of this technology including the engineering principles employed. 10 marks
  
  - (ii) How are control or input signals and power transmitted to the implanted components while leaving the skin intact? 5 marks
  
  - (iii) What is the effect of including more electrode surfaces? 2 marks
  
  - (iv) Is it better to implant the device early in a child who is deaf from birth or should one wait until the child becomes a teenager? Why? 3 marks
  
3. Functional Electrical Stimulation (FES) has had a long history of helping subjects with complete or partial loss of control of skeletal muscle. The subject is a partial quadriplegic and has control of a shoulder muscle (upper trapezius). Design a system that uses the trapezius muscle to control a FES system that stimulates the forearm muscles (flexors) to close the hand and grasp an object. The strength of the grasp should be proportional to the strength of the shoulder muscle contraction. Use a block diagram for your system including the transducers (electrodes) and their placement. Describe the function of each block and give the specifications. 20 marks
  
4. Current computer technology has allowed the rehabilitation engineer to design sophisticated environmental control systems for the disabled individual. Let us assume that the individual is a low level quadriplegic with some hand or finger control. He or she is limited to a powered wheelchair and wants to live as independently as possible. Design an environmental control system that would allow the individual to live in an apartment. What are the functions in the apartment that can be controlled and how? What safety concerns must be kept in mind when designing the system? Is it necessary to have special connecting wiring installed for each controller? What user interfaces would be most suitable? Use block diagrams in your description 20 marks

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5. It is well known that quadriplegics and even paraplegics require special care when designing their seating systems such as for a wheelchair.
- (i) Why is seating such a problem for these individuals and what areas of the seated anatomy require special attention? 5 marks
- (ii) What are the biomechanical principles used in determining safe and effective seating or support 5 marks
- (iii) What seating technologies are presently available 5 marks
- (iii) What modern measurement tools could you use to determine pressure distribution for the selected system or design? 5 marks
6. Severely disabled cerebral palsied children or adults with neurological disease have no verbal methods of communicating and require alternate communication aids. Computer technology has allowed us to address the issues of communication for these individuals much more effectively than in the past.
- (i) Describe some electronic aids currently available for such individuals 5 marks
- (ii) Despite the sophistication of computer technology the user still has to control it. For the severely disabled subject with very poor motor and verbal control, what modes of interface are available and what are the advantages and disadvantages of each mode? 8 marks
- (iii) The objective of aided communication is as high as possible data rate with low error rate or easy error correction. What strategies could you think off to accomplish this? 7 marks
7. Powered wheelchairs provide mobility for individuals with insufficient arm strength to propel a standard wheelchair but have some degree of control. When selecting or designing a powered wheelchair a number of factors must be taken into consideration. Discuss each of the following:
- (i) Power and torque requirements considering the proposed activity pattern, the individual and the type of terrain (floor) to be encountered 5 marks
- (ii) Stability considerations 5 marks
- (iii) Electronic control of the motors considering safety and smooth operation 5 marks
- (iv) control input if the standard joystick is not suitable (e.g. for a high quadriplegic with little limb muscle control 5 marks

**Marking Scheme - indicate marking scheme on a separate page or on front of cover page**

1. 20 marks total (i) 10 marks ; (ii) 10 marks
2. 20 marks total (i) 10 marks; (ii) 5 marks; (iii) 2 marks; (iv) 3 marks
3. 20 marks total
4. 20 marks total
5. 20 marks total (i) 5 marks; (ii) 5 marks; (iii) 5 marks; (iv) 5 marks
6. 20 marks total (i) 5 marks; (ii) 8 marks; (iii) 7 marks
7. 20 marks total (i) 5 marks; (ii) 5 marks; (iii) 5 marks; (iv) 5 marks