

National Exams May 2012

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.
A Casio or Sharp approved 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.

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) cerebral palsy 10 marks
 - (ii) ALS (amyotrophic lateral sclerosis) 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 Electromyography (EMG) is a powerful tool for measuring deficits in neuromuscular control resulting from central nervous system trauma such as strokes, head injuries or even spinal cord injuries. The systems can employ one to many channels of muscle activity as well as other functional measures. Describe the instrumentation for a single channel EMG including typical specifications for each functional block from electrodes to final display. What features of the EMG signal are typically used to describe or quantify the muscle activity? What other functional measures will aid in interpreting the results? 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

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 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