



# **STUDY GUIDE**

**FOR**

**BIOMEDICAL ENGINEERING  
TECHNOLOGY CERTIFICATION**

**(CANADA)**

**2010**



## PREFACE

This Study Guide has been prepared to provide an overview to those wishing to take the Biomedical Engineering Technology Certification examination set by the Canadian Board of Examiners for Biomedical Engineering and Dialysis Technologists and Technicians.

It provides information about the Certification program in Canada, a suggested reading list and a “mini-examination”, which reveals the style and type of questions one can expect in the actual examination. Correct answers are provided for self study. In the case of the essay questions, a guide to the type of information that should be included in the answer is provided.

Every effort has been made to ensure accuracy throughout this guide, however, should errors arise, the Canadian Board of Examiners for Biomedical Engineering and Dialysis Technologists and Technicians will not be held responsible.

NOTE: No part of this study guide may be reproduced by any means either electronically, facsimile, photocopied or transmitted without written consent from the Canadian Board of Examiners for Biomedical Engineering and Dialysis Technologists and Technicians.

## Enquiries

You may direct your enquiries to the Secretariat:

e-mail	<a href="mailto:bmetcertcanada@ncf.ca">bmetcertcanada@ncf.ca</a>
Telephone	613-825-1837
Address	BMET Certification Canada 97 Pheasant Run Drive Nepean, ON K2J 2R3 Canada



## **Canadian Biomedical Engineering Technology Certification Program**

Thank you for your interest in the Canadian Biomedical Engineering Technology Certification Program. Included in this Study Guide are the program information, application procedure, eligibility requirements, fees and exam format for either a Technologist or a Technician, and an application form.

The procedure is as follows:

1. Upon receipt of a completed application form and fee, you will receive a receipt for your payment, which will indicate that your file has been activated.
2. The Secretariat will send out reference requests to the people indicated on your form.
3. Upon receipt of these completed references, your file is directed to the Board of Examiners for review. The Board will determine if you meet the requirements for examination, or if additional information, or further study is required.
4. When the Secretariat has been advised of your acceptance for examination, a proctor will be appointed to oversee the written examination. The proctor will be a qualified examiner in your city/town, or as close as possible.
5. You will be given 8 hours to complete the examination, the format of which is detailed later in this Study Guide. The use of hand-held scientific calculator (no calculators that allow text storage or formulation(s)) and one 7.6 cm by 12.7 cm card with formulas is allowed. The card shall only contain formulas (no text) on both sides and shall have a font size of not less than 8 pitch. No electronic communication devices will be allowed in the examination room.
6. Upon successful completion of the written examination, the Board will advise you of your results. The Board then makes its recommendation to the International Certification Commission, and a Certificate will be issued.
7. If you have not achieved a passing mark on the written exam, you will be given a time period to study in your area(s) of weakness, and then you can rewrite an examination that focuses on this area.
8. Your Certificate is sent to the Canadian Board Chairman for signature and then you will be consulted as to whether you wish it to be sent to your supervisor for presentation or to have it presented at the Canadian Conference Awards Luncheon/Banquet.

The aim is to assist you to successfully complete this examination; therefore, you will be given several opportunities to rewrite until the Board is satisfied that you meet the standards required. We will also make every effort to provide examinations in a location that you might easily access.

An annual renewal fee is implemented to maintain the Canadian Certification process and provides your listing to the International Certification Commission Directory of Certified Individuals.



## **CERTIFICATION OF BIOMEDICAL ENGINEERING TECHNOLOGISTS/TECHNICIANS**

The International Certification Commission (ICC) has a membership, which provides broad representation of relevant members of the health care community. It includes representatives from engineering, medical, industrial, and government groups and agencies. It supervises the certification of biomedical engineering technologist and technician, clinical engineers, and other related specialists through the organization of examining boards.

As guided by the Commission, the Canadian Board of Examiners for Biomedical Engineering Technologists and Technicians (BMET Certification) considers that a biomedical engineering technologist or technician is a person knowledgeable in the theory of operation, the underlying physiologic principle, and the practical, safe, clinical application of biomedical equipment. His/her capabilities may include installation, calibration, inspection, preventative maintenance, and repair of general biomedical and related technical equipment, and in equipment control, safety and maintenance.

### **CERTIFICATION EXAMINATION IN CANADA**

In Canada, technologists and technicians, (as determined by the candidate's provincial certification) write the same multiple choice examination. However, the essays section is different for each. Throughout this text the acronym BMET refers to both technologist and technician.

The basic eligibility requirement for being examined for certification is registration with your provincial association as a certified engineering technologist or technician (see Eligibility, next page). The certification examination is designed to test your fundamental knowledge of electronics circuitry and biomedical capabilities.

### **The content of the examination is based on the following premises:**

The BMET must be able to communicate intelligibly with physicians, and other hospital staff members. Also, in order to fulfill his responsibilities in the area of safety, calibration, and related areas, he/she must have a reasonable knowledge of anatomy and physiology. The knowledge should include familiarity with terminology and body functions/systems.

The BMET should possess a broad knowledge of equipment and laboratory instrumentation used in a clinical setting. His/her knowledge should include, but not be limited to, the theory of operation, clinical application, and unique safety requirements relating to physiological monitors, analytical laboratory instruments, vacuum and gas pressure vessels and controls, anaesthesia equipment, information systems interfaces, ventilators, imaging devices (including MRI, CT, PET, X-Ray and ultrasound), physiological instruments, electrosurgical units, lasers (YAG, CO<sub>2</sub>, etc), renal dialysis, noninvasive surgical instruments.....etc.

The BMET should be able to perform theoretical troubleshooting using schematics, for equipment ranging from the simple fibre optic light source to the microprocessor based electromyograph. The BME Technologist should also possess basic management and supervisory skills.



## **ELIGIBILITY REQUIREMENTS**

1. A certified member, in good standing, of a provincial association of engineering technicians and technologists, recognized by the Canadian Council of Technicians and Technologists.
2. The candidate shall have a minimum of 3 years experience in a clinical environment.

### **OR**

Candidates, who are graduates of a recognized BMET post-secondary school program, will be allowed to count a maximum of 1-year internship period as part of the 3-year requirement.

3. It is not necessary that the candidate be currently employed by a hospital, but it is required that the candidate have the above experience.
4. The applicant shall submit the names of at least 5 references. These references must be health care professionals who are familiar with the candidate's competence in the following areas:
  - a) Technical ability.
  - b) Clinical experience interfacing with physicians.
  - c) Clinical experience interfacing with nursing staff.
  - d) And 2 others who have knowledge of the candidate's work experience.

Note: If a physician reference (b) is not available, include an additional nursing reference (c).

The names of references are requested on the application form. Confidential questionnaires will be mailed to the referees by the Secretariat. These forms are returned directly to the Secretariat.

### **FEE**

The application fee is subject to annual review, (see schedule). This fee is non-refundable after you have been accepted for examination. The fee is to cover the cost of processing your application and one examination session (if you are determined eligible to test for certification). If after the receipt of references and review by the Board, it is decided that you are not eligible for examination; your fee will be refunded, less an administration fee to cover costs to that point.



## **APPLICATION**

A BMET Certification Application form must be completed (included in this Study Guide). Curriculum Vitae are not acceptable in lieu of the completed form.

Mail the completed application form to the Secretariat.

The Secretariat will obtain the applicant's references and send the application together with the references to the Board of Examiners for review.

## **REVIEW BY EXAMINERS**

The Board of Examiners will decide whether or not the applicant is qualified to take the examination. The applicant is then informed of his/her eligibility to take the examination.

If the Board does not recommend testing, the applicant is informed and he/she may choose to follow the appeal procedure. Information about the appeal procedure will be provided by the Board's Secretariat upon request.

## **CERTIFICATION**

### **Examination Format:**

The examination is divided into two parts. The first part is in multiple-choice format and includes five (5) sections that cover the topics of Anatomy and Physiology, Basic Electronics, Medical Instrumentation, Troubleshooting, and Canadian Standards.

The second part contains Essay questions pertaining to the practice and organizational management of Biomedical Engineering Programs.

A minimum mark of 50% is required in each of the six (6) sections. 75% of the marks gained in the first five (5) sections, plus 25% of the mark gained in the essay section, will constitute the final mark attained. The final mark attained must equal or exceed 60%, with all sections receiving a mark of 50% or more, for a pass to be granted.

## **CERTIFICATION RENEWAL FEE**

Renewal Fees are due in the first January following successful completion of the examination and then in January of each year thereafter. The Certification Fee Schedule lists the amounts involved in the process.

### **CERTIFICATION FEE SCHEDULE**

<b>EXAMINATION FEE</b>	<b>\$195.00</b>
<b>REFUND</b> (not accepted for examination)	<b>\$145.00</b>
<b>SUPPLEMENTAL EXAM</b> (per section)	<b>\$90.00</b>
<b>ANNUAL RENEWAL FEE</b>	<b>\$60.00</b>



## APPLICATION FORM FOR BMET CERTIFICATION

### INSTRUCTIONS

To avoid delays in processing your application fill out the application form clearly, accurately and completely.

Your eligibility for certification will be judged on:

- The information you provide on this application form
- The opinions of your references
- The results of your written examination

Be sure to:

- Sign the statement at the bottom of this page
- Include the examination fee (C\$195) with your completed application
- make cheques payable to : BMET CERTIFICATION CANADA

Mail the completed application form to:

The Secretariat  
BMET Certification Canada  
97 Pheasant Run Drive  
Nepean, ON  
K2J 2R3 Canada

### CANDIDATE'S STATEMENT

I, (PRINT NAME) \_\_\_\_\_, certify that all information that I have entered on this application form, and any accompanying documents, is correct. I understand that any misrepresentation may result in the rejection of this application, or the revocation of any certificate issued as a result of this application. I am also aware that any certification that I may receive from the Certification Commission will not constitute, and shall not be construed as, a license. I authorize, and release from all liability, the Certification Board of Examiners (Canadian) in doing so, to make any enquiries that are necessary in ascertaining my eligibility for certification.

Signature of Applicant \_\_\_\_\_

Date \_\_\_\_\_

**PERSONAL INFORMATION (PLEASE PRINT)**

NAME: \_\_\_\_\_  
(As you wish it to appear on your certificate)

Salutation: Miss ☐ Ms. ☐ Mrs. ☐ Dr. ☐ Mr. ☐ Check one only.

HOME ADDRESS: \_\_\_\_\_  
Street City Province Postal Code

HOME TELEPHONE: \_\_\_\_\_ HOME E-MAIL: \_\_\_\_\_  
Area Code Number

PRESENT EMPLOYER: \_\_\_\_\_

WORK ADDRESS: \_\_\_\_\_  
Street City Province Postal Code

DEPARTMENT: \_\_\_\_\_ CURRENT POSITION: \_\_\_\_\_

WORK TELEPHONE: \_\_\_\_\_ WORK E-MAIL: \_\_\_\_\_  
Area Code Number

NAME AND TITLE OF IMMEDIATE SUPERVISOR: \_\_\_\_\_

SEND PERSONAL LETTER MAIL TO: HOME ☐ WORK ☐

SEND PERSONAL ELECTRONIC MAIL (E-MAIL) TO: HOME ☐ WORK ☐

NAME OF PROVINCIAL ASSOCIATION OF TECHNICIANS/TECHNOLOGISTS WITH WHICH YOU ARE CERTIFIED: \_\_\_\_\_

DATE OF JOINING THIS ASSOCIATION: \_\_\_\_\_ MEMBERSHIP NUMBER: \_\_\_\_\_

TITLE: \_\_\_\_\_ CLASSIFICATION: \_\_\_\_\_  
TECHNICIAN OR TECHNOLOGIST? C.E.T., A.Sc.T., ETC.



OFFICE USE ONLY

	NAME OF SCHOOL	LOCATION	PROGRAMME	FROM	TO	DEGREE
High School						
Technical Institute						
College						
Other						





## BIOMEDICAL ENGINEERING EXPOSURE

During any part of your formal education, were you exposed to working in a biomedical environment (internship), which was included in the curriculum?

☐ Yes ☐ No

If "Yes", please list dates, institution and a brief description of the work you performed:

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Have you attended any major biomedical conferences, seminars, or meetings sponsored by an accredited organization?

☐ Yes ☐ No

If "yes", please list:

Date	Event	Sponsor

List your major disciplinary interests in the field of biomedical technology (e.g. Haematology, Respiration, Cardiology, etc..)

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Upon successful completion of the Certification Examination process you may opt for your name to be listed on the ICC Web site as a Canadian Certified Biomedical Engineering Technician/Technologist.

I wish my name to be listed on the ICC Web site ☐ Yes ☐ No

**Note that the default of "Yes" will be applied if you fail to complete this section.**



## EMPLOYMENT HISTORY

Dates			Start with your most recent employment and account for each year since High School. Include the name and location of your employers, titles of your positions and descriptions of your duties. If more space is required add a separate sheet.
From Mo. Yr.	To Mo. Yr.	Total Time Yrs. Mos.	

## OUTSTANDING ACHIEVEMENTS

Attach a separate sheet to describe any outstanding achievements on your part that you feel the Board of Examiners should evaluate when considering your application. This could include publications, special projects, incident investigations, research projects, safety programmes, etc..



## REFERENCES

List the names and contact information (PLEASE PRINT) of five (5) health care delivery professionals who may be consulted for the purpose of providing references in the following areas:

- a. technical ability
- b. clinical experience interfacing with physicians
- c. clinical experience interfacing with nursing staff
- d. and two (2) others who have knowledge of your work experience

**Note: If a physician reference (b) is not available, replace (b) with a second nursing reference (c)**

**Obtain permission to use the references that you provide and inform them that they will be requested to complete a questionnaire, which will be sent to them via e-mail (preferred) or surface mail.**

**REF. 1** NAME & TITLE: \_\_\_\_\_  
POSITION \_\_\_\_\_  
ORGANIZATION: \_\_\_\_\_  
ADDRESS: \_\_\_\_\_  
TELEPHONE: \_\_\_\_\_ E-MAIL: \_\_\_\_\_  
Street City Province Postal Code  
AREA CODE NUMBER

**REF. 2** NAME & TITLE: \_\_\_\_\_  
POSITION \_\_\_\_\_  
ORGANIZATION: \_\_\_\_\_  
ADDRESS: \_\_\_\_\_  
TELEPHONE: \_\_\_\_\_ E-MAIL: \_\_\_\_\_  
Street City Province Postal Code  
AREA CODE NUMBER

**REF. 3** NAME & TITLE: \_\_\_\_\_  
POSITION \_\_\_\_\_  
ORGANIZATION: \_\_\_\_\_  
ADDRESS: \_\_\_\_\_  
TELEPHONE: \_\_\_\_\_ E-MAIL: \_\_\_\_\_  
Street City Province Postal Code  
AREA CODE NUMBER

**REF. 4** NAME & TITLE: \_\_\_\_\_  
POSITION \_\_\_\_\_  
ORGANIZATION: \_\_\_\_\_  
ADDRESS: \_\_\_\_\_  
TELEPHONE: \_\_\_\_\_ E-MAIL: \_\_\_\_\_  
Street City Province Postal Code  
AREA CODE NUMBER

**REF. 5** NAME & TITLE: \_\_\_\_\_  
POSITION \_\_\_\_\_  
ORGANIZATION: \_\_\_\_\_  
ADDRESS: \_\_\_\_\_  
TELEPHONE: \_\_\_\_\_ E-MAIL: \_\_\_\_\_  
Street City Province Postal Code  
AREA CODE NUMBER



## **SUGGESTED REVIEW MATERIALS**

Note: For all standards, harmonized with IEC standards, shall be listed in the new five-digit format (CAN/CSA-C22.2 No. 601.1-M90 may appear as CAN/CSA-C22.2 No. 60601.1).

### Standards:

CAN/CSA-C22.2 No. 114-M90 (R2000) Diagnostic Imaging and Radiation Therapy Equipment.  
CAN/CSA-C22.2 No. 125-M84 (R1999) Electromedical Equipment.  
CAN/CSA-C22.2 No. 151-M1986 Laboratory Equipment.  
CAN/CSA-Z5359-04 Low-Pressure Connecting Assemblies for Medical Gas Systems.  
CAN/CSA-Z168.3-M97 Anaesthetic Machines for Medical Use.  
CAN/CSA-C22.2 No. 60601.1-M90 (R2001) Medical Electrical Equipment Part 1.  
CAN/CSA-C22.2 No. 60601.2. XX Medical Electrical Equipment Part 2: All Sections.  
CAN/CSA-Z32.2-04 Electrical Safety and Essential Electrical Systems in Health Care Facilities.  
ANSI Z136.1-2000 American National Standard for Safe Use of Lasers.  
CAN/CSA-Z386-01 Laser Safety in Health Care Facilities.  
Canadian Society For Transfusion Medicine (CSTM) Standards.  
Advancement of Medical Instrumentation (AAMI), HF 18-1993, Electrosurgical Devices Standard

### Publications:

Complete Guide to Electronics Troubleshooting  
James Perozzo  
Delmar Publishers Inc. January 1994  
ISBN 0-8273-5045-7

Essential of Anatomy and Physiology 3<sup>rd</sup> Ed.  
Martini and Bartholomew  
Prentice Hall  
Pearson Education, Inc.  
Upper Saddle River, New Jersey 07458 October 1999  
ISBN 0-1301-4662-5

Introduction to Biomedical Equipment Technology 4<sup>th</sup> Ed.  
Joseph J. Carr and John M. Brown  
Columbus, Ohio May 2000  
ISBN 0-1301-0492-2

X-Ray Repair  
Joseph J. Panichello  
Charles C. Thomas Publisher Ltd.  
Springfield, Illinois  
ISBN 0-3980-7020-2

Organic and Biological Chemistry Structures of Life  
Karen C. Timberlake  
The Benjamin/Cummings Publishing Co. Inc.  
San Francisco, California July 2002  
ISBN 0-8053-3132-8

Op Amps and Linear Integrated Circuits 4<sup>th</sup> Ed.  
Ramakant A. Gayaward  
Prentice Hall  
Upper Saddle River, New Jersey 07458 August 1999  
ISBN 0-1301-4386-3



Following is a “mini examination” which represents the subjects and types of questions that are found in the actual certification examination. Answers to the questions, including points to include in the essay questions, are provided towards the end of this Study Guide for self evaluation.

### **ANATOMY AND PHYSIOLOGY**

- 1) The hard membrane covering the brain is known as the:  
☐
  - a) Myocardium
  - b) Dura
  - c) Subdura
  - d) Endometrium
  
- 2) Approximately what percentage of a body cell is composed of water:  
☐
  - a) 30
  - b) 55
  - c) 75
  - d) 90
  
- 3) What is the primary function of the AV (atrioventricular) node in the human heart:  
☐
  - a) It produces the dicrotic notch on pressure waveforms
  - b) It excites the myocardial muscles of the ventricles
  - c) It operates as a delay line, allowing propagation of conduction of the ventricles
  - d) It is the primary pacemaker of the heart
  
- 4) Leucocytes are also referred to as:  
☐
  - a) Red Cells
  - b) Plasma
  - c) White Cells
  - d) Platelets
  
- 5) Which section of the spine is closest to the head:  
☐
  - a) Lumbar
  - b) Thoracic
  - c) Cervical
  - d) Sacrum
  
- 6) Intercostal spaces are:  
☐
  - a) Spaces between the ribs.
  - b) Cavities found in the brain.
  - c) Air spaces in the lung.
  - d) Found in the inner ear.



7) The resting potential of the inside of the neuron is approximately:

- a) 20 mV (milliVolts)
- b) -70 mV (milliVolts)
- c) 70 mV (milliVolts)
- d) -100 mV (milliVolts)

☐

8) The Nodes of Ranvier are part of:

- a) Muscle Cells
- b) The pancreas
- c) Neurons
- d) The heart

☐

9) The body has three types of muscle, smooth, striated and:

- a) Ciliated
- b) Long
- c) Epitheal
- d) Cardiac

☐

10) The autonomic nervous system does NOT regulate the:

- a) Digestive system
- b) Circulation
- c) Skeletal muscles
- d) Excretory system

☐

**BASIC ELECTRONICS**

1) In a RS232C system, using  $\pm 12$  V (Volt), logic 1 would be:

☐

- a) + 5 V (Volt)
- b) – 12 V (Volt)
- c) + 12 V (Volt)
- d) – 2 V (Volt)

2) A two input Exclusive OR gate will have a high output when:

☐

- a) Input 1 = 1 and Input 2 = 0
- b) Input 1 = 0 and Input 2 = 1
- c) Input 1 = 1 and Input 2 = 1
- d) (a) and (b)

3) Calculate the voltage gain of an inverting follower if the feedback resistor is 120K ohms and the input resistor is 40 K ohms:

☐

- a) 80
- b) 4800
- c) 0.33
- d) -3

4) A Hardware timer in a microcontroller is loaded with a number and counted up to overflow to produce a delay. If one machine cycle is 1.085  $\mu$ S (microsecond) and the timer is loaded with FC67h, what is the delay?

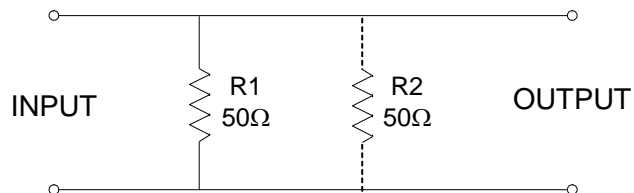
☐

- a) 999.29  $\mu$ S (microsecond)
- b) 1.085 mS (millisecond)
- c) 70,107.3  $\mu$ S (microsecond)
- d) 999.29 mS (millisecond)

5) By adding R2 to the following circuit, the power loss is:

☐

- a) 6dB
- b) 4.8 dB
- c) 3 dB
- d) 2 dB



6) What is a butterworth filter:

☐

- a) Notch filter
- b) Second order, high pass, active filter
- c) Second order, low pass, active filter
- d) Bandpass filter
- e) All of the above

- 7) Four resistors are connected in series across a 100 volt source. The values are  $2000\ \Omega$  ;  $1500\ \Omega$  ;  $1000\ \Omega$  ; and  $500\ \Omega$ . What is the voltage across the  $1000\ \Omega$  resistor ? :

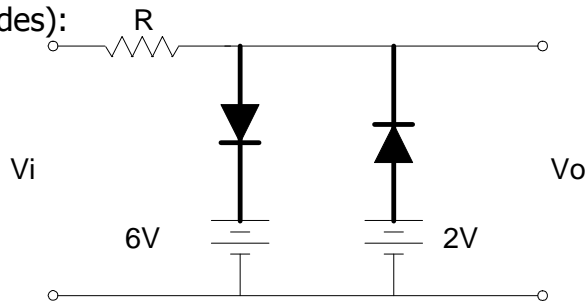
☐

- a) 50 volts
- b) 20 volts
- c) 30 volts
- d) 70 volts

- 8) With a  $\pm 15\text{ V}$  (Volt) input, the maximum negative excursion of the output will be (assume silicon diodes):

☐

- a)  $-2.0\text{ V}$  (Volt)
- b)  $-2.7\text{ V}$  (Volt)
- c)  $-6.7\text{ V}$  (Volt)
- d)  $-1.4\text{ V}$  (Volt)



- 9) What is a non-maskable interrupt?

☐

- a) An interrupt that cannot be changed.
- b) The lowest priority interrupt.
- c) An interrupt that is not disguised.
- d) An interrupt that cannot be ignored by software and is the highest priority.

- 10) The impedance of a video cable is  $75\ \Omega$ . Why would the end of the cable be terminated in  $75\ \Omega$ :

☐

- a) To minimize reflections
- b) Improve the signal to noise ratio.
- c) Attenuate the signal.
- d) To satisfy the requirement of CAN/CSA#60112 for video cable.

- 11) The four colour bands on a resistor are: Red, Violet, Orange, Gold. The value and tolerance of this resistor is:

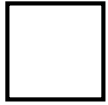
☐

- a)  $2.7\ \Omega$  , 10%
- b)  $27\ \Omega$ , 2%
- c)  $270\text{ K}\ \Omega$ , 5%
- d)  $27\text{ K}\Omega$ , 5%





12) A series circuit contains an inductance of 25 millihenrys, a capacitance of 40 microfarads and a resistance of 50 ohms. What is the impedance of this series circuit at 159 Hz (hertz).



- a)  $50/0^\circ$  ohms
- b)  $100/180^\circ$  ohms
- c)  $25/90^\circ$  ohms
- d)  $12.5/0^\circ$  ohms



## **MEDICAL AND LABORATORY INSTRUMENTATION**

1) What does DISS mean with regard to gas fittings?

- a) Safety mechanism for gas cylinders.
- b) Non-interchangeable low pressure connection system.
- c) An adaptor to interchange various gas hoses.
- d) Non-interchangeable high pressure connection system.

☐

2) A vaporizer interlock mechanism is designed to prevent:

- a) More than one vaporizer to be turned on at a time.
- b) Removal of a vaporizer from an anaesthesia machine.
- c) Filling a vaporizer during use.
- d) All of the above.

☐

3) Nuclear Magnetic Resonance Scanning is achieved by:

- a) A thin beam of narrow-band ionizing energy.
- b) Detecting subtle differences in magnetic susceptibility.
- c) Analyzing the signature echo of the hydrogen atoms in the tissue.
- d) The use of an extremely sensitive magnetometer to differentiate tissue variations.

☐

4) The unit of Tesla is equivalent to:

- a) 10 Gauss
- b) 100 Gauss
- c) 1000 Gauss
- d) 10000 Gauss

☐

5) The cryogenic agent used in an MRI unit is related to:

- a) Detector.
- b) Magnet.
- c) Gradient Coils.
- d) Radio Frequency Exciter.

☐

6) The wavelength of a CO<sub>2</sub> Laser emission is:

- a) 805  $\mu\text{m}$  (micrometers)
- b) 10.6  $\mu\text{m}$  (micrometers)
- c) 6.8  $\mu\text{m}$  (micrometers)
- d) Adjustable between 8.85 and 12.76  $\mu\text{m}$  (micrometers)

☐

7) A Laser Safety Committee and Laser Safety Officer shall be established for:

- a) Class 3A and Class 3B laser use.
- b) Class 4 and Class 5 laser use.
- c) Class 3B and Class 4 laser use.
- d) All classes of lasers.

☐



8) A Pulse Oximeter uses what two wavelengths of light to measure oxygen saturation and heart rate?

☐

- a) Red and infrared.
- b) Red and Ultra-violet.
- c) Red and orange.
- d) Red and blue.

9) A demand pacemaker does the following:

☐

- a) Paces asynchronously.
- b) Senses and paces if R wave is not present.
- c) Senses and paces if R wave is present.
- d) Paces manually as requested by operator.

10) A capnography unit is capable of measuring:

☐

- a) Functional residual capacity.
- b) End tidal carbon dioxide.
- c) Cardiac output.
- d) Helium content.

11) Lithotripsy describes a method of:

☐

- a) Radiating skin to remove warts.
- b) Physiological action resulting in deposit of calcium.
- c) Shock wave generation to break up kidney stones.
- d) Orthopaedic surgery to improve gait.

12) Infant incubator temperature may be controlled by what two parameters?

☐

- a) Skin temperature or incubator air temperature.
- b) Incubator air temperature and room air temperature.
- c) Skin temperature and incubator surface temperature.
- d) Rectal temperature and incubator air temperature.

13) A toco transducer measures what parameter?

☐

- a) Fetal heart rate.
- b) Uterine contractions.
- c) Amniotic fluid pH and uterine contractions.
- d) Maternal heart rate and respiration rate.

14) A scintillation counter is based on:

☐

- a) Specific gravity.
- b) Resistivity gradient.
- c) Ionic activity.
- d) Radioactivity.



15) A refractometer can be used for:

☐

- a) Blood clotting time assays.
- b) Muscular tension determination.
- c) Measuring specific gravity of urine.
- d) Degree of hyperbilirubin estimations.

16) Electrophoresis is a technique used to:

☐

- a) Separate proteins.
- b) Analyze amino acids.
- c) Coagulate amorphous phosphates.
- d) Separate substances of low molecular weight.

17) In a spectrophotometer, the grating is part of the:

☐

- a) Monochromator.
- b) Detector.
- c) Sample chamber.
- d) Exciter power supply.

18) During the process of cardioversion, the delivered energy is synchronized to the:

☐

- a) Leading edge of the R wave.
- b) Trailing edge of the R wave.
- c) Trailing edge of the T wave.
- d) Peak of the P wave.

19) A cardiac bypass unit is used to:

☐

- a) Remove blood from the operative site
- b) Provide oxygenation.
- c) Maintain circulation.
- d) All of the above.

20) X-rays are generated through:

☐

- a) Secondary emission.
- b) Primary emission.
- c) Thermionic flicker.
- d) Gas ionization

21) The rotor mechanism in a X-ray tube is designed to:

☐

- a) Prevent the glass envelope from fracturing during exposure.
- b) Prevent cathode failure.
- c) Prevent anode melt down.
- d) All of the above.



## **SAFETY AND STANDARDS**

- 1) The principle difference between standard CAN/CSA-C22.2 No. 125-M1984 Electromedical Equipment and standard CAN/CSA-C22.2 No. 60601.1-M90 Medical Electrical Equipment is:

☐

- a) CAN/CSA-C22.2 No. 60601.1 is a safer standard than CAN/CSA-C22.2 No. 125.
- b) CAN/CSA-C22.2 No 60601.1 classifies equipment by the degree of protection against electric shock and CAN/CSA-C22.2 No. 125 classifies equipment by the degree of confidence that a device is not a source of, or sink for, current that could be harmful to a patient.
- c) CAN/CSA-C22.2 No. 125 allows Type CF Equipment to have higher leakage currents for applied parts.
- d) CAN/CSA-C22.2 No 60601.1 was added to the standards to harmonize with the International Electrical Commissions (IEC) Standard 60601.1 and there is no difference.

- 2) If you had a sleeve and band identification colours of gray/white on a low-pressure connecting assembly, CAN/CSA- Z5359-04 would indicate its use for the following gas(s):

☐

- a) Carbon dioxide and oxygen mixtures.
- b) Nitrogen and oxygen mixtures.
- c) Nitrous oxide.
- d) Nitrous oxide and oxygen mixtures.

- 3) The workplace hazardous material information system (WHMIS) does NOT cover the sale or importation of the following:

☐

- a) Compressed gases.
- b) Corrosive materials.
- c) Decanted products.
- d) Items covered in the Food and Drug Act.

- 4) For dialysis applications, a mixed deionization process is used to:

☐

- a) Absorb smells from the incoming feed water.
- b) Remove minerals from the incoming feed water.
- c) Filter out pyrogens and bacteria.
- d) Warm water before entering the reverse osmosis chamber.

- 5) The Canadian Society For Transfusion Medicine (CSTM) Standards limits the heating of blood products in a blood warmer to:

☐

- a) 42° Celsius.
- b) Core body temperature.
- c) 50° Celsius.
- d) 10° Celsius above room temperature.



- 6) Standard CAN/CSA-C22.2 No. 60601.2.4-M90 Medical Electrical Equipment, Part 2: Particular Requirements for the Safety of Cardiac Defibrillators and Cardiac Defibrillator-Monitors specifies that an energized (charged) defibrillator must automatically disarm if not discharged after:

- a) 15 to 30 seconds.
- b) 120 to 180 seconds.
- c) 30 to 120 seconds.
- d) 60 to 90 seconds.

☐

- 7) Standard CAN/CSA-C22.2 No. 151-M1986 Laboratory Equipment allows for a non-permanently connected device, under a open neutral and ground condition, to have a leakage current that shall not exceed:

- a) 20  $\mu$ A (microamperes).
- b) 500  $\mu$ A (microamperes).
- c) 5 mA (milliamperes).
- d) 2 mA (milliamperes).

☐

- 8) Standard CAN/CSA-C22.2 No. 60601.2.2-92 Medical Electrical Equipment, Part 2: Particular Requirements for the safety of High Frequency Surgical Equipment specifies where certain functions are indicated by coloured indicator lights that coagulation be indicated by the colour:

- a) Green.
- b) Yellow.
- c) Red.
- d) Blue.

☐

- 9) Standard CAN/CSA-C22.2 No. 60601.2.16-92 Medical Electrical Equipment, Part 2: Particular Requirements for the Safety of Haemodialysis Equipment specifies that:

- a) Integral blood pumps shall not exceed flow rates of 1000 ml/hour (milliliters/hour).
- b) The dialyzing fluid shall have a relative concentration of hydrogen atoms which shall not exceed a pH of 7.1.
- c) In the event of a supply mains failure, an audible alarm shall sound lasting for at least 1 minute.
- d) The haemodialyser transmembrane pressure shall not exceed 10 cmH<sub>2</sub>O (centimeters of water).

☐

- 10) An air embolism can be caused by a malfunction of which one of these devices?

- a) Gas aerator.
- b) High speed dental drill.
- c) Low volume aspirator.
- d) Nebulizer.

☐



- 11) Standard CAN/CSA-C22.2 No. 60601.2.19-92 Medical Equipment, Part 2: Particular Requirements for the Safety of Baby Incubators specifies that barriers to be opened or removed to allow access to the baby, shall be able to withstand a force of 20 N (Newtons) at the center of the access. The rationale for this is:

☐

- a) Poorly designed barriers may fail to retain the baby.
- b) To prevent the doors or ports from opening when jarred during transportation.
- c) To enable the doors and ports to withstand the pressure created by the heating of the air within the incubator.
- d) To enable the doors and ports to withstand the pressure created by the seal around the opening.

- 12) Infants requiring supplemental oxygen, because their arterial oxygenation is not considered adequate while breathing ambient air, are at increased risk of this if the amounts are excessive:

☐

- a) Dehydration.
- b) Cerebral Palsy.
- c) Hypercalcemia.
- d) Retrolental Fibroplasia.

- 13) Standard CAN/CSA-C22.2 No. 60601.2.20-92 Medical Electrical Equipment, Part 2: Particular Requirements for the Safety of Transport Incubators specifies that the capacity of any transportable electrical power source shall be sufficient to maintain the incubator temperature of 36° Celsius with an ambient environment temperature of 15° Celsius for at least:

☐

- a) 5 hours.
- b) 90 minutes.
- c) 4 hours.
- d) 180 minutes.

- 14) Standard CAN/CSA-C22.2 no. 60601.2.22-94 Medical Electrical Equipment, Part 2: Particular Requirements for Safety of Diagnostic and Therapeutic Laser Equipment specifies that the actual laser output measured in the operating plane shall not deviate from the set value by more than:

☐

- a) 5%
- b) 10%
- c) 15%
- d) 20%

- 15) An isolation transformer reduces the chassis leakage current of a device by:

☐

- a) Removing the connection of the neutral to ground.
- b) Reducing the capacitance of the power cord.
- c) Reducing line voltage fluctuations.
- d) Removing the ground connection.



16) Standard CAN/CSA-C22.2 No. 60601.1-M90 Medical Electrical Equipment, Part 1: General Requirements for Safety, specifies that the allowable leakage current from the enclosure of type CF equipment, under normal conditions is:

☐

- a) 1  $\mu$ A (microamperes).
- b) 10  $\mu$ A (microamperes).
- c) 50  $\mu$ A (microamperes).
- d) 100  $\mu$ A (microamperes).

17) A device with a non-detachable power cord shall have the grounding conductor of the power cord wired in this configuration upon entering the device:

☐

- a) Connected to the mounting screw of the mains transformer.
- b) Connected to the chassis.
- c) Connected to the access panel or service cover.
- d) Connected to the patient applied part connector or operators control panel.

18) Standard CAN/CSA-Z32.2-04 Electrical Safety and Essential Electrical Systems in Health Care Facilities allows for the temporary use of power bars in patient care areas provided that:

☐

- a) They are placed on a preventative maintenance program.
- b) Mounted or supported above the level of the floor.
- c) If mounted on a cart, the power is protected from the entry and entrapment of liquids.
- d) All of the above.

19) Standard ANSI Z136.1-2000 American National Standard for Safe Use of Lasers specifies that a Class 2 laser and laser systems have the following requirement:

☐

- a) In the visible range of the electromagnetic spectrum 400nm to 710nm (nanometers).
- b) Emitting radiation considered hazardous to the skin and eyes from direct or scattered radiation.
- c) Emitting radiation that is not considered hazardous.
- d) For positioning and alignment of patients in Computer Tomography (CT) and Magnetic Resonance Imager (MRI) scanners only.

20) Standard CAN/CSA-Z386-01 Laser Safety in Health Care Facilities specifies the following shall be present on all non-temporary controlled area signage (Caution & Danger Signs):

☐

- a) "Laser Radiation – Do Not Stare into Beam or View with Optical Instruments".
- b) "Use Laser Safety Eye Wear with an Optical Density of at least 4.0".
- c) Type of laser or the emitted wavelength.
- d) Maximum Permissible Exposure (MPE)





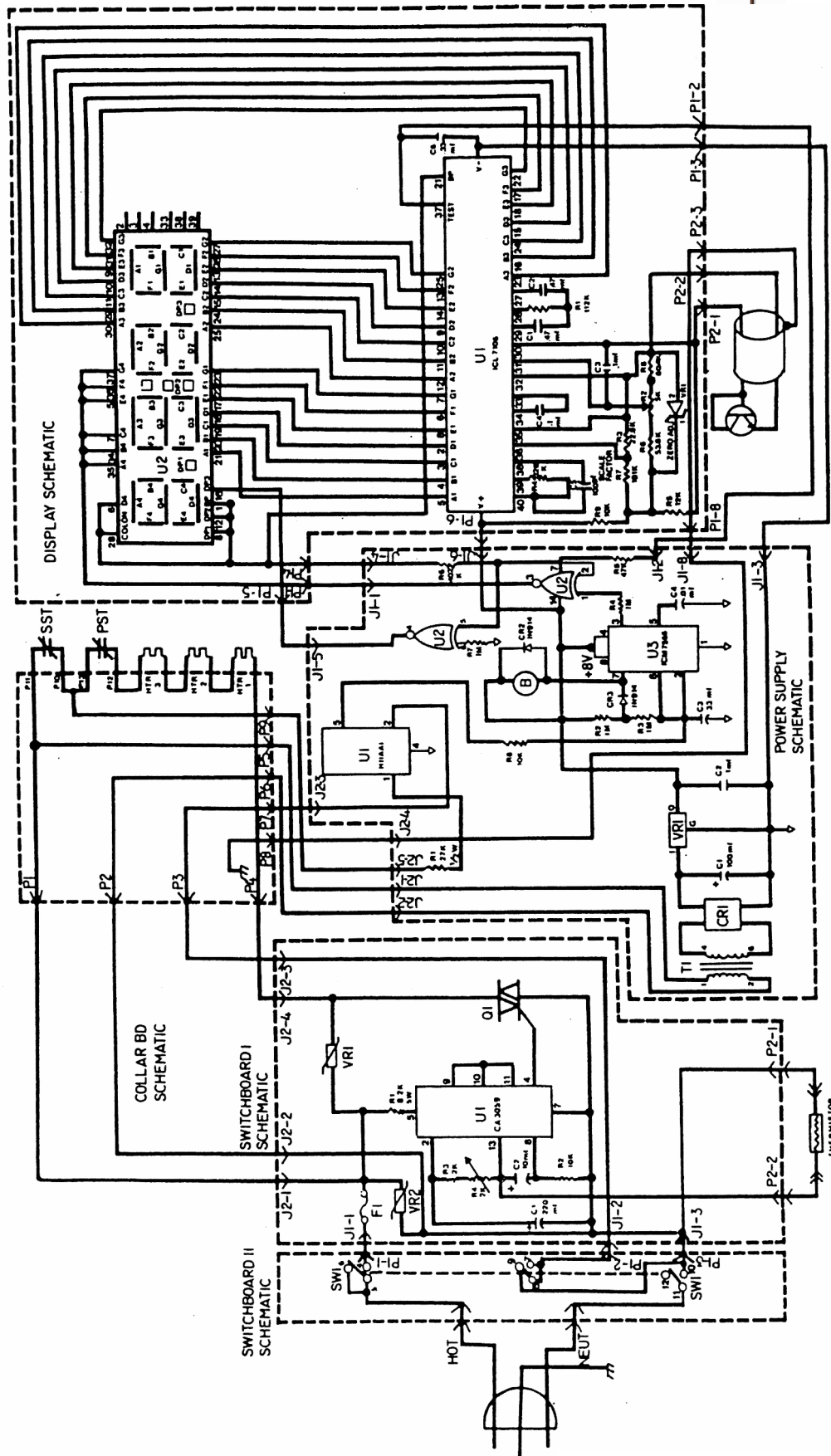
## **TROUBLESHOOTING**

Referring to Schematic 1 (Blood Warmer Circuit):

- ☐ 1) The audible alarm (B) is sounding but the expected flashing letter "A" on the display is not present. This is most probably caused by:
- a) VR1 (power supply schematic) open circuit.
  - b) U2, pin 3, open circuit.
  - c) U2, pin 4, short circuit.
  - d) C2 open circuit.
- ☐ 2) The audible alarm is not sounding, yet the display is indicating that an alarm condition exists (flashing letter "A"). This is most probably caused by:
- a) CR2 open circuit.
  - b) C2 short circuit.
  - c) Printed circuit trace between pin 7 of U3 and CR2 anode is open circuit
  - d) SST faulty.
- ☐ 3) The temperature of the heater assembly is within specifications but the digital display is blank. This is most probably caused by:
- a) F1 blown.
  - b) CR1 open circuit.
  - c) PST open.
  - d) Q1 short circuit.

Referring to Schematic 2 (Infant Incubator):

- ☐ 4) The junction of R69 and pins 9 & 10 of AR9 measures +10 Volts. What condition would most likely cause this:
- a) RT1-A short circuit.
  - b) RT1-A open circuit.
  - c) J20 pins 3 & 4 shorted.
  - d) R44 open circuit.
- ☐ 5) Power failure is detecting when the normal voltage potential on the cathode of CR3 is absent. If the power failure alarm is sounding, but the mains power to the incubator is present, the most likely cause is:
- a) C4 short circuit.
  - b) CR5 open circuit.
  - c) CR3 open circuit.
  - d) BTRY1 voltage low.



**BMET SCHEMATIC 1**





## **ESSAY QUESTIONS**

The essay questions are to test your ability to write reports and express your opinions in a clear and concise manner. Topics may cover any aspect of Biomedical Engineering, including departmental organization and management or technical issues. The expected word count is an indication of the detail one should include in the essay. Marks are earned for clarity, style, accuracy of information and word count.

- 1) Your hospital administration has been approached by the Department of Surgery requesting that a surgical laser be purchased, from donated monies, for beneficial use in certain procedures in the O.R. The hospital has never had a surgical laser before and the surgeons requesting it have never used one before.
  - a) What steps need to be taken before the laser is purchased.
  - b) What modifications, if any, would be required in the O.R.
  - c) What on-going procedures need to be put in place for both the equipment concerned and the staff of the O.R.

(200 words)

- 1) You have been given the task of designing a preventative maintenance and repair program for the medical equipment in a brand new hospital. All the equipment is new and located in its correct department.
  - a) Explain how you would go about organizing this program. Include:
    - Your method of determining the staff compliment required to successfully operate the program.
    - What inspection frequency would you recommend for the following devices: physiological monitors, infusion pumps, defibrillators, and electrosurgical units.
    - Explain your rationale for the frequencies selected.

(200 words)

**MULTIPLE-CHOICE QUESTIONS ANSWER KEYS****Anatomy and Physiology**

- |    |   |
|----|---|
| 1  | B |
| 2  | C |
| 3  | C |
| 4  | C |
| 5  | C |
| 6  | A |
| 7  | B |
| 8  | C |
| 9  | D |
| 10 | C |

**Basic Electronics**

- |    |   |
|----|---|
| 1  | B |
| 2  | D |
| 3  | D |
| 4  | A |
| 5  | C |
| 6  | D |
| 7  | B |
| 8  | B |
| 9  | D |
| 10 | A |
| 11 | D |
| 12 | A |

**Troubleshooting**

- |   |   |
|---|---|
| 1 | B |
| 2 | C |
| 3 | B |
| 4 | A |
| 5 | A |

**Medical and Laboratory Instruments**

- |    |   |
|----|---|
| 1  | B |
| 2  | A |
| 3  | C |
| 4  | D |
| 5  | B |
| 6  | B |
| 7  | C |
| 8  | A |
| 9  | B |
| 10 | B |
| 11 | C |
| 12 | A |
| 13 | B |
| 14 | D |
| 15 | C |
| 16 | A |
| 17 | A |
| 18 | B |
| 19 | D |
| 20 | A |
| 21 | C |

**Safety and Standards**

- |    |   |
|----|---|
| 1  | B |
| 2  | A |
| 3  | D |
| 4  | B |
| 5  | A |
| 6  | C |
| 7  | C |
| 8  | D |
| 9  | C |
| 10 | B |
| 11 | A |
| 12 | D |
| 13 | B |
| 14 | D |
| 15 | A |
| 16 | D |
| 17 | B |
| 18 | D |
| 19 | A |
| 20 | C |



## **ESSAY QUESTION 1 - Key points to include in a typical answer:**

Appoint Laser Safety Officer (LSO) for organization.

The Laser Safety Officer shall have final sign-off on the purchase order.

The Laser Safety Officer is responsible for the review, implementation and audits of the following items with a laser safety program as per standard CAN/CSA Z386:

- Specifications of laser being requested:
  - Laser medium (e.g. CO<sub>2</sub>, YAG etc.)
  - Frequency
  - Output Power
  - Class of laser
  - Nominal hazard zone (NHZ)
  - Nominal Ocular Hazard Distance (NOHD)
  - Maximum permissible exposure (MPE)
- Engineering controls:
  - Dulling of surgical instruments
  - Interlocking of doors
  - Key control
  - Window covering (laser blinds)
  - Laser signs
- Credentialing:
  - Certification of surgical staff (Laser Safety Personnel)
  - Credentialing of physician/surgeon
- Ocular protection (laser specific for staff)
- Medical surveillance (eye examinations)
- Maintenance routines
- Standard operating procedures:
  - Ocular safety
  - Non-beam hazards
  - Handling and care of laser fibers (if applicable)
  - Credentialing
  - Administrative and procedural controls (i.e. checklists)
  - Laser logs
- Patient protective equipment:
  - Laser EET tube
  - Laser ocular protection
- Smoke evacuator and/or specialty masks
- Fire extinguisher



## **ESSAY QUESTION 2 – Key points to include in a typical answer:**

- Computerized inventory and preventive maintenance system
- numbering and identifying equipment
- planning the maintenance schedule to provide a manageable workload throughout the year
- individual equipment inspection times could be determined from other hospitals with a biomedical engineering programme.
- determine total time required to perform inspections for all equipment
- manpower requirements based on total time to perform in-house inspections, what items are on contract, plus an estimation of repair time. Productivity factors of typical service staff should be mentioned.
- Frequencies of inspection will depend on expected equipment usage; the critical nature of equipment; history of reliability, and manufacturers recommendations, but could typically be:
  - cardiac monitor 1 to 2 times per year
  - infusion pump 1 to 2 times per year
  - defibrillator 2 to 4 times per year
  - electrosurgical unit 2 to 3 times per year