Benha University | **1st term 2011 / 2012**
Benha Faculty of Engineering | **Electrical Department**
Clinical Equipment Management (E527) | **5Th year (Control)**
Dr.Wael Abdel-Rahman Mohamed | **Time: 3 Hrs**

Exam with model Answer

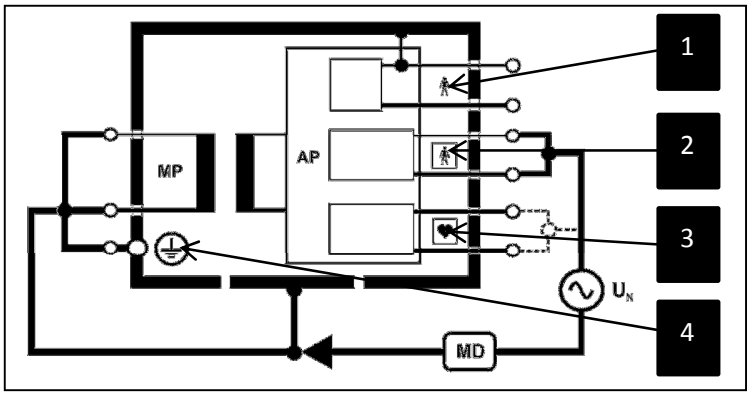
Question (1): [15 Points]

a) Would the risk of microshock be reduced if all intracardiac catheters were grounded? Why?

No; because grounded intracardiac catheters will provide a path for the microshock current to pass through the patient.

b) In an excellent review article Professor Chris Hull makes the odd claim that when an isolation transformer is used "a broken earth (ground) lead actually makes it safer!" Under what circumstances is this strange statement correct?

Solve by yourself.



c) For the medical device shown in this figure, what does the indicated symbols mean.

1- Type B: earthed applied part. [B for body; connected to skin].
2- Type BF: earth-free (floating) applied part. [B for body; connected to skin & F for floating].
3- Type CF: earth-free (floating) applied part for cardiac applications. [C for cardiac; direct connection to heart & F for floating].
4- Class I, earthed equipment design.

d) Below is a list of basic safety recommendations for use in hospitals and other clinical settings. Give a rational for each precaution.

SAFETY RECOMMENDATION	(REASON)
1) AVOID GROUNDING PATIENT.	Patient less likely to become part of a completed circuit.
2) GROUND ALL ELECTRICAL EQUIPMENTS NEAR THE PATIENT.	If faulty equipment becomes live, the current will follow in the low resistance earth wire to the ground.
3) USE LIM IN OPERATING ROOMS.	To protect patient from electrical shock hazards (at least for the first fault).
4) ***NEVER*** USE GFCI IN CRITICAL CARE AREAS.	The loss of power to life support equipment can also be equally deadly!
5) KEEP THE FLOOR DRY.	Liquids decrease the patient resistance and also provide good current path.

SAFETY RECOMMENDATION	(REASON)
6) KEEP ELECTRICAL EQUIPMENT OUT OF REACH OF THE PATIENT IF POSSIBLE.	They cannot change settings; avoids contact with equipment should it become faulty; exceptions: work own monitor in coronary care, administer own pain killers in oncology ward.
7) DURING THE DEFIBRILLATION PROCEDURE, IT IS IMPORTANT THAT NO PERSONNEL TOUCH THE PATIENT OR THE BED.	Not have an electric shock.
8) DON'T WEAR METAL JEWELRY WHEN WORKING ON ELECTRIC CIRCUITS.	Metals are good path for current; so the risk of electrical hazards increases.
9) LIM IS ALWAYS USED WITH LINE ISOLATION TRANSFORMER	To monitor for the first fault. If it is not found; the patient may be at risk without our knowledge.

e) What is meant by "Equipotential ground system"? Why and where it is used in healthcare systems.

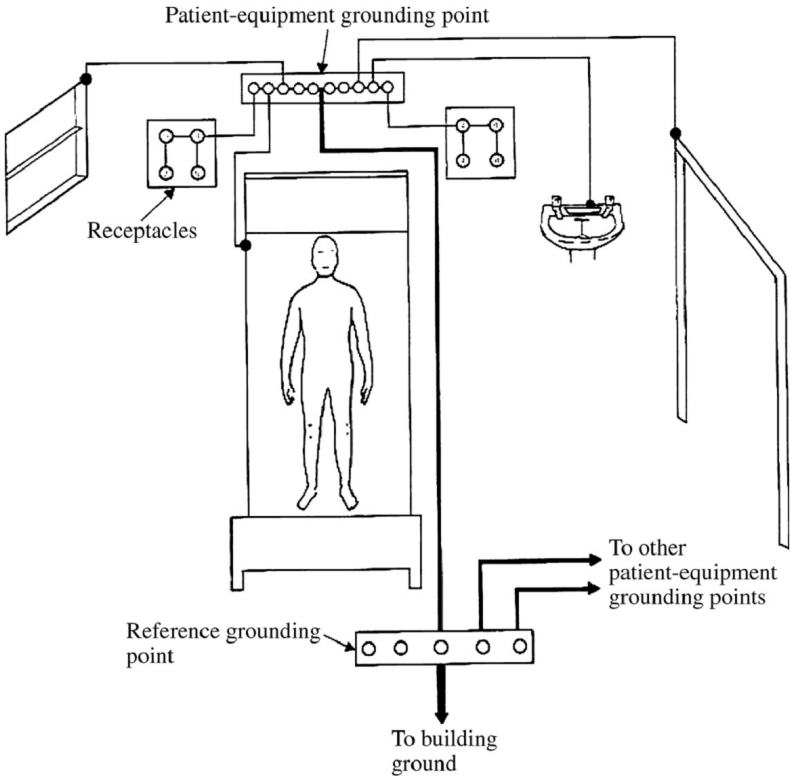
All the receptacle grounds and conductive surfaces in the vicinity of the patient are connected to the patient-equipment grounding point. Each patient-equipment grounding point is connected to the reference grounding point that makes a single connection to the building ground.

It is used because keeping all conductive surfaces and receptacle grounds at the same potential protects patients from:

- Macroshocks
- Microshocks
- Ground faults elsewhere (!)

(The difference between the receptacle grounds and other surface should be no more than 40 mV).

It might be used in all healthcare areas to protect patients.



Question (2): [15 Points]

1) **If a non-grounded patient catheter touches the chassis of an electronic circuit. If the N wire is connected to the chassis of the equipment and the 220V instrument draws 500W, compute the voltage of the chassis with respect to ground. If the power cord resistance is 0.25 Ω.**
   Current passes through hot wire = 500W / 220V = 2.27 A.
   Current will be divided equally between neutral and ground wires = 1.14 A.
   Voltage of chassis with respect to ground = 1.14A * 0.25 Ω = 0.284 V = 284 mV.
   (Note: the patient is safe since the patient catheter is not grounded)

2) **For the circuit shown in figure, and according to the provided human impedance, find the potential of the high voltage transformer that passes a dangerous let go current into the patient. (mains frequency is 50 Hz)**
   Solved in question 4 part 3.
3) **What is meant by susceptibility parameters? (mention three of them). And what is the purpose of the earth wire connection in 3-point plugs?**
   Parameters that changes the physiological effect of the current on patients like:
   1) Frequency.
   2) Duration.
   3) Weight.
   4) Points of entry.

   The purpose of the earth wire is to make a path for leakage current and fault current.
4) **Describe at least three (3) different situations in which macroshock can occur and three (3) different situations in which microshock can occur.**
   Solve by yourself.
5) **Patients in healthcare environment are subjected to many types of hazards. Explain three of them.**
   - Electrical hazards
     - Electrical shocks (micro and macro) due to equipment failure, failure of power delivery systems, ground failures, burns, fire, etc.
   - Mechanical hazards
     - mobility aids, transfer devices, prosthetic devices, mechanical assist devices, patient support devices
   - Environmental hazards
     - Solid wastes, noise, utilities (natural gas), building structures, etc.
   - Biological hazards
     - Infection control, viral outbreak, isolation, decontamination, sterilization, waste disposal issues
   - Radiation hazards
     - Use of radioactive materials, radiation devices (MRI, CT, PET), exposure control

Question (3): [Practical part] [15 Points]

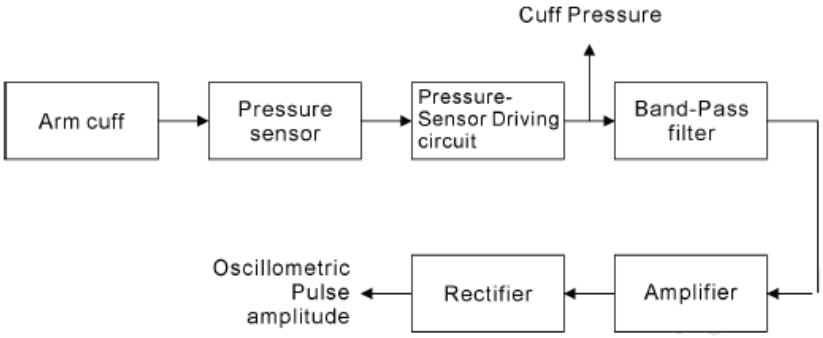
1) Answer the following:
   a) **According to your conclusion why the body impedance experiment carried on AC voltage rather than DC?**
      Because the dominant part of the impedance in reality is the capacitive component and it is important to see the impedance as a function of (L&C) not only R

      $Z=\sqrt{R^2 + (XL - XC)^2}$

   b) **Draw the circuit of 2nd order low and high pass filters.**
      Solve by yourself.
   c) **Illustrate the test of low pass filter has a corner frequency of 10 Hz.**
      Solve by yourself.

d) **When the physician tells you "Your blood pressure is 120/80" for what 120 and 80 refers?**
120- **Systolic pressure**, 80-**diasolic pressure**.

e) **Draw the corresponding block diagram that represents Oscillomertic Blood Pressure circuit design.**

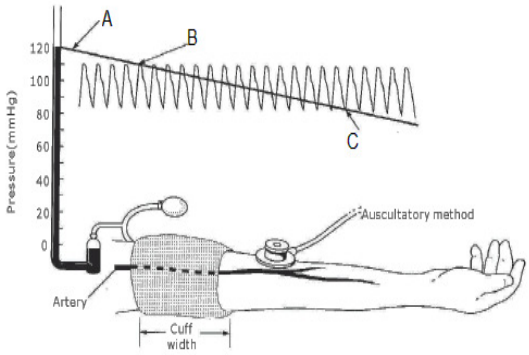


2) **In the figure below:**

a. ***A*** **refere to cuff pressure, while** ***B*** **and** ***C*** **indicates systolic pressure and distolic pressure respectivily .**

b. ***B*** **means that ventricular pressure is greater than arterial pressure and this causing Aortic valve to be opened this generates the first sound.**

c. ***C*** **means that ventricular pressure is less than arterial pressure and this causing Aortic valve to be closed this generates the second sound.**

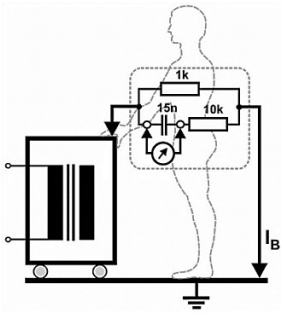


Question (4): [15 Points]

1- **Draw a complete equivalent circuit and compute the RMS current through the patient's heart for the following situation. The patient's hand touches a faulty metal lamp that is 120Vrms above ground. A saline-filled catheter (R=50KΩ) for measuring blood pressure is connected to the patient's heart. Some of the pressure-transducer strain-gage wiring is grounded, and the transducer is somewhat isolated electrically. However, there is *20MΩ of leakage resistance in the insulation between the ground and the saline* in the transducer. There is *also 100pf of capacitance between the ground and the saline*. Assume that the skin resistance of the patient is 1MΩ. Is there a microshok hazard?**
Solved exactly in sheets.

2- **If a grounded patient catheter touches the chassis of a non-grounded electronic circuit (220V/50Hz). Suppose the electronics circuit has a strong capacitive coupling of 1000pf between the power line and the patient lead. The catheter resistance is 1KΩ and the skin resistance is 50KΩ. Compute the leakage current that passes through the patient's heart. Assume a viscera resistance is 200Ω. (Comment on the result.)**
Solved exactly in sheets.

3- **For the circuit shown in figure, and according to the provided human impedance, find the potential of the high voltage transformer that passes a dangerous let go current into the patient. (mains frequency is 50 Hz)**
Compute the total impedance of the human body
$Z = 1K \,//\, (10K + X_c)$
V = I Z ; where I = 5mA (let go current)
Note: it is a high voltage transformer but the human touches its chassis not its wires; so the value of the voltage will be low voltage due to leakage.



With best wishes