

## MHS 321 (Biomedical Electronics)

### Medical Physics

Medical physics is the application of the principle of knowledge and laws of physics in the establishment of medical care, equipment, tools and other health care modalities to preserve and elongate the life of humans.

Medical physics is divided into 3 fields

- 1 Diagnostic Radiology
- 2 Radiation Oncology
- 3 Nuclear Medicine
- 4 Medical Imagining
- 5 Medical Electronics

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#### Diagnostic Radiology

This is the form of medical imagining which involves the use of medical instruments to take images in the body.  
e.g. X-ray - They are used in taking images of the skeleton

Ultrasound - They used high definition frequency sound wave to create images of tissues in the body.

\* CT (Computerized Tomography) - They use combination of X-rays and computer technologies to take and produce images of the inside of the body.

\* MRI (Magnetic Resonance image) - They use strong magnetic field to produce 3D anatomical and physiological process of the body.

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### Nuclear Medicine

This is the part of the medicine that uses strong radiation to create diseases, e.g. cancer cells are destroyed using radiation.

The above techniques cannot be applied without equipment and that led to the concept of Biomedical Equipment and the medical lab scientist is the one that can use the equipment.

### Other aspects of biomedical physics

\* Study of operations

\* Working principles

\* Structure and maintenance of biomedical equipment.

- Biomedical equipments are used in the routine monitoring of patients.

## Names of Biomedical equipments

- X-ray
- ultrasound
- hot air oven
- water bath
- Thermometer
- Ventilator
- Infusion pump
- Centrifuge ~~centrifuging system~~
- Pulse Oximeter
- Nerve Stimulator

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Electronics is a branch of physics and technology which is concerned with the movement of electron and with the way in which these movements can be usefully applied.

Exam focus - Why is it possible to use a biomedical equipment on the human body and it ~~works~~ works

Answer - Biomedical equipments are able to work on human body with the aid of SIGNALS. Signals are detected by Sensors, and are

## BIO MEDICAL EQUIPMENTS

They are equipments designed to aid in the diagnosis, monitoring or treatment of medical conditions.

Converted into electrical signals by transducers that can be processed by the biomedical instrument. Cells are the basic units of body relevant and can detect signals with the help of voltage in it. When cells are dead and biomedical equipments are applied the voltage will be low or no voltage at all.

### ANATOMY & PHYSIOLOGY

#### Basic Electricity concepts and terms

- Voltage
- Current
  - a) Direct current
  - b) Alternating current
- Power
- Resistance

#### VOLTAGE

It is a measure of the potential difference b/w two points in a circuit. In the human body, the cell voltage is between the range of 0 to 90 milli volts. When voltage is triggered, we get action potential difference.

Voltage is defined as

$$V = I/R \text{ and the unit is (V) volts}$$

It can be called electromotive force because it propels action.

### ANSWER EMMANUEL

#### CURRENT

This can be defined as the number of charge or electrons passing through a point per unit time in a circuit.

It is defined as ~~unit current~~ ~~current~~ ~~unit~~

$$I_A = \frac{I_C}{S}$$

$C \rightarrow$  Charge

$S \rightarrow$  Seconds

$A \rightarrow$  Ampere

$I \rightarrow$  Current

Current can be classified into two

## DIRECT CURRENT (DC)

They have a direct source and flows in one direction  
e.g Batteries.

## ALTERNATING CURRENT (A.C.)

Have a high voltage and are more destructive. They pass through transformer otherwise known as indirect sources, so they are not from direct sources. They changes direction with time and allows for transmission of power efficiently over long distance (A.C.).

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## RESISTANCE

It is the opposition or hindrance to the flow of current. The term resistivity refers to the extent to which a material can form resistance to the flow of charge. There are materials of high and low resistance.

## POWER

It is the energy that is gained or lost in a circuit per unit time. Unit is Watts (W).

By definition, 1 Watts is equal to Joules per Second

$$P(W) = IV$$

or

$$W = 1J/\text{sec}$$

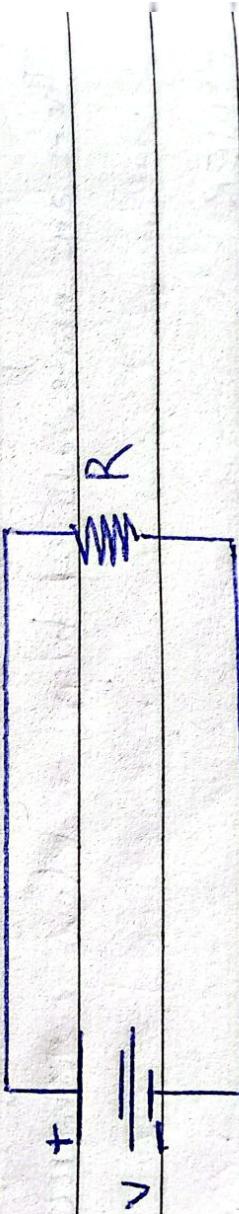
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#### OHM'S LAW

Ohm's law units the basic quantities of electricity and states that the current flowing in a circuit is directly proportional to the applied potential difference and inversely proportional to the resistance provided all physical conditions are kept constant.

$$V = IR$$

Current cannot flow without voltage as current more voltage drops and its experiences resistance in form of heat.



## RECTIFICATION

This is the process of converting alternating current (AC) to direct current (DC). It is the process of conversion of current that is alternating to direct current. It is achieved using a set of diodes. When the diodes are combined, they form a Rectifier.

Rectifier is the equipment used in achieving rectification.

- Cathode ray oscilloscope used to measure voltage supply.

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### Q Calculation

A battery that gives a constant voltage in ~~one~~ one direction has a p.d. of 2V across 2cm. What is the voltage of that ~~battery~~ battery?

An electric circuit is a network consisting of a closed loop giving a return path for the current of a path for transmitting electric current.

Types of electric circuit; Closed, Open, Short, Series & parallel circuit.

However, there are different compound that make up electric circuit which include

i) Resistor

ii) Capacitor

iii) Transistor

iv) Diode

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Materials / components can be classified based on the ability to conduct the flow of current,

i) Conductors

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ii) Insulators

iii) Semi-conductors

### CONDUCTORS

Conductors permits a general flow of electrons with very little external force or applied force of electrons and flow of charge forces e.g. copper, metals, silver, gold, aluminium.

### INSULATORS

Materials that do not conduct charge, they have high resistance to flow of electrons / charge.

## SEMICONDUCTOR

Diode, transistors, emitters, specific groups of elements that exhibit characteristics o/w conductors and insulators.

They are neither good Conductors or good Insulators.  
They are used to make and fabricate most components in equipments made of silicon or germanium.

They work in between and do very high functions.  
Many Components work well on DC or AC except

Diode & Capacitors.

Light emitting diode (LED)

10 They are like lamps with the abilities of what a bulb will do.

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Resistors can be Combined in series or parallel. How to combine resistors in Series.

Voltage will be shared among the resistor, while the Current remains constant.  
What is the Combined resistance of two  $5\ \Omega$  resistors when connected in series?

$$R_{\text{total}} = R_1 + R_2 + \dots$$

$$5\ \Omega + 5\ \Omega = 10\ \Omega$$

The chains keeps getting increased on a linear form  
Voltage divided in IS gotten by connecting resistors  
in series. It is their addition.

Using the above question solve for resistor in parallel.

$$\frac{1}{R} + \frac{1}{R} = \frac{R_1 + R_2}{R_1 \times R_2}$$
$$\frac{50 + 50}{50 \times 50} = \frac{160}{2500} = 0.04$$

Find inverse cm = 50

$$R = \frac{1}{50} =$$

$$\text{Inverse} = 50 \frac{1}{2} = 25 \Omega$$

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A chip is a little board consisting of smaller component

\* An integrated circuit Chip / microchip

\* Amplifier

\* Oscillator

\* Time

\* Microprocessor

When classifying components we have

1] Active Components

2] Passive Components

## PASSIVE COMPONENT

Do not add energy to the circuit they are not capable of producing any input energy in a circuit.  
They cannot perform active functions e.g. Resistors, Capacitors, Inductors.

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## ACTIVE COMPONENT

They add energy and perform active function such as amplification, rectification, switching of current diode, transistors, Silicon chip of operational amplifiers used to step up weak signals.

## Maximum requirements in a simple electric circuit

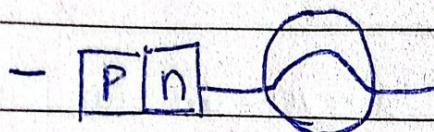
- 1) Acts as a power source (battery, gen., power supply)
- 2) Load divider (resistor, capacitor)
- 3) Conductors (The drive of flow current)
- 4) Protective devices (fuse, Circuit breaker)

## Questions

i. Name a Semi-Conductor material

ii) How does the conducting ability of a Semi-Conductor compare with that of a metallic conductor.

iii) What is the effect on a pure Semiconductor of doping it so that it becomes an N-type material.



The figure above shows a PN junction diode <sup>with</sup> a small bulb.

NB - Backward & forward bias depends on voltage  
(Pg 46 of textbook)

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2 Copy and complete the diagram to show how the battery should be connected so that the diode is forward biased.

ii) What will be the effect on a light bulb.

iii) Redraw the diagram using the appropriate circuit

Symbol for the diode

iv) What will be the effect of reversing the battery connection.

## ANSWERS

Temp dependence

i. Diode, transistors, amplifiers, emitters) - Devic

ii. Semi conductors have less electrical conductivity

in metals electrons carry current.

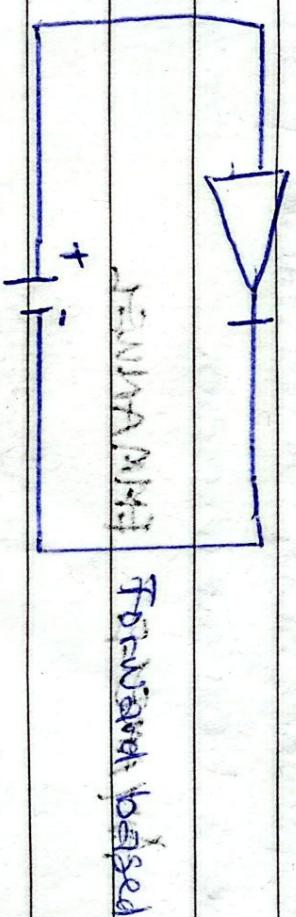
iii. Current carried by flow of electrons of positively charged holes.

By doping pure silicone with group 5 elements like phosphorus or arsenic, extra valence electrons are added that become unbound from individual atom and allow the cd to become an electrically N type semi conductors N type has more electrons. When you add certain electron from group 3, you form P type. e.g. Boron, Aluminium. More holes you have a P-type.

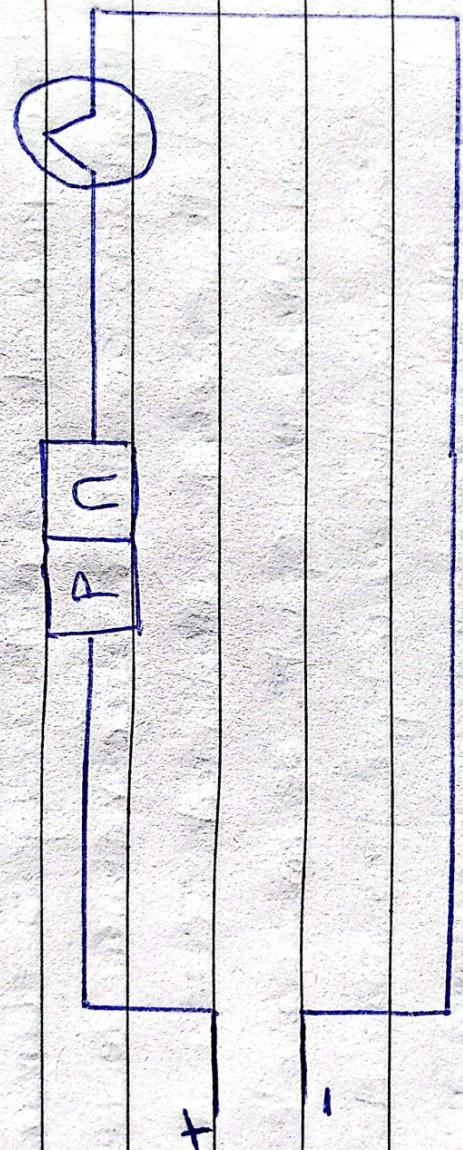
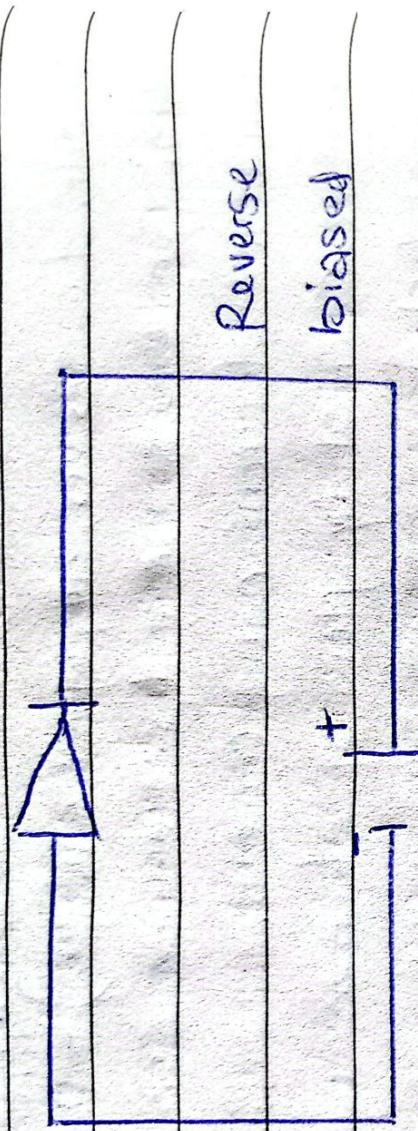
P represent type N represents electrons (Pg 48)

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2.



When the positive is connected to the P type, it is forward biased.



2.i. The higher resistance Current decrease or no Current the resistance of the diode will increase in backward bias

For forward bias, the resistance of diode will decrease and Current increases.

ANSWER

## Faults finding and maintenances of biomedical equipments

These equipment have trouble shooting techniques

1. Calibration
2. Visual Checks
3. Function Checks

NB - Checks are carried out every 6 months

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Calibration has to do with Comparing the output of instruments under test to that of instruments of known accuracy when the same inputs given to both.

We calibrate because all medical instrument suffer drift.

### Factors responsible for drift

1. Environmental conditions in which they are used
2. Frequency of use.  
Drifting introduces error to the result offered by these instrument.

## BIOMEDICAL ELECTRONICS

### Test Revision

1. Electronics is concerned with the movement of Electrons and how this movement can be usefully applied.

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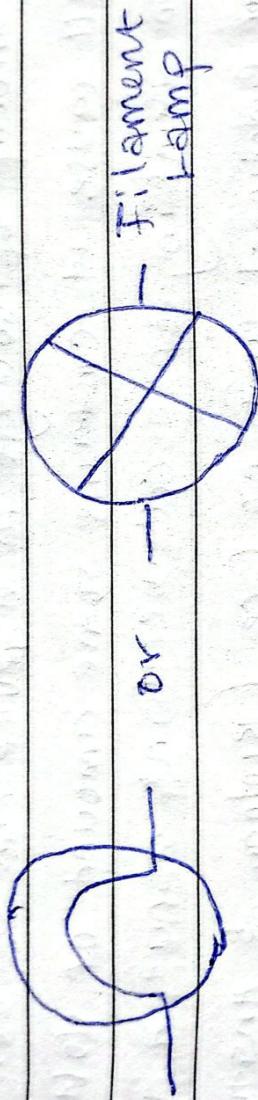
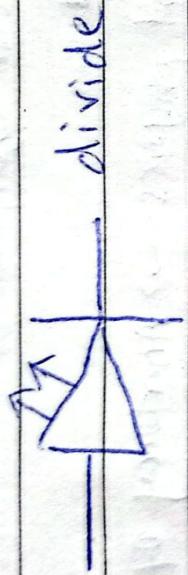
2. Integrated Circuit. Consists of combination of several diodes, resistor, and capacitors in a chip.
3. Minimum requirements for an electric circuit
  - \* Power - Source - battery
  - \* Load device - Capacitor, lamp
  - \* Conductors - wire
  - \* Protective devices - Fuse, circuit breaker, Switch
4. Lamp - Produces a visual display of electric fluid.
5. Motors - Converts electric energy to mechanical energy.

$$6. V = \frac{W}{Q} = \frac{60J}{30} = 2V$$

$$7. Q = 240 \text{ coul} = \frac{240}{60} = 4 \text{ Ampere}$$

8. Transistors can either be used as  
Switches, Amplifier, Filters

9. Each Transistor has 3 terminal  
Base, Emitter, Collector
- (filament)
10. Draw the symbol of a bulb and a diode



Exam focus - In few words show the importance of  
biomedically applications in medical field.

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## BIOMEDICAL ELECTRONICS (REVISION)

- 1] Reproduction of the concept of electron
- 2] Definition of Biomedical electronics, concept of electron  
[definition of electrons]

3] Use and application of biomedical equipment as per the principles of biomedical equipment.

### 1) Principles Of Electronics

- 5) Bio suspect of Biomedical physics → Anatomy of the cells
- 6) The amount of voltage in a device can be detected
- 7) It cause it contains some amount of voltage.
- 8) When thinking of a cell we think about its
  - Basic functional unit of life (Biology & Anatomy)
  - Electronic (dry cell)

### ANYANSE EMINENCE

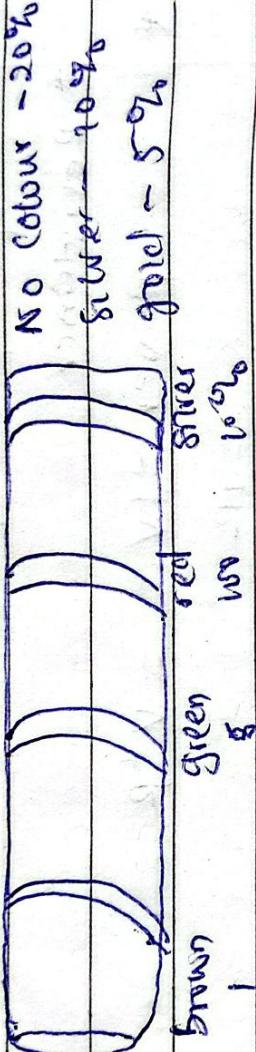
- \* The link between electronics and the human body
- \* Use of equipment in naming and mentioning.
- \* Fine → Application of the basic unit of life and electronics into
  - 1) Diagnostic purposes
  - 2) Therapeutic purposes

\* Electronic component - Resistor (grouped linear, fixed, variable)  
Non linear

\* Symbols of electric components.

### \* Resistor Colour codes

- \* Where does the first colour and, second, third, 4th signify
- first band - Resistance value
- Second band - Resistance value
- multiplier - No. of zeros to be written after the first digit.
- Tolerance - Range of which the resistance can tolerate the flow of current.



$$\text{Resistance} = 1500 \Omega$$

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$$\text{Tolerance} = 10\% \times \frac{1500}{1} = 150 \text{ ohms}$$

$$\text{Upper - lower limit} = 1500 \pm 150$$

$$\text{Upper} = 1500 + 150 = 1650 \text{ ohms}$$

$$\text{Lower} = 1500 - 150 = 1350 \text{ ohms}$$

### ANSWER

What is the current in the lamp (lens) rated at

$$i) \approx 2.40 \text{ A normal brightness}$$

$$ii) - 240 \text{ or } 40 \text{ watt respectively}$$

\* Instruments used to indicate signals in the brain & muscle

\* Basic electricity concept and terms. (definition, unit of measurement, instrument and formulae to derive it)

\* Ohm's Law ( $V = IR$ ) (Basic formula)

N.B. → Always write the unit after solving

\* Current =  $\frac{\text{charge}}{\text{time}}$  (AC, DC)

\* Concept of Rectification

\* Resistance

$$\text{Power} = IV = V^2 R$$

$$= 12$$

\* materials that allow the flow of current, do not pathway

\* Examples of conduction, indicators, semi conductors

\* A battery gives a constant voltage in one direction

What is 2cm, what will be the voltage?

ANSWER = 1.2V

Answer: Emmanuel