VTU | | | | | | | | | 　　　　　　　　　　BBOC407

Fourth Semester B.E./B.Tech. Degree Examination, June/July 2025
Biology for Engineers (CSE)

Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. M : Marks , L: Bloom's level , C: Course outcomes.

		Module – 1	M	L.	C
Q.1	a.	Define Cell. Explain function and structure of cell.	7	L2	CO1
	b.	List the various hurmones and write the functions of them.	7	L2	CO1
	c.	Demonstrate the properties and function of lipids.	6	L3	CO1
		OR			
Q.2	a.	What are stem cells? Discuss the function of stem cells.	7	L2	CO1
	b.	List the vitamins and write the functions of them.	7	L2	CO1
	c.	Demonstrate the properties and function of nucile seids.	6	L3	CO4
		Module – 2			
Q.3	a.	Define Biomolecute. List the classification of biomolecules with each one example in short in engineering application.	7	L2	CO2
	b.	Explain the applications of enzymes in biesensms and bio bleaading.	7	L2	CO2
	e.	What is DNA finger printing? Explain the process involved in DNA finger printing.	6	L3	CO5
		OR			
Q.4	a.	Explain the properties of cellulose as an effective water filter.	7	L2	CO2
	b.	List the properties of PHA and explain the engineering applications of PHA.	7	L2	CO2
	c.	Demonstrate whyy as a protein.	6	L3	CO3
		Module – 3			
Q.5	a.	Define ECG. Explain in detain.	7	L2	CO3
	b.	How kidney will be used as a filteration system, explain with one type of dialysis example.	7	L2	CO3
	c.	Illustrate Brain as a CPU system.	6	L3	CO3

		OR			
Q.6	a.	Briefly discuss the various bio engineering solutions for muscular dystrophy.	7	L2	CO3
	b.	Explain roboris nrme for Prosthetic devise.	7	L2	CO3
	c.	Illustrate eye as a camera system.	6	L3	CO4
		Module – 4			
Q.7	a.	Compare the process of photo synthesis to the functioning of photo synthesis to the functioning of photoeplatic cells.	7	L2	CO4
	b.	Super hydrophobic and self cleaning surfaces. Explain in detail.	7	L2	CO4
	c.	Write a note on Lotos last effect.	6	L3	CO4
		OR			
Q.8	a.	Compare HBOC's and FTC.	7	L2	CO4
	b.	How shark skin and swim suits are using biological concepts.	7	L2	CO4
	c.	Write a note on GPS technology.	6	L3	CO4
		Module – 5			
Q.9	a.	Explain in detail flew AI will be used in all disease diagnosis.	7	L2	CO5
	b.	Demonstrate bioremediation and biomining.	7	L3	CO5
	c.	Explain muscular system as a scaffold.	6	L3	CO5
		OR			
Q.10	a.	Explain in detail electrical nose in food science.	7	L2	CO5
	b.	Demonstrate bioprinting technique list all of them.	7	L3	CO5
	c.	Explain DNA origamt and lies computing.	6	L3	CO5

Q1. a.] Define Cell & Explain function & Structure (12...)

Golgi apparatus — Centrosome
— Nucleus
Lysosome
— Cytoplasm
— Mitochondria
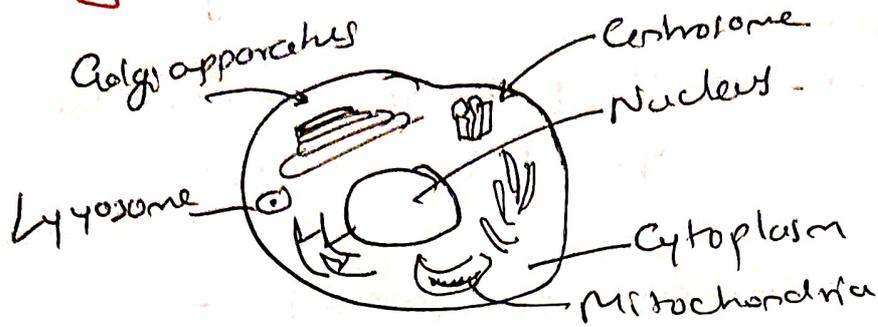
A cell is a smallest structural & functional unit of life. All living organism madeup of cell. with one or more numbers. All vital activities happens inside cells

Structure of Cell
1. Cell wall → Rigid outer layer of Cellulose
   Provides shape, support & Protection
2. Plasma membrane
   Thin flexible boundary surrounding cell
   Controls movement of substances in & out
3. Cytoplasm.
   Jelly like substance Inside Cell membrane
4. Nucleus.
   Control Center of Cell
   Contains genetic material DNA
   Regulate growth, metabolism & reproduction
5. Mitochondria → Power house of Cell
6. Ribosomes → Protein Synthesis
7. Endoplasmic Reticulum → Transport materials
8. Gogli apparatus → Packaging & Secretion
9. Vacuole → Storage
10. Chloroplast → Controls photosynthesis in plants

Functions
1) Carries metabolic activities
2) Produce Energy through respiration
3) Synthesis Protein & Enzymes
4) Store genetic information
5) Helps growth & repair of organism

? List various harmones & write their functions (7 marks) ②

1. Growth Harmone
   * Stimulate growth of bones & body tissue
   * Regulates physical development

2. Thyroxine
   * Controls metabolism of fats & proteins
   * Regularter body temperature & energy production

3. Insulin
   * Lowers blood glucose level
   * Converts glucose into glycogen

4. Glucagon
   * Increas blood glucolevel
   * Converts glycogen into glucose

OR

5. Andruhaline
   * Prepare body for emergency
   * Increate heart rate, blood pressure & energy supply

6. Ovary
   * Develope female secondary sexual charet ter
   * Regulate menstrual cycle.

7. Testis
   * Develop male sexual charectr
   * Helps sperm formation

Q2c. Properties & functions of lipids   6 mark

Properties of lipids

   1) Lipids are insoluble & donot dissolve in water
   2) They only dissolve organic solvents ether, alchoblek
   3) Lipids feel oily to touch & changes phase at room temp.

Functors of lipids

   1) Act as long energy reserve for the body
   2) Form essential componet ie. cell membrane
   3) Helps thermal insulation & control body temperature

Q2a. What are stem cells, discuss function of stem cell. ?

Blood Cell

Fat Cell

Enterocytes

Muscle Cell

Bone Cell
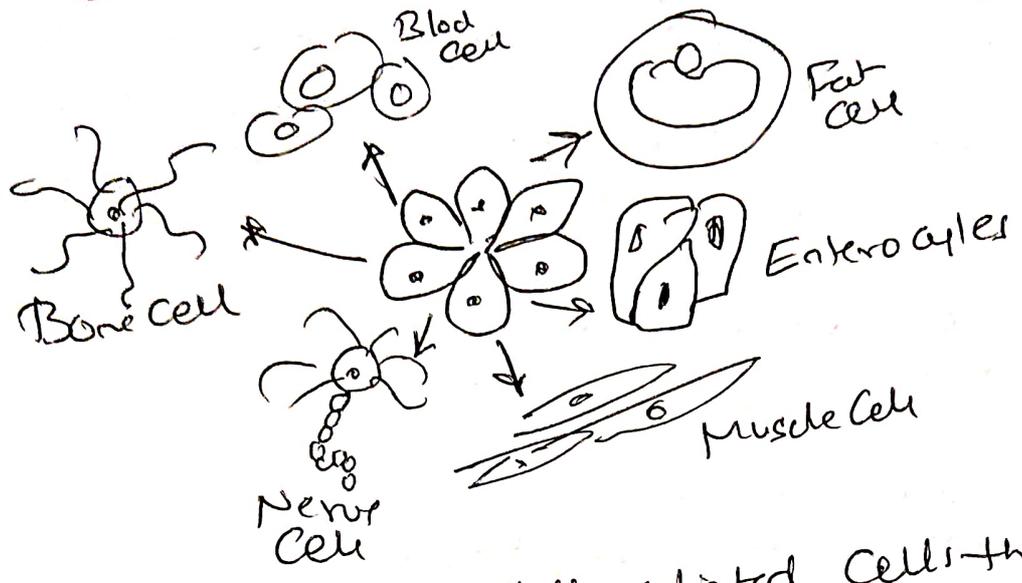
Nerve Cell

Stem Cells are undifferentiated Cells that have ability to self renew & differentiate into specialized cell Such as muscle Cell, blood cell, nervecell etc.

Functions of Stem Cell

1. Cell differentiation.
   * Can develop different types of specialized Cell
   * Essential for forming tissue

2. Growth & Development
   * Embryonic Development
   * Formation of various body system

3. Tissue Repair & Regeneration
   * Replace damaged or dead tissue
   * healing wound & repairing tissue

4. Maintain Body tissue
   * Replenis Body tissue like skin & blood

5. Medical Application
   * Used in bonemarrow transplant
   * Used in regenative medicine

Q2b. List the vitamins & write their functions 7marks

1. Vitamin A.
   → Essential for vision at night
   → Maintain healthy skin & epithelial tissue

Vitamin B complex
→ Helps energy metabolism
→ Support nervous system function & red blood cell formation

3. Vitamin C
→ Required for collagen formation
→ Enhances wound healing

4. Vitamin D
→ Helps absorb calcium & phospherous
→ Maintain healthy bone & teeth

5. Vitamin E
→ Act as antioxidant
→ Protects cell membrane from damage

6. Vitamin K
→ Essential for blood clotting
→ Helps in wound healing

7. Vitamin B12
→ Necessary for blood cell formation
→ Maintain normal nerve function

Q2c. Demonstrate properties & functions of nucleic acid 6marks

Cytocine
Guanine
Adenine
Uracil

RNA

DNA
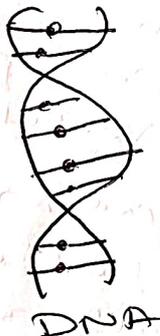
Cytocine
Guanine
Adenine
Thymine

Properties

1) Polymetric in nature —
long chain polymers made up of repeating units called nucleotides

2) Acidic character —
Acidic in nature due to presence of phospherous

3) Water soluble
will dissolve in water but don't dissolve in organic compound

Functions

→ They store genetic information
→ They synthesis protein
→ Regulates cell growth
→ Reproduction through gene expansion

Q2a. Define biomolecules, list classification of biomolecule example in short engg. application — 7marks

A biomolecule is organic molecule produced by living organism that is essential for life processes such as Structure, energy, growth & reproduction.

Classification & Examples

1) Carbohydrates → Glucose & Strach
   * Biofuel production
   * Bioplastic & food production

2) Proteins → Enzymes, Collagen.
   * Textile, Detergents & pharmacetical.

3) Lipids → Fats & Phospholipids
   * Biodiesel production, ~~Drug~~
   * Drug delivery System

4) Nucleic Acids → DNA, RNA
   * Vaccines.
   * Store genetic information

5) Vitamics → Viteric C, Vitemic D etc
   * Pharmacetical Applications
   * Food fortification Industry

Q3b. Explain the application of Enzymes in biosensors & biobeething 7marks

Analyte ⇄ (Enzy me) (⇄) → Electrode A
Product   mediator
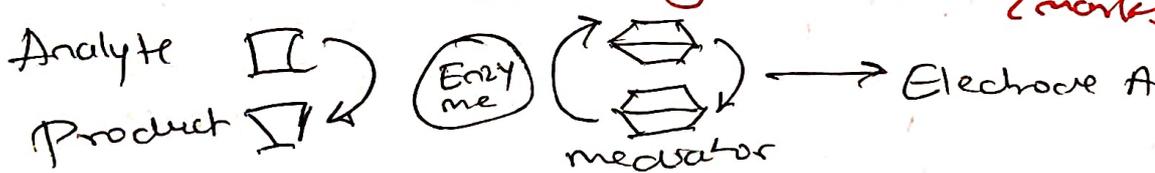
Biosensors is an analytical device that combine biological component with physochemical detector, to detect specific substance.

Role of Enzymes in Biosensor
   * Enzymes act as biorecognition element
   * Reacts with target elements to produce measurable signal

Example.
   1) Glucose Biosensor → measure blood glucose level

...aic Biosensor → Detect urea Concentration

cholesterol Biosensor → Measure cholesterol level

u. Environmental monitoring → Detect toxins & pollutants

3C. What is DNA Finger Printing? Explain the process in DNA Finger Printing 6marks

DNA finger printing is a laboratory experiment to identify an individual based on unique pattern present in their DNA. Expect for identical twin, has unique DNA Finger Print

<u>Process</u> → DNA Extracted from Biological Sample such as blood, hair, saliva or tissue

↗ Extracted DNA cut into fragments using specific restriction enzymes

→ They Separated and passed through a garose gel under an electric field

→ Separated DNA Bands are visualised & compared for genetic similarities

Q4a.
Explain Properties of cellulose as an effective water filter 7marks

Raw water

Micro filtration | Ultrafiltration | Nanofiltration | Reverse Osmasis
0.2-5 bar | 1 to 10 bar | 5-10 bar | 10-150 bar
10-0.01 micron | 0.1 to 0.01 micron | 0.01-0.0001 micron | 0.001-0.0001 micron
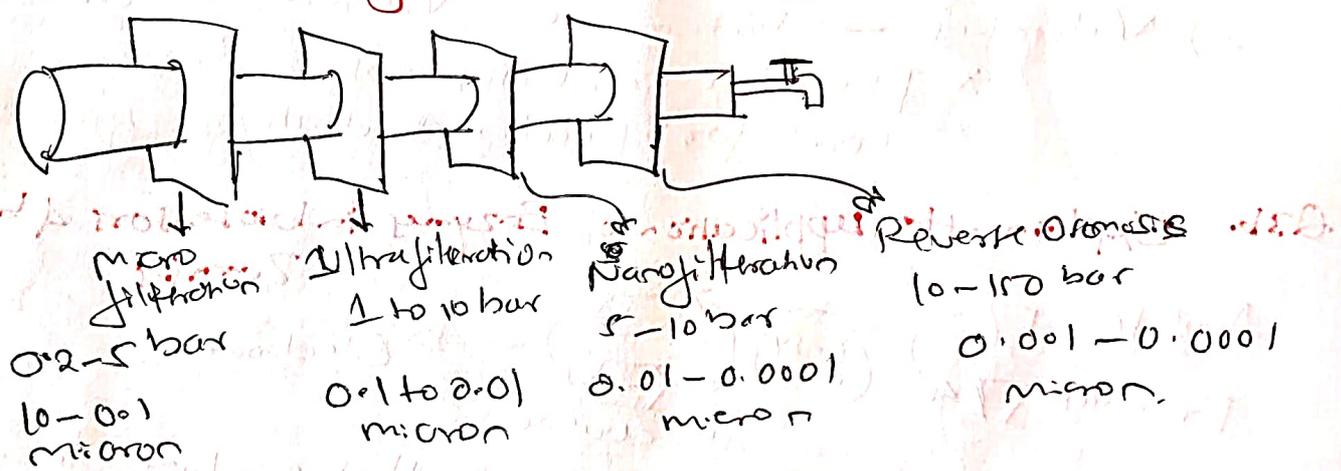
<u>Properties of cellulose</u>

→ Network fine fibre creating micro & nano size pores
→ Allows water pass through & suspend particles
→ Contains Hydroxyl to attract bind water molecules
→ Enhance water permiability & flow rate
→ maintain structural integrity under continious flow
→ Can chemically modified
→ Con remove heavy metals, bacteria & pathogens
→ Does not cause secondary pollutants

4b. List various properties of PHA & its Engineering Applications 7 marks

Properties of PHA

1) Complete degrads into CO_2 & water under natural condition
2) Non toxic, suitable for medical application
3) Can be processed using conventional plastic processing methods
4) Exhibits good strength & flexibility compared to petrochemical plastics.

Engineering Application

1) Used in tissue scaffold, drug delivery system
2) Manufacturing of biodegradable films, containers etc
3) Controled releases of fertilisers in agriculture field.

4c. Demonstrate WHEY Protein 6 marks

Whey is a high quality, globular protein, obtained as a byproduct during the production of cheese from milk. It remains in the liquid portion after milk curdles and casein is removed

→ Whey is an animal protein
→ It is composed of amino acids
→ Rich is essential Amino acids like BCAAs
→ It is a globular protein
→ Easily soluble in water & rapidly digestable
→ Contains β-lactoglobulin, α-lactalbumin.
→ Helps in muscle growth & rebuild
→ Helps in Enzyme & Harmone Synthesis

5a. Define ECG & Explain in details 7 marks
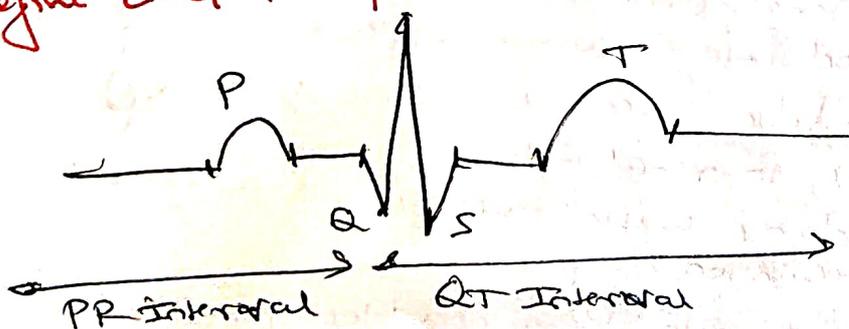
ECG
Electrocardiogram.

...cho cardiogram (ECG) is a graphical recording of the ...cal activity of heart obtained from electrodes placed the surface of the body. It is used to access the heart function & detect cardiac abnormalities

Principle of ECG.

* Heart muscle generate electrical signal during each heartbeat
* Impulse spread through heart & body fluids
* ECG Detects these electrical signals & convert them into a waveform.

Component

P. wave — Represents Atrial depolarisation
Indicates Contraction of atria.

QRS Complex — Represents ventricular depolarisation
: Controls Contraction of ventricles
largest deflection in ECG

T-wave — Represents ventricular repolarisation

Uses

1) Detects arrhythmias, heart block
2) Helps monitoring heart rate
3) Routine cardiac checkup & emergency diagnosis

5b.

How kidney will be used as a filteration system, explain with one type of dialysis example.

Kidney as filteration system

→ Each kidney contains nephrons
→ Blood filteration occurs in the glomerulus where waste material, urea, excess salt & water are filtered into Bowmans capsule
→ Useful substances like glucose, amino acids are reabsorbed in renal tubules
→ Final urine contains waste excreted, & purified blood return for circulation
→ Removes metabolic waste, Regulates blood pressure, maintain electrolytes

Afferent Arteriole   Efferent Arteriole
urine
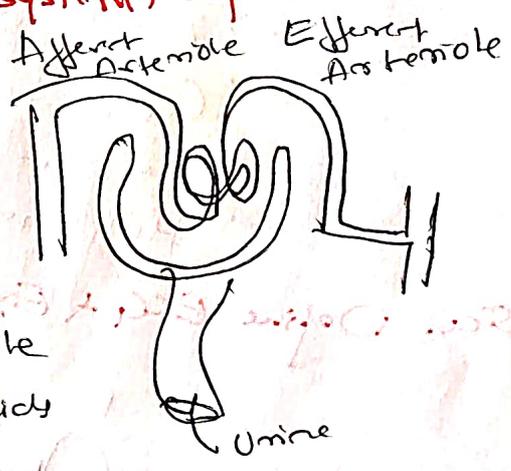
5c. Illustrate brain as CPU system.

Brain → Signal Processing → Feature Extraction → Classification

Classification ↓

mental task and related potential. ⌐ Feedback ⇐ Control Interface
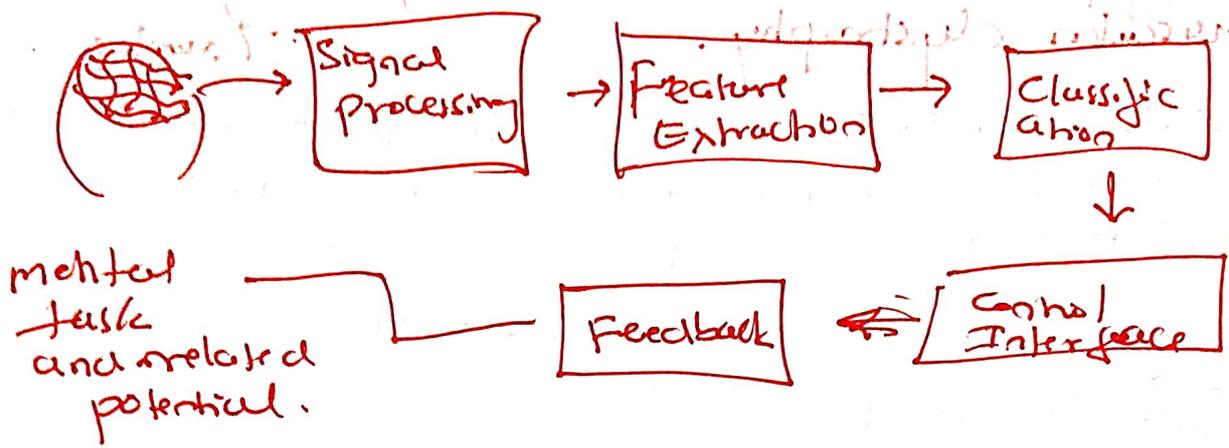
1. Brain as input Unit.
   * Sensory organs (eye, skin, nose, tongue) act like input devices
   * Send Signals as input to brain using sensory nerves
   * Eye Sends visual, ears sends sound etc

2. Brain As processing unit
   * The cerebrum analyse, intercept & process incoming information
   * Perform thinking, reasoning, memory & decision making
   * Billions of neurons network work together like microprocessors.

3. Brain as memory unit.
   * Stores information in short term & long term memory
   * learning from past experience & descision

4. Brain as control Unit
   * Controls voluntary & involuntary activities
   * Regulates heartbeat, breathing, movement etc
   * Maintains Coordination & Balance

5. Brain as output controller
   * Command motor nerves based on information
   * Muscles & glands acts as o/p devices

briefly discuss various bio engineering solution for muscular dystrophy. (10)

7 marks

Muscular Dystrophy (MD) is a genetic disorder characterized by progressive muscle weakness due to defect in muscle protein.

Major Bio engineering Solutions

1) Gene Therapy
* Correct & Replace defective gene
* Insert functional dystrophin using viral vectors
* Helps slow disease progression

2) Stem Cell Theraphy
* Use Stemcell to regenerates damaged muscle
* Promote muscle repair

3) Biomedical implants
* Orthotic devices, braces & exoskeletone support
* Improve mobility + quality of life

4) Tissue Engineering
* Develop artifical muscle using tissue culture
* Aids in muscle regeneration research

6b. Explain Robotic arm for Prosthetic Devices   7 marks

Muscle Signal
↓
Myoelectric Sensors
↓
Signal Ampliflyer
↓
Microcontroller
↓
Motor Drives
↓
Actuators
↓
Robotic Arm movement

Sensors
mech linkage
Sensors
Gears system
motor
servo motor
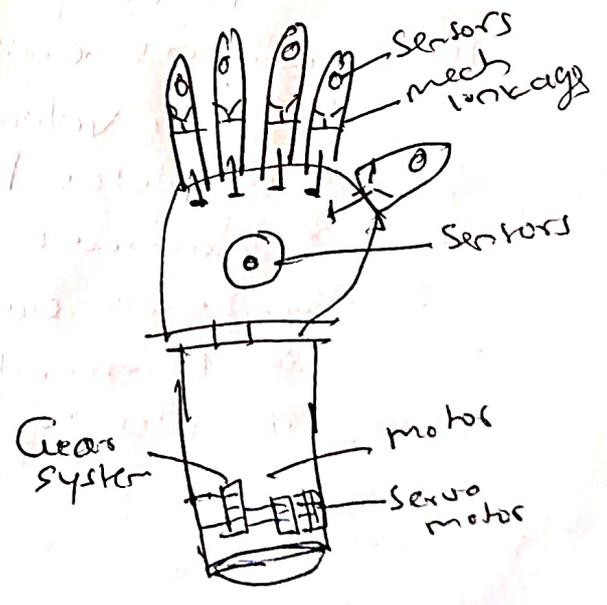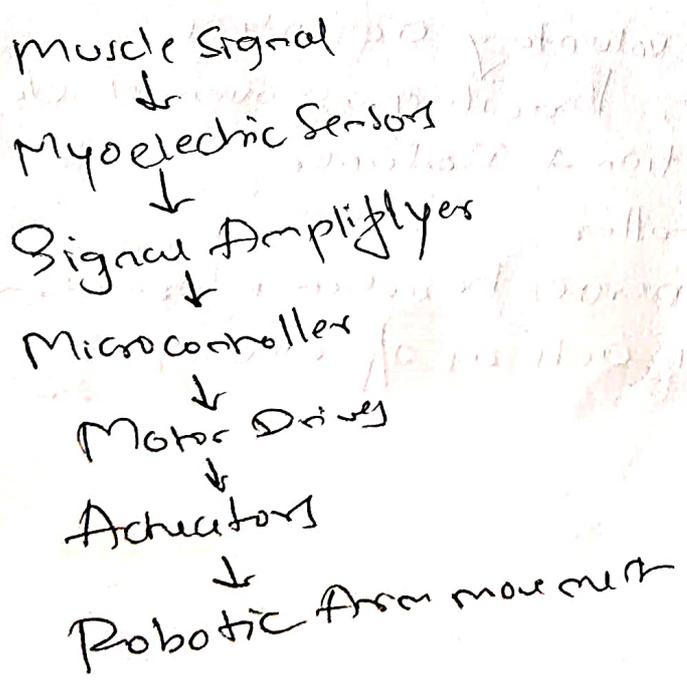
Robotic prosthetic arm is an artificial limb that replaces a missing arm & performs movements similar to a natural arm.

→ Mioelectric sensors detect electrical signals from muscles
→ Signals are processed through microcontroller
→ Motors signal controls signals into mechanical movement
→ Arm performs actions like gripping, lifting and rotating

6c Illustrate. Eye as a Camera system

Human Eye	Camera
1) Eye lens focus light on retina	1) Camera lens focus light on film
2) Iris controls size of pupils	2) Aperture controls amount of light
3) Pupils allows light to enter eye	3) Aperture opening allows light
4) Retina acts as light sensitive surface	4) Film sensors records image
5) Brain interprets image	5) Signal cable transfer image data
6) Optic nerves transfer image data	6) Image processor process image
7) Eye adjust focus continuously	7) Camera adjust focus manually or automatically.

7a. Compare process of photosynthesis to the function of photosynthesis with photovoltaic cells.

Photo synthesis

1) Convert Sunlight into chemical Energy	1) Convert Sunlight into electrical energy
2) Use chlorophyll to absorb energy	2) Uses p-n semiconductor to absorb energy
3) Produce oxygen as by-product	3) No chemical by-product
4) Requires CO_2 & water with sunlight	4) Requires only sunlight
5) Energy stored internally as food	5) Energy must be stored externally in batteries

per hydrophobic & self cleaning surfaces. Explain in detail.

Hydrophobic to Super hydrophobic   7 marks   ⑫

$$\theta = 90 \qquad \theta > 90° \qquad \theta > 150°$$
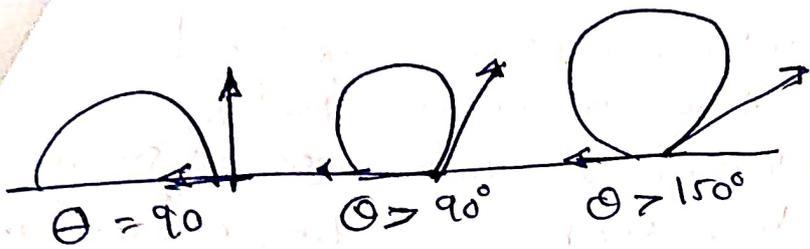
$90° - 150°$ Hydrophobic
$> 150°$ Super hydrophobic.

1. Super hydrophic Surfaces.

It is the one that shows extreme water repellency, with water contact angle greater than 150°. Water droplets beads of and rolls out easily

→ High contact angle $> 150°$
→ Droplets nearly sperical in shape
→ Prevent water from spreading
→ Micro & Nano scale roughness achieve by surface

2. Self cleaning Surfaces.

These are the surfaces that removes dust, dirt & contamination Automatically without natural washing

* Lotus effect observed as water droplets roll over a Surface and carry dirt particles along with it
* Most self cleaning surfaces are superhydrophobic

#Applications
1) Glass & Building materials
2) Texttile Industry
3) Biomedical devices
4) Marine & Industrial application

7c. Write a note on lotus leaf effect 6 marks

Nanoscale wool
water droplets
micro scale epidermal cells
Angled leaf.
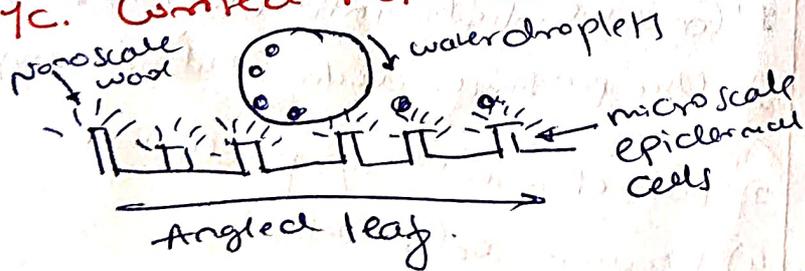
The lotus leaf effect is a natural self cleaning process that observed on a surface of lotus leaves where water droplets roll off easily and carry out dust & dirt particles

Engineering application
→ Self cleaning glass & coating
→ Water repellent texttile
→ Anti corrosion surfaces
→ Solar pannel & building materials.

8a. Compare HBOC's with PEC's — 7 marks

HBOC's	PEC
1) Hemoglobin Based oxygen Carrier	1) Photo electrochemical Cells.
2) Carry + deliver oxygen in human body	2) Convert Solar energy into electrical or chemical energy
3) Based on hemoglobin molecules	3) Based on Semiconductor material
4) Used in medical + biomedical application	4) Used in renewable energy + engineering application
5) Function inside biological System	5) Functions in electrochemical system
6) Aim to support life & metabolism	6) Aim to support clean & sustainable energy
7) Mimic oxygen transport in blood cells	7) Main Natural Photosynthesis,

@V

8b. How shark skin & Swim suit use biological concepts.
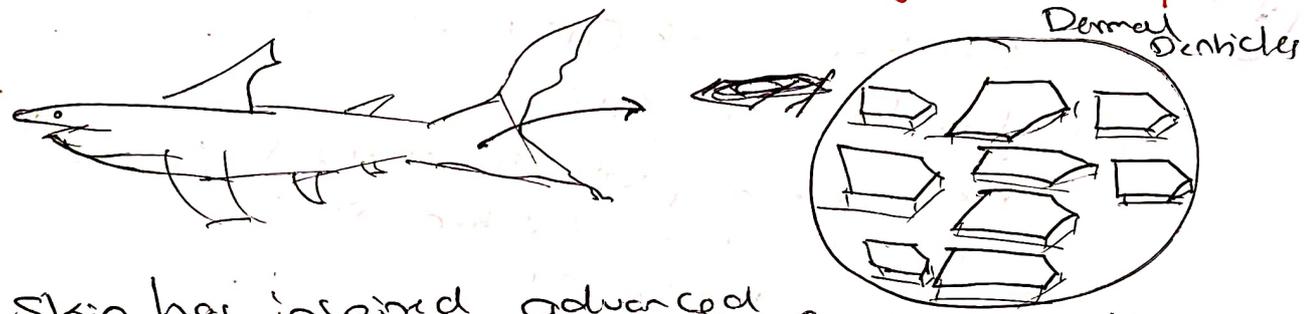
Dermal Denticles

Shark Skin has inspired advanced engineering design in swinsuits through the concept of biomimicry, where biological structures are copied to solve engineering problems

Biological Concept
→ Shark Skin covered with dermal denticles
→ These denticles have ribbelt structure aligned with water flow
→ They reduce drag & turbulence
→ Prevent attachment of microorganisms

In swimsuit same concept is adopted with with ribbed surface pattern similar to shark skin.. This structure reduces water resistance. Improve Swimmers speed & efficiency also enhances stability & flow control of water.

Q Write a note on GPS Technology   5 marks

Space satellite.

Control Signal   User Signal
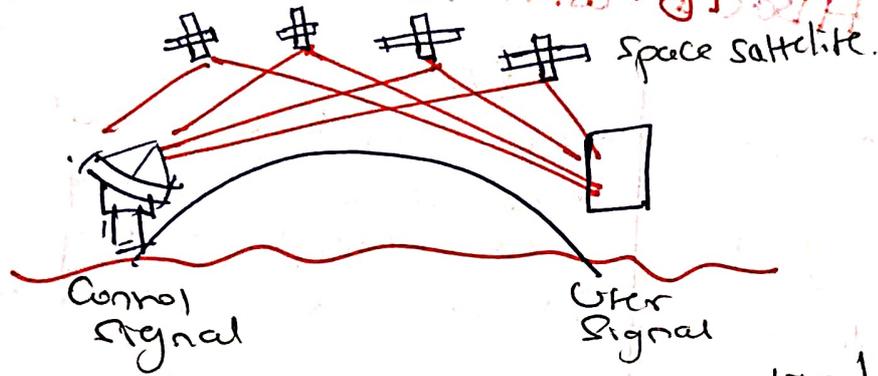
GPS (Global Positioning System) is a satellite based navigation System used to determine exact position, velocity & time of a receiver anywhere on earth

Principles
* It works on principle of triangulations
* It receives & calculates its position by receiving signal from multiple satellite
* Distance is compound using time delay b/w signal transmission & reception

Components of GPS
1) Space Segments → Network GPS satellite orbiting earth
2) Control Segment → Ground station monitor & manage Satellite
3) User Segment → GPS Receiver (mobile, vehicle etc)

Application of GPS
* Navigation of vehicle, ships & aircrafts
* mobile phone location service
* Survey & mapping
* Military application

Qa. Explain in detail how AI will be used in disease detection   7 marks

Artificial Intelligence is widely used in data collection & disease diagnosis to impro accuracy, speed & early detection. It supports clinical descissions

1) Data Collections
Medical data collected at various sources
1) Patient records
2) Medical Images
3) Lab reports (ECG, Genetic data)
4) wearable sensors like smartwatches

This is in the form of AI input.

2) Data Processing
  1) Raw medical data cleaned 4 standardised
  2) Missing values, noises, errors are removed
  3) Images are enhanced, normalised + segmented
  4) Steps ensures reliable & accurate analysis.

3). Feature Extraction.
  1) Important disease related features are identified
  2) Reduce data complexicity & improve model efficiency

4) AI Model Training
  Machine learning & deep learning
  Patterns are compared with healthy & diseased condition.
  Continuous learning & Improvement.

9b. Demonstrate Bioremediation & Biomining

Bioremediation — It is a process of using microorganisms such as bacteria, fungi, alage to remove, degrade, detoxy pollutants from soil, water & air

* Microorganism user pollutant as source of their energy
* Toxic substances are converted into non toxic substances

Application.
  1) Cleaning oil spills
  2) Treatment of sewage & industrial pollutants
  3) Removal of pestisicles, heavy metals

Advantage
  1) Eco friendly & Cost effective
  2) Minimal environmental disturbance.

Biomining
  Biomining. is extraction of valuable metal from low grade ores using microorganism

Working Principle.
  Bacteria oxidize metal sulfiieds
  Metal like copper, gold and urenium released into solution
  This process called bioleaching

Advantages'
  Reduce use of harch chemicals
  Use full low grade ores
  Environmental safety

# Explain Muscular System as scaffold

The muscular system can be explained as biological scaffold because it provides structural support, shape and framework for movement & tissue organisation in the body

Explanation

1) Structural Support
2) Attachment & Alignment
3) Force Transmission
4) Cellular Scaffold
5) Role in Regeneration

Muscle from supportive framework around bones and organs. helping maintain body posture, and shape

Muscle attach to bones via tendons, holding skeletal

Muscle tissue contains extracellular matrix (ECM) that support muscle cells, supplies 4 nutrients And aid repair and regeneration

10a. Explain in details
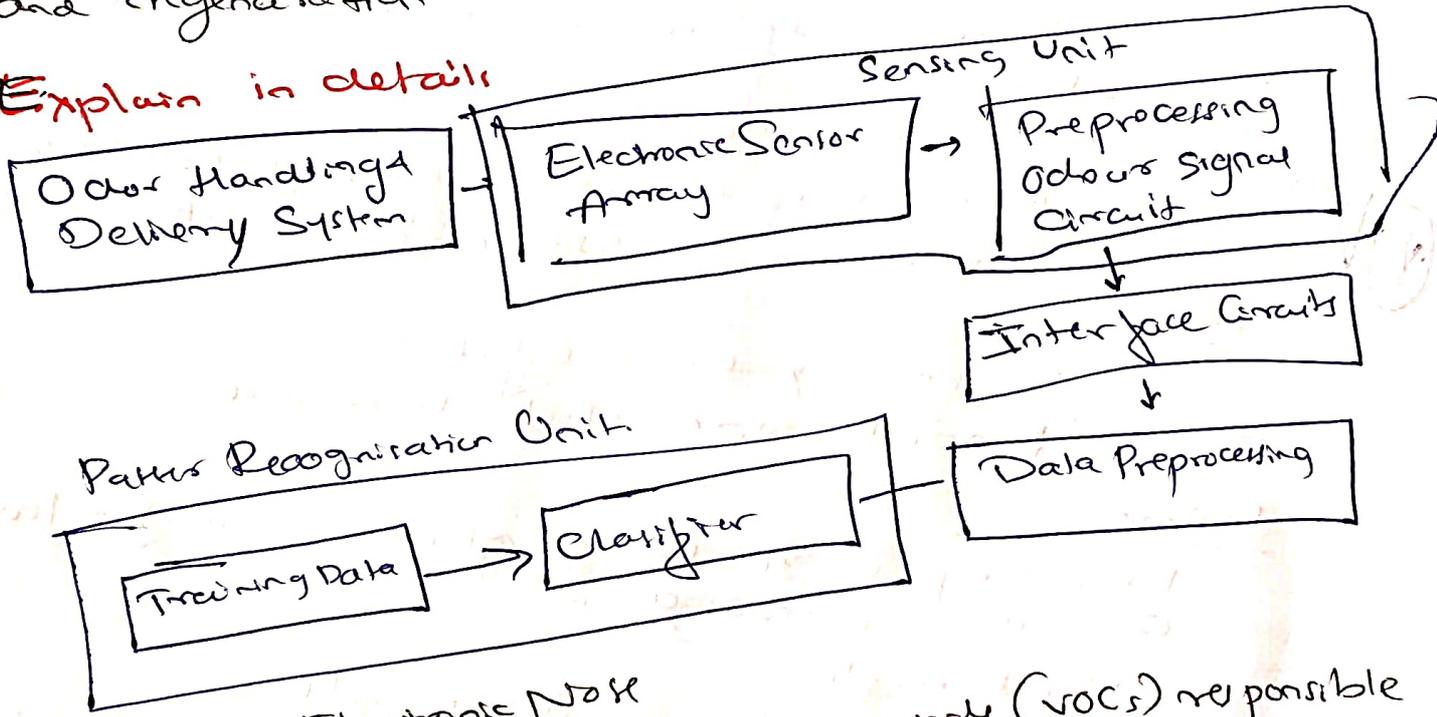
Principle of Electronic Nose

1) Food releases volatile organic compounds (VOCs) responsible for aroma

2) The E-nose uses an array of chemical sensors with partial selectivity

3) Each odor produces a unique sensor response pattern

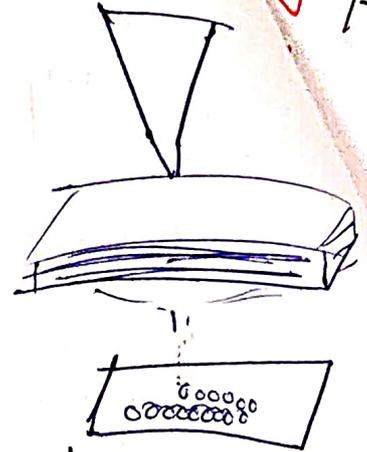4) Pattern recognition algorithms identify and classify the odors

10b. Demonstrate bioprinting technique & list them all

Inkjet Printing — Piezoelectric Actuator
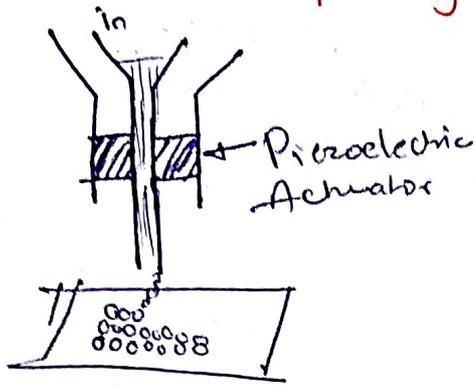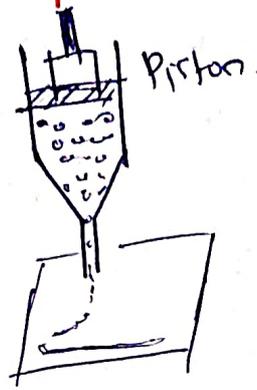
Extrusion Printing — Piston

Layer printing

Demonstration of Working Technique

1. **Bio ink preparation** — living cells are mixed with biomaterial. The mixture is called bioInk

2. **Digital Design** —
   A 3D model of tissue/organ is created using CAD or medical imaging

3. **Layer–Layer Printing** —
   Bioink deposited precisely according to design
   Layer are built from 3D biological structure

4. **Cross Linking / Stabilization**
   Printed structure is stabilized using chemical thermal

5. **Maturation**
   A printed tissue · cultered in bioreactor

10c Explain DNA Origami & Bio computing

1) DNA origami is a nanotechnology techniy in which a long single stranded DNA models is folded into precise nanoscale shape using short DNA stered called Stepple Strands

Working Principle
1) Complementary base paring (A-T, G-C) is used
2) Staple Stands bind specific regions of a long DNA
3) This cause the DNA to fold into desired 2D or 3D model.

Application
1) Drug delivery nanoscale
2) Biosensor & nano-devices
3) Tissue Engineering

2. BioComputing

BioComputing is a biological molecules or systems, especially DNA, Proteins, or cells to perform computational operations similar to electronic computers.

Working Principle

* Biological reactions represents logic operation
* DNA stores. act as data and Enzymes act as Processes
* DNA Logic gates (AND, OR, NOT) perform computation

Applications

* Disease diagnosis and smart drug delivery
* Solving Complex computational problems
* Development of bio inspired computing system

Prof. Rajar Acharya