Renewable Energy Emerging Trends in Electronics (4361106) - Summer 2024 Solution

Milav Dabgar

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Question 1(a) [3 marks]

What is Renewable energy? Explain its importance.

Solution

Answer: Renewable energy is energy derived from natural sources that replenish themselves over time, such as solar, wind, hydro, biomass, and geothermal.

Table 1. Importance of Renewable Energy

Aspect	Benefit
Environmental	Reduces greenhouse gas emissions and pollution
Economic	Creates jobs and reduces energy costs long-term
Energy Security	Reduces dependence on fossil fuel imports
Sustainability	Inexhaustible energy sources for future generations

Key Points:

- **Clean Energy**: Zero carbon emissions during operation
- **Cost-effective**: Decreasing technology costs make it economical
- **Job Creation**: Growing industry providing employment opportunities

Mnemonic

“”EEES” - Environmental protection, Economic benefits, Energy security, Sustainability”

Question 1(b) [4 marks]

List the types of Electric Vehicles. Explain each in brief.

Solution

Answer:

Table 2. Types of Electric Vehicles

Type	Full Form	Description
BEV	Battery Electric Vehicle	Fully electric, powered only by battery
HEV	Hybrid Electric Vehicle	Combines gasoline engine with electric motor
PHEV	Plug-in Hybrid Electric Vehicle	Can be charged from external power source
FCEV	Fuel Cell Electric Vehicle	Uses hydrogen fuel cells for power

Key Features:
- **BEV**: Zero emissions, requires charging stations
- **HEV**: Better fuel efficiency, self-charging through regenerative braking
- **PHEV**: Dual power options, extended range
- **FCEV**: Quick refueling, water as only emission

Mnemonic

""Big Hybrid Plug Fuel" for BEV, HEV, PHEV, FCEV"

Question 1(c) [7 marks]

What is the difference between solar energy and solar thermal energy? Discuss the block diagram of home solar rooftop system.

Solution

Answer:

Table 3. Solar Energy vs Solar Thermal Energy

Parameter	Solar Energy (PV)	Solar Thermal Energy
Conversion	Direct sunlight to electricity	Sunlight to heat energy
Technology	Photovoltaic cells	Solar collectors/panels
Output	Electrical energy	Thermal energy (hot water/steam)
Applications	Power generation, lighting	Water heating, space heating
Efficiency	15-22%	70-80%

Block Diagram: Home Solar Rooftop System

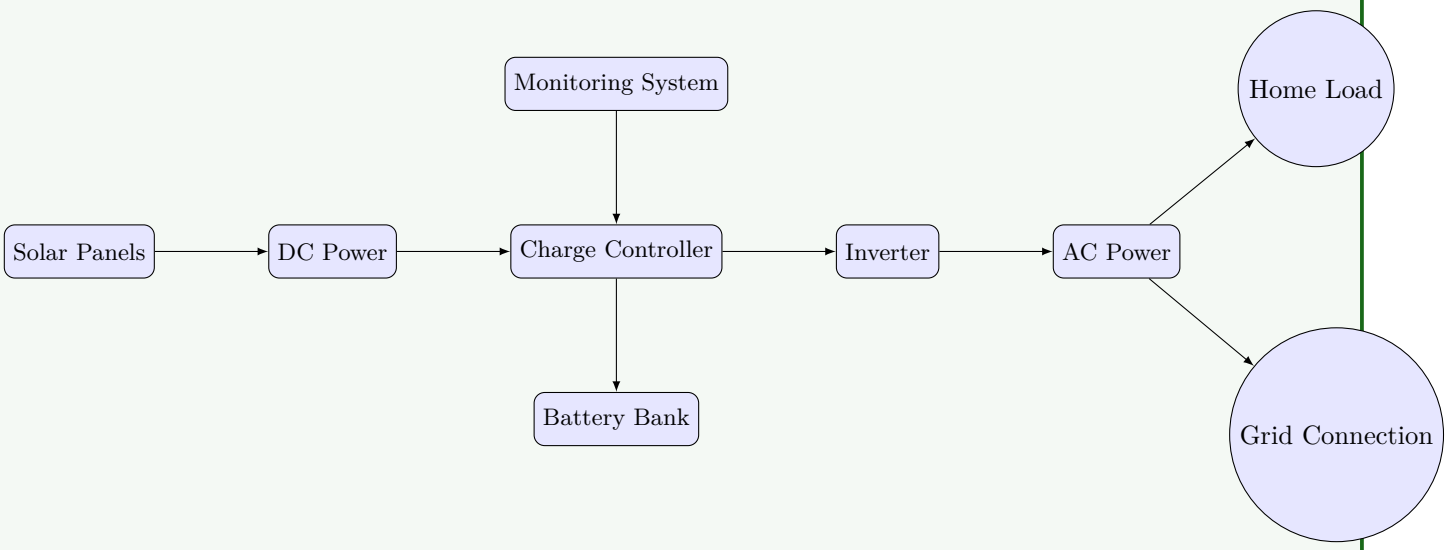


Figure 1. Home Solar Rooftop System

Key Components:
- **Solar Panels**: Convert sunlight to DC electricity
- **Charge Controller**: Regulates battery charging
- **Inverter**: Converts DC to AC power
- **Battery Bank**: Stores excess energy
- **Grid Connection**: Two-way power flow

Mnemonic

""Solar Converts Battery Inverter Grid" for main components"

Question 1(c) OR [7 marks]

What is solar photovoltaic effect? Explain principle of photovoltaic conversion.

Solution

Answer: Solar photovoltaic effect is the generation of electric current when light falls on semiconductor materials.
Principle of Photovoltaic Conversion:

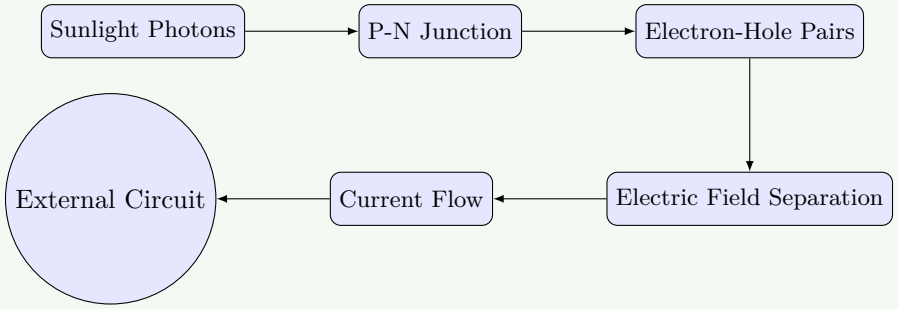


Figure 2. Photovoltaic Conversion Process

Working Process:
- **Photon Absorption**: Light photons hit semiconductor material
- **Electron Excitation**: Electrons gain energy and move to conduction band
- **P-N Junction**: Creates electric field separating charges
- **Current Generation**: Flow of electrons creates electrical current

Key Points:
- **Energy Conversion**: Light energy → Electrical energy
- **Semiconductor Material**: Usually silicon-based
- **Direct Conversion**: No moving parts required
- **Quantum Effect**: Based on photoelectric effect principle

Table 4. PV Cell Materials

Material	Efficiency	Cost	Application
Monocrystalline Silicon	18-22%	High	Residential
Polycrystalline Silicon	15-17%	Medium	Commercial
Thin Film	10-12%	Low	Large scale

Mnemonic

""Photons Push Electrons Producing Power""

Question 2(a) [3 marks]

What is nanotechnology? List any three applications based on nanotechnology.

Solution

Answer: Nanotechnology is the science of manipulating matter at the molecular and atomic scale (1-100 nanometers).

Table 5. Nanotechnology Applications

Application	Description	Benefit
Medical	Drug delivery systems, cancer treatment	Targeted therapy
Electronics	Smaller, faster processors and memory	Higher performance
Energy	Solar cells, batteries, fuel cells	Better efficiency

Key Points:
- **Scale**: Works at nanometer level (10^{-9} meters)
- **Precision**: Atomic-level manipulation
- **Revolutionary**: Transforms multiple industries

Mnemonic

“”Nano Makes Everything Better” - Medical, Electronics, Energy”

Question 2(b) [4 marks]

Write short note on Tidal wave energy as important emerging renewable energy technology.

Solution

Answer: Tidal wave energy harnesses the kinetic energy of ocean tides and waves to generate electricity.
Key Features:
- **Predictable**: Tides follow regular patterns
- **High Density**: Water is 800 times denser than air
- **Consistent**: Available day and night
- **Clean**: No emissions or fuel consumption

Table 6. Tidal Energy Systems

Type	Method	Advantage
Tidal Barrage	Dam across estuary	High power output
Tidal Stream	Underwater turbines	Minimal environmental impact
Wave Energy	Surface wave motion	Abundant resource

Applications:
- **Coastal Power Generation**: Remote coastal communities
- **Grid Integration**: Supplement to other renewable sources
- **Island Nations**: Ideal for maritime countries

Mnemonic

“”Tides Provide Predictable Power””

Question 2(c) [7 marks]

What is smart water monitoring system? Explain the block diagram of Smart water Quality monitoring system.

Solution

Answer: Smart water monitoring system uses IoT sensors to continuously monitor water quality parameters and provide real-time data for decision making.

Block Diagram: Smart Water Quality Monitoring System

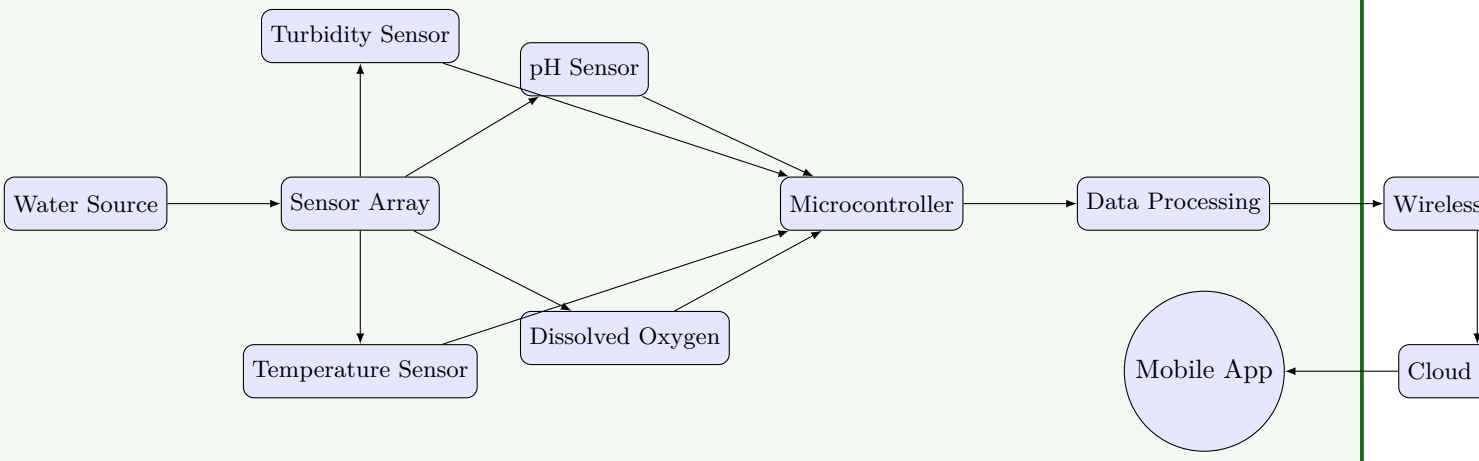


Figure 3. Smart Water Quality Monitoring System

Key Components:

- **Sensors**: Monitor pH, turbidity, temperature, dissolved oxygen
- **Microcontroller**: Arduino/Raspberry Pi for data processing
- **Communication**: WiFi/GSM for data transmission
- **Cloud Platform**: Data storage and analysis
- **User Interface**: Mobile app for monitoring

Benefits:

- **Real-time Monitoring**: Continuous water quality assessment
- **Early Warning**: Immediate alerts for contamination
- **Data Analytics**: Historical trends and predictions
- **Cost Effective**: Reduces manual testing costs

Table 7. Water Quality Parameters

Parameter	Normal Range	Sensor Type
pH	6.5-8.5	pH electrode
Turbidity	<1 NTU	Optical sensor
Temperature	15-25°C	Thermistor
Dissolved Oxygen	>5 mg/L	Electrochemical

Mnemonic

“”Smart Sensors Send Signals Safely””

Question 2(a) OR [3 marks]

What is wearable technology? Name atleast two applications of wearable technology?

Solution

Answer: Wearable technology refers to electronic devices that can be worn as clothing or accessories, incorporating smart sensors and connectivity.

Applications:
- **Health Monitoring**: Smartwatches tracking heart rate, steps, sleep patterns
- **Fitness Tracking**: Activity monitors measuring calories, distance, exercise
- **Medical Devices**: Continuous glucose monitors, blood pressure monitors
- **Smart Glasses**: Augmented reality displays, hands-free computing

Key Features:
- **Portable**: Lightweight and comfortable to wear
- **Connected**: Bluetooth/WiFi connectivity to smartphones
- **Sensor-rich**: Multiple sensors for data collection

Mnemonic

""Wearables Watch Wellness Wirelessly""

Question 2(b) OR [4 marks]

List the different types of solar cell. List different energy sources for Electric vehicle.

Solution

Answer:

Table 8. Types of Solar Cells

Type	Material	Efficiency	Cost
Monocrystalline	Single crystal silicon	18-22%	High
Polycrystalline	Multi-crystal silicon	15-17%	Medium
Thin Film	Amorphous silicon	10-12%	Low
Cadmium Telluride	CdTe compound	16-18%	Medium

Table 9. Energy Sources for Electric Vehicles

Source	Description	Advantage
Battery	Lithium-ion cells	High energy density
Fuel Cell	Hydrogen conversion	Quick refueling
Ultracapacitor	Rapid charge/discharge	Fast charging
Regenerative Braking	Kinetic energy recovery	Energy efficiency

Mnemonic

""Solar: Mono Poly Thin Cadmium" / "EV: Battery Fuel Ultra Regen""

Question 2(c) OR [7 marks]

Describe the block diagram of a drone and its major components.

Solution

Answer:
Block Diagram: Drone System

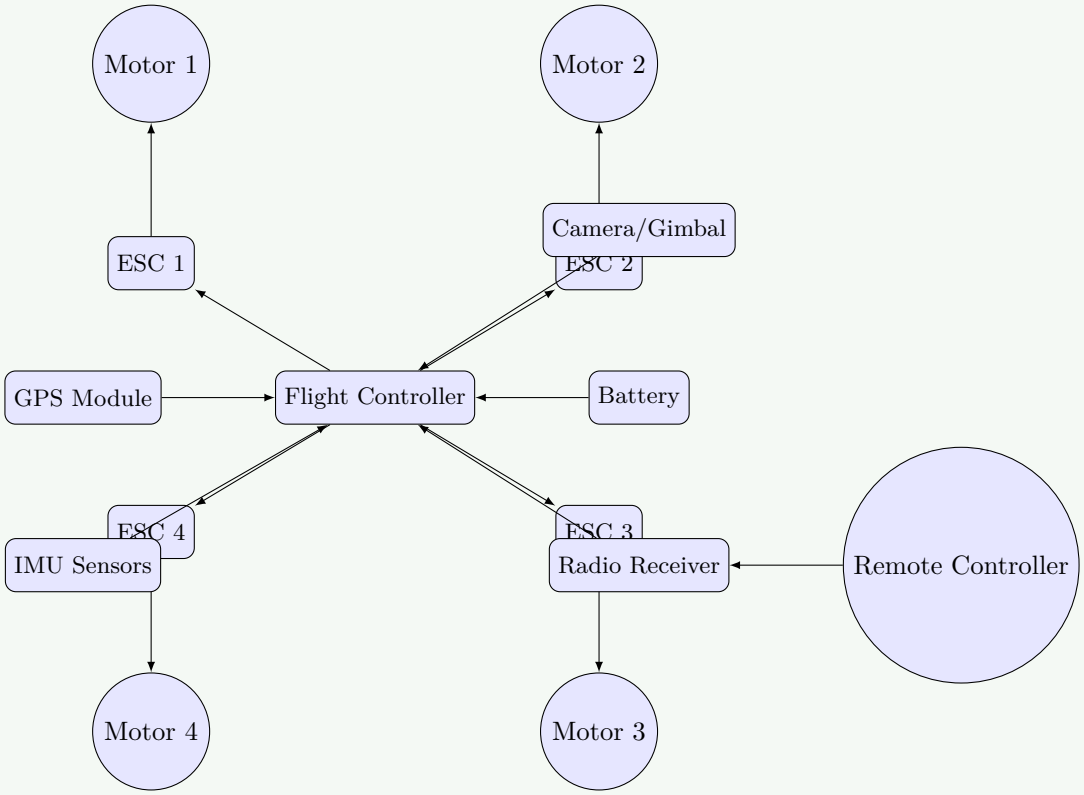


Figure 4. Drone System Architecture

Major Components:

Table 10. Drone Components

Component	Function	Importance
Flight Controller	Central processing unit	Brain of drone
ESC	Motor speed control	Precise motor control
Motors & Propellers	Generate thrust	Flight capability
Battery	Power supply	Flight duration
GPS	Position tracking	Navigation
IMU	Motion sensing	Stability control

Key Systems:

- **Propulsion System**: 4 motors with propellers for lift and control
- **Control System**: Flight controller with stabilization algorithms
- **Navigation System**: GPS and compass for positioning
- **Power System**: LiPo battery for electrical power
- **Communication**: Radio link with ground controller

Working Principle:

- **Lift**: Rotors create upward thrust
- **Control**: Varying rotor speeds controls movement
- **Stability**: Sensors maintain balance and orientation

Mnemonic

“”Drones Fly Using Motors, Electronics, Sensors, Power””

Question 3(a) [3 marks]

What is IoT? List Key Components of IoT.

Solution

Answer: IoT (Internet of Things) is a network of interconnected physical devices that collect and exchange data through the internet.

Table 11. Key Components of IoT

Component	Function	Example
Sensors	Data collection	Temperature, humidity sensors
Connectivity	Data transmission	WiFi, Bluetooth, GSM
Data Processing	Information analysis	Cloud computing
User Interface	Human interaction	Mobile apps, dashboards

Key Features:
- **Interconnected**: Devices communicate with each other
- **Smart**: Automated decision making
- **Data-driven**: Continuous monitoring and analysis

Mnemonic

“”IoT Connects Smart Devices Using Internet””

Question 3(b) [4 marks]

Compare between organic and inorganic electronics.

Solution

Answer:

Table 12. Organic vs Inorganic Electronics

Parameter	Organic Electronics	Inorganic Electronics
Material	Carbon-based compounds	Silicon, metals
Manufacturing	Low temperature, printing	High temperature, clean room
Flexibility	Flexible, bendable	Rigid, brittle
Cost	Lower production cost	Higher production cost
Performance	Lower speed, efficiency	Higher speed, efficiency
Applications	Displays, solar cells	Processors, memory

Key Differences:
- **Processing**: Organic uses solution-based processing
- **Substrate**: Organic can use plastic substrates
- **Durability**: Inorganic more stable and durable
- **Innovation**: Organic enables new form factors

Mnemonic

“”Organic: Flexible, Cheap, Printable vs Inorganic: Fast, Stable, Expensive””

Question 3(c) [7 marks]

Draw block diagram of smart street light control and monitoring system. Discuss advantages and applications of AR/VR technology in industry.

Solution

Answer:
Block Diagram: Smart Street Light System

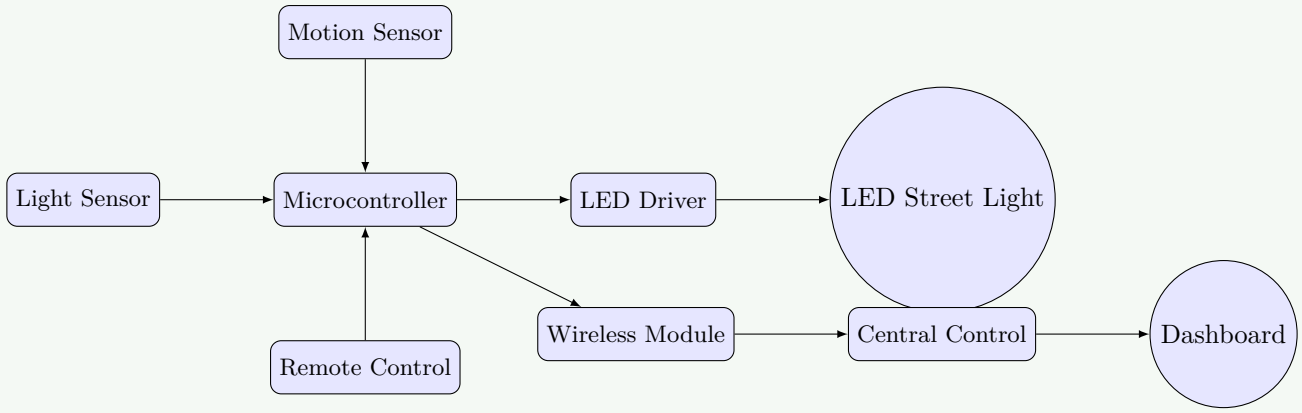


Figure 5. Smart Street Light Control System

AR/VR Technology in Industry:

Table 13. AR/VR Applications

Industry	AR Application	VR Application
Manufacturing	Assembly instructions	Training simulations
Healthcare	Surgery assistance	Medical training
Education	Interactive learning	Virtual classrooms
Retail	Product visualization	Virtual showrooms

Advantages:

- **Enhanced Training**: Safe, repeatable learning environments
- **Remote Collaboration**: Virtual meetings and shared workspaces
- **Design Visualization**: 3D prototyping and modeling
- **Maintenance Support**: Real-time guidance and troubleshooting

Mnemonic

“”AR/VR: Training, Design, Remote, Maintenance””

Question 3(a) OR [3 marks]

What is Smart System? List any four types of smart system.

Solution

Answer: Smart System is an intelligent system that uses sensors, data processing, and automation to make decisions and adapt to changing conditions.

Table 14. Types of Smart Systems

Type	Description	Example
Smart Home	Automated home control	Lighting, HVAC, security
Smart City	Urban infrastructure management	Traffic, utilities, waste
Smart Grid	Intelligent power distribution	Energy management
Smart Healthcare	Medical monitoring systems	Patient monitoring, diagnostics

Mnemonic

“”Smart: Home, City, Grid, Health””

Question 3(b) OR [4 marks]

List the advantages and applications of organic electronics.

Solution

Answer:

Table 15. Advantages of Organic Electronics

Advantage	Description	Benefit
Flexibility	Bendable, stretchable	Wearable devices
Low Cost	Cheap manufacturing	Mass production
Large Area	Printing on large surfaces	Big displays
Low Temperature	Room temperature processing	Energy efficient

Applications:
- **OLED Displays**: Smartphones, TVs, lighting
- **Organic Solar Cells**: Flexible solar panels
- **Organic Transistors**: Flexible circuits
- **Electronic Paper**: E-readers, smart labels

Mnemonic

“”Organic: Flexible, Cheap, Large, Low-temp””

Question 3(c) OR [7 marks]

Draw basic block diagram of (i) wearable smart watch and (ii) biometric system.

Solution

Answer:
(i) Wearable Smart Watch Block Diagram:

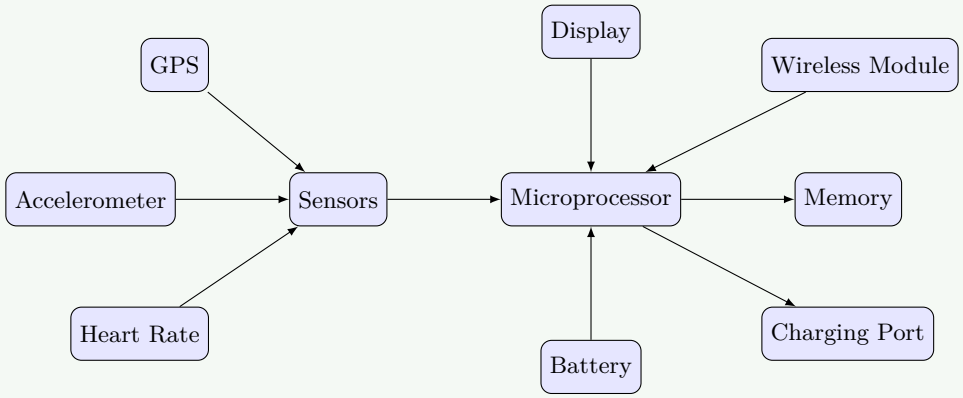


Figure 6. Smart Watch Architecture

(ii) Biometric System Block Diagram:

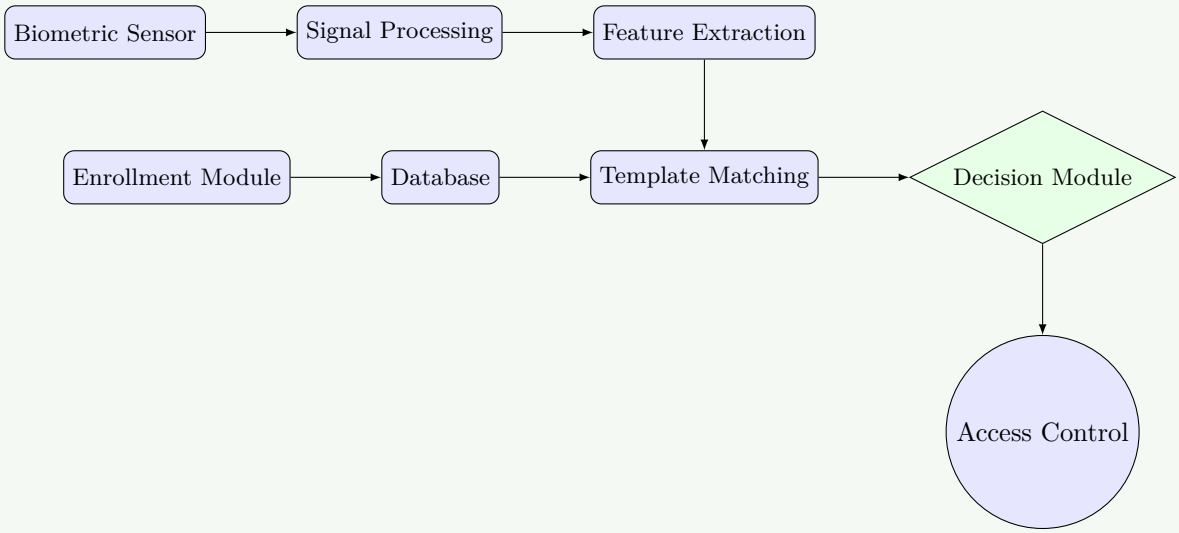


Figure 7. Biometric System

Components:

- **Smart Watch**: Sensors (HR, Accel, GPS), Processor (ARM), Display (OLED), Connectivity, Power.
- **Biometric**: Sensor, Processing Unit, Database, Matching Engine, Decision Logic.

Mnemonic

""Smart Watch: Sense, Process, Display, Connect" / "Biometric: Capture, Process, Match, Decide""

Question 4(a) [3 marks]

Give full form of NOOBS, GPIO LXDE in raspberry pi.

Solution

Answer:

Table 16. Raspberry Pi Acronyms

Acronym	Full Form	Purpose
NOOBS	New Out Of Box Software	Easy OS installation
GPIO	General Purpose Input Output	Hardware interface pins
LXDE	Lightweight X11 Desktop Environment	Desktop interface

Mnemonic

“”New GPIO, Lightweight Experience””

Question 4(b) [4 marks]

Write a short note on OLED.

Solution

Answer: OLED (Organic Light Emitting Diode) is a display technology using organic compounds that emit light when electric current is applied.

Table 17. OLED vs LCD

Parameter	OLED	LCD
Backlight	Not required	Required
Contrast	Infinite	1000:1
Thickness	Ultra-thin	Thicker
Power	Lower (dark images)	Constant

Applications:
- **Smartphones**: Samsung, iPhone displays
- **TVs**: Premium television sets
- **Automotive**: Dashboard displays
- **Wearables**: Smartwatch screens

Mnemonic

“”OLED: Organic, Light, Emitting, Display””

Question 4(c) [7 marks]

Explain the architecture and block diagram of Raspberry Pi.

Solution

Answer:
Block Diagram: Raspberry Pi Architecture

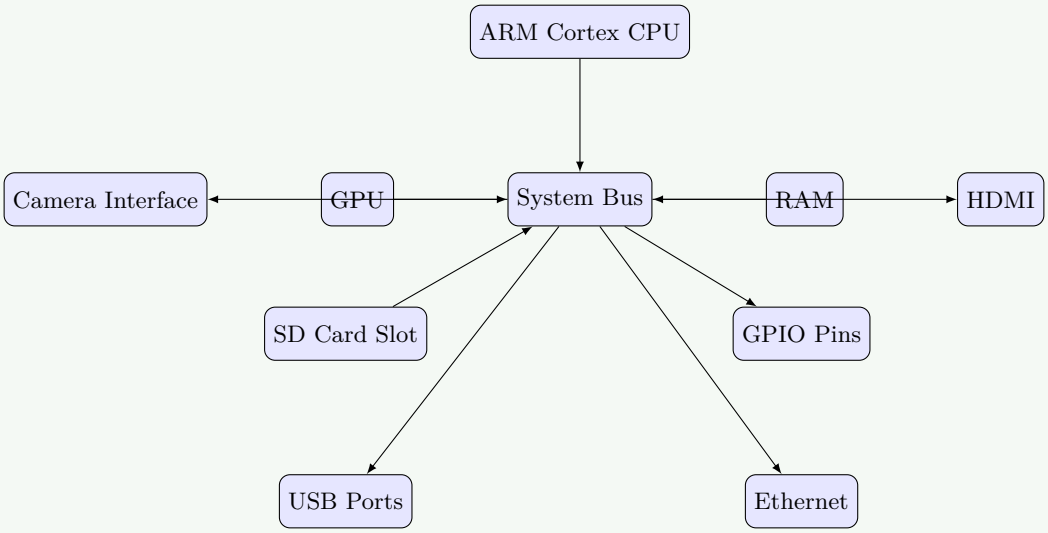


Figure 8. Raspberry Pi Architecture

Key Components:

- **CPU**: ARM Cortex-A72 Quad-core (Main processing)
- **GPU**: VideoCore VI (Graphics processing)
- **RAM**: 4GB LPDDR4 (System memory)
- **Storage**: MicroSD card (Operating system)
- **GPIO**: 40-pin header (Hardware interface)
- **Connectivity**: WiFi, Bluetooth, Ethernet (Network access)

Mnemonic

“”Pi: Processor, Interfaces, Projects, Internet””

Question 4(a) OR [3 marks]

What is Raspberry Pi and its advantages and disadvantages?

Solution

Answer: Raspberry Pi is a small, affordable single-board computer designed for education and hobbyist projects.

Table 18. Advantages and Disadvantages

Advantages	Disadvantages
Low Cost	Limited Performance
Small Size	No Built-in Storage
GPIO Pins	Requires SD Card
Linux Support	No Real-time OS
Educational	Power Supply Issues
Community Support	Limited RAM

Mnemonic

“”Pi: Cheap, Small, Educational vs Limited, External, Power””

Question 4(b) OR [4 marks]

Write a short note on OFET.

Solution

Answer: OFET (Organic Field Effect Transistor) is a transistor using organic semiconducting materials for switching and amplification.

Table 19. OFET Structure

Component	Material	Function
Gate	Metal electrode	Controls current flow
Dielectric	Insulating layer	Isolates gate from channel
Source/Drain	Metal contacts	Current injection/collection
Channel	Organic semiconductor	Current conduction path

Applications:

- **Flexible Displays**: Bendable screens
- **Smart Cards**: RFID applications
- **Sensors**: Chemical and biological detection

Mnemonic

""OFET: Organic, Flexible, Easy, Transistor""

Question 4(c) OR [7 marks]

List the types of Ports in Raspberry Pi. Discuss various operating systems of raspberry Pi.

Solution

Answer:

Table 20. Raspberry Pi Ports

Port Type	Quantity	Function
USB	4 ports	Connect peripherals
HDMI	2 micro HDMI	Video output
GPIO	40 pins	Hardware interface
Ethernet	1 port	Wired network
Audio	3.5mm jack	Audio output
Camera/Display	CSI/DSI	Module interfaces

Operating Systems:

Table 21. Raspberry Pi Operating Systems

OS	Type	Best For
Raspberry Pi OS	Debian-based	General use, beginners
Ubuntu	Linux distribution	Server applications
LibreELEC	Media center	Home entertainment
RetroPie	Gaming	Retro gaming console
Windows 10 IoT	Microsoft OS	IoT development

Mnemonic

“”Pi Ports: USB, HDMI, GPIO, Ethernet” / ”Pi OS: Official, Ubuntu, Media, Gaming””

Question 5(a) [3 marks]

Explain NumPy python library For Machine Learning.

Solution

Answer: NumPy (Numerical Python) is a fundamental library for scientific computing, providing support for large multi-dimensional arrays and mathematical functions.

Table 22. NumPy in Machine Learning

Function	Usage	Example
Arrays	Data storage	`np.array([1,2,3])`
Linear Algebra	Matrix operations	`np.dot(a,b)`
Statistics	Data analysis	`np.mean()`, `np.std()`
Random	Data generation	`np.random.rand()`

Key Features:
- **N-dimensional Arrays**: Efficient array operations
- **Mathematical Functions**: Linear algebra, Fourier transforms
- **Memory Efficient**: Faster than Python lists

Mnemonic

“”NumPy: Numbers, Python, Arrays, Math””

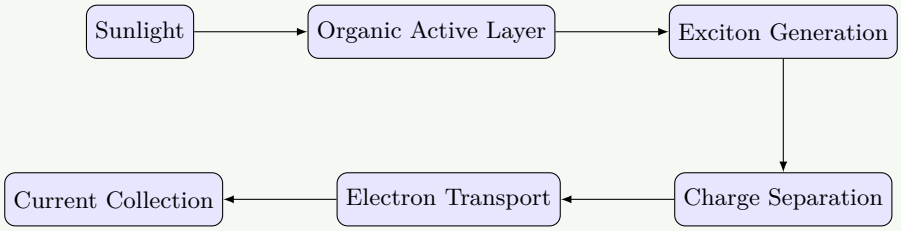
Question 5(b) [4 marks]

What is organic photovoltaic cell (OPV)? Explain its working principle.

Solution

Answer: OPV (Organic Photovoltaic) cell is a solar cell using organic semiconductors to convert light into electricity.

Figure 9. OPV Working Principle



Key Steps:
- **Absorption**: Organic molecules absorb photons
- **Exciton**: Bound electron-hole pairs created
- **Separation**: Excitons split at donor-acceptor interface
- **Transport**: Electrons and holes move to electrodes
- **Collection**: External circuit completes the flow

Mnemonic

“”OPV: Organic, Photons, Voltage, Excitons””

Question 5(c) [7 marks]

List any four Machine learning tools. Discuss any one in brief.

Solution

Answer:

Table 23. Machine Learning Tools

Tool	Type	Best For
TensorFlow	Deep learning framework	Neural networks
Scikit-learn	General ML library	Traditional algorithms
PyTorch	Deep learning framework	Research and development
Keras	High-level API	Rapid prototyping

Detailed Discussion: TensorFlow TensorFlow is an open-source machine learning framework developed by Google for building and deploying ML models.

Features:
- **Tensors**: Multi-dimensional arrays for data representation
- **Graphs**: Computational flow for model visualization
- **Flexibility**: Research to production versatility

Code Example:

```
import tensorflow as tf
model = tf.keras.Sequential([
    tf.keras.layers.Dense(128, activation='relu'),
    tf.keras.layers.Dense(10, activation='softmax')
])
```

Mnemonic

“”TensorFlow: Tensors, Graphs, Scale, Deploy””

Question 5(a) OR [3 marks]

Explain Pandas python library For Machine Learning.

Solution

Answer: Pandas is a Python library for data manipulation and analysis, providing data structures and tools for handling structured data.

Table 24. Pandas Functions

Function	Usage	Example
Data Loading	Import datasets	`pd.read_csv()`
Data Cleaning	Remove/fill missing	`df.dropna()`
Data Selection	Filter data	`df[df['col'] > 5]`
Aggregation	Group and summarize	`df.groupby().mean()`

Mnemonic

""Pandas: Python, Analysis, Data, Structure""

Question 5(b) OR [4 marks]

Explain the Differences between augmented reality and virtual reality.

Solution

Answer:

Table 25. AR vs VR Comparison

Parameter	Augmented Reality (AR)	Virtual Reality (VR)
Environment	Real world + digital overlay	Completely virtual world
Device	Smartphone, AR glasses	VR headset, controllers
Immersion	Partial immersion	Full immersion
Interaction	Real world + digital objects	Virtual objects only
Example	Pokemon Go, Google Maps AR	Oculus Quest, Flight Sims

Mnemonic

""AR: Augments Reality vs VR: Virtual Reality""

Question 5(c) OR [7 marks]

What is Machine learning? Discuss various types of Machine learning.

Solution

Answer: Machine Learning is a subset of artificial intelligence that enables computers to learn and make decisions from data without being explicitly programmed.
Supervised Learning Process:

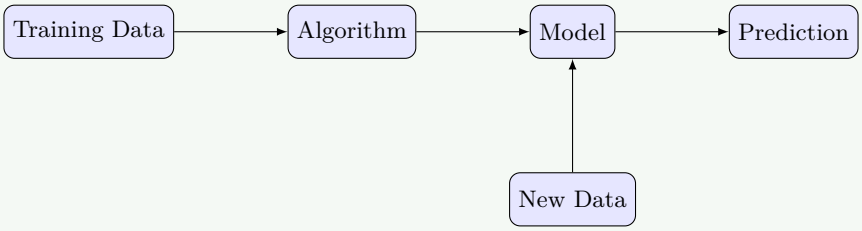


Figure 10. Supervised Learning Flow

Types of Machine Learning:

Table 26. ML Types

Type	Description	Use Cases
Supervised	Learns from labeled data	Spam, Price prediction
Unsupervised	Finds patterns in unlabeled data	Customer segmentation
Reinforcement	Learns through trial and error	Robotics, Game playing

Mnemonic

“”ML Types: Supervised teaches, Unsupervised discovers, Reinforcement rewards””