Question 1(a) [3 marks]

Define Renewable Energy and explain its importance.

Answer:

Renewable Energy is energy derived from natural sources that are continuously replenished, such as solar, wind, hydroelectric, biomass, and geothermal energy.

Table: Types of Renewable Energy Sources

Type	Source	Advantage
Solar	Sun's radiation	Clean, abundant
Wind	Air movement	No emissions
Hydro	Water flow	Reliable power
Biomass	Organic matter	Carbon neutral

Importance:

- **Environmental protection**: Reduces pollution and greenhouse gases
- **Energy security**: Reduces dependence on fossil fuels
- **Economic benefits**: Creates jobs and reduces energy costs

Mnemonic: "SEEB" - Solar, Environmental, Economic, Biomass

Question 1(b) [4 marks]

Explain Solar Photovoltaic effect & Principle of photovoltaic conversion.
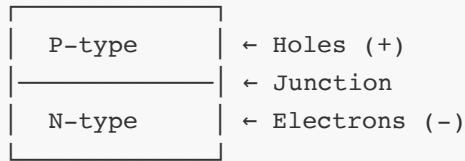
Answer:

Photovoltaic Effect is the generation of electric current when light strikes a semiconductor material.

Working Principle:

- **Photon absorption**: Light photons hit solar cell surface
- **Electron excitation**: Electrons gain energy and move to conduction band
- **Charge separation**: Built-in electric field separates positive and negative charges
- **Current generation**: Flow of electrons creates DC electricity

Diagram:

```
Light Photons
     ↓
  ┌────────────┐
  │  P-type    │  ← Holes (+)
  │────────────│  ← Junction
  │  N-type    │  ← Electrons (-)
  └────────────┘

       ↓
Electric Current
```

Mnemonic: "PACE" - Photons, Absorption, Charge, Electricity

Question 1(c) [7 marks]

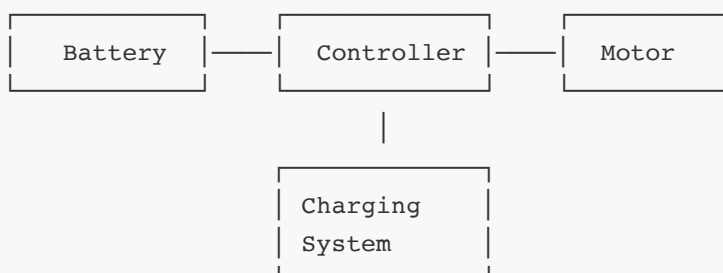**Describe the types of Electric Vehicle (EV) and different Energy sources for EV.**

Answer:

Table: Types of Electric Vehicles

EV Type	Full Form	Power Source	Range
BEV	Battery Electric Vehicle	Battery only	150-400 km
HEV	Hybrid Electric Vehicle	Battery + Engine	600+ km
PHEV	Plug-in Hybrid	Battery + Engine	50-100 km electric
FCEV	Fuel Cell Electric	Hydrogen fuel cell	400-600 km

Energy Sources for EVs:

- **Battery**: Lithium-ion batteries store electrical energy
- **Fuel Cell**: Converts hydrogen to electricity
- **Ultracapacitor**: Quick energy storage and release
- **Flywheel**: Mechanical energy storage
- **Regenerative Braking**: Recovers energy during braking
- **Hybrid Sources**: Combination of multiple energy sources

Diagram: EV Architecture

```
┌───────────┐   ┌───────────┐   ┌───────────┐
│  Battery  │───│ Controller│───│   Motor   │
└───────────┘   └───────────┘   └───────────┘
                      │
                ┌───────────┐
                │ Charging  │
                │ System    │
                └───────────┘
```

Mnemonic: "BHPF-BUFR" - Battery, Hybrid, Plugin, FuelCell - Battery, Ultracap, Flywheel, Regen

Question 1(c) OR [7 marks]

Discuss different types of Renewable Energy Sources.

Answer:

Table: Renewable Energy Sources Comparison

Source	How it Works	Advantages	Applications
Solar	Converts sunlight to electricity	Clean, abundant	Rooftop systems, farms
Wind	Wind turns turbines	No fuel cost	Wind farms, offshore
Hydroelectric	Water flow generates power	Reliable, long-lasting	Dams, rivers
Biomass	Organic matter combustion	Carbon neutral	Power plants, heating
Geothermal	Earth's heat energy	Constant availability	Heating, electricity

Emerging Trends:

- **Tidal Wave**: Ocean wave energy conversion
- **Solar Thermal**: Concentrated solar power systems
- **Hydrogen**: Clean fuel from renewable sources

Benefits:

- **Sustainability**: Never depletes
- **Environmental**: Minimal pollution
- **Economic**: Reduces energy costs long-term

Mnemonic: "SWHBG-THS" - Solar, Wind, Hydro, Biomass, Geothermal - Tidal, Hydrogen, Solar thermal

Question 2(a) [3 marks]

Define Nanotechnology & List Applications of Nanotechnology.

Answer:

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

Applications:

- **Electronics**: Smaller, faster processors
- **Medicine**: Drug delivery systems
- **Energy**: Solar cells, batteries
- **Materials**: Stronger, lighter composites

Mnemonic: "NEMS" - Nano Electronics, Medicine, Solar

Question 2(b) [4 marks]

Give Full forms of: UAV, IOT, AI, M2M

Answer:

Table: Technology Abbreviations

| Abbreviation	Full Form	Application
UAV	Unmanned Aerial Vehicle	Surveillance, delivery
IOT	Internet of Things	Smart homes, cities
AI	Artificial Intelligence	Machine learning, automation
M2M	Machine to Machine	Industrial automation

Mnemonic: "UIAM" - UAV, IOT, AI, M2M

Question 2(c) [7 marks]

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

Answer:

Block Diagram:
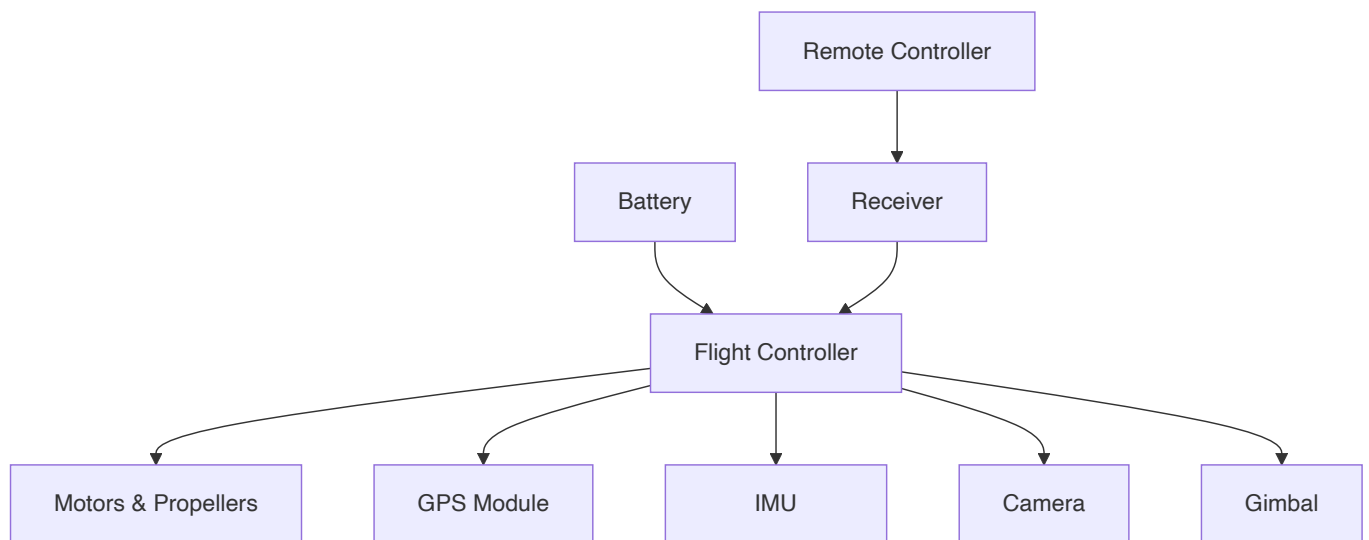
Major Components:

- **Flight Controller**: Brain of drone, processes sensor data
- **Motors & Propellers**: Provide thrust and control movement
- **Battery**: Powers all electronic components
- **GPS Module**: Provides location and navigation data
- **IMU Sensors**: Measure acceleration, rotation, magnetic field

- **Camera**: Captures images and videos
- **Gimbal**: Stabilizes camera for smooth footage

Working Principle:

- **Control**: Remote sends commands to receiver
- **Processing**: Flight controller interprets commands
- **Stabilization**: IMU sensors maintain balance
- **Navigation**: GPS provides position feedback

Mnemonic: "FMBGIC" - Flight controller, Motors, Battery, GPS, IMU, Camera

Question 2(a) OR [3 marks]

Discuss IOT and its importance.

Answer:

Internet of Things (IOT) connects everyday devices to the internet for data exchange and remote control.

Importance:

- **Automation**: Smart homes and cities
- **Efficiency**: Optimized resource usage
- **Monitoring**: Real-time data collection

Mnemonic: "AEM" - Automation, Efficiency, Monitoring

Question 2(b) OR [4 marks]

Define wearable technology. Name at least three applications of wearable technology.

Answer:

Wearable Technology refers to electronic devices worn on the body to monitor health, fitness, or provide information.

Applications:

- **Smart Watches**: Fitness tracking, notifications
- **Smart Glasses**: Augmented reality, navigation
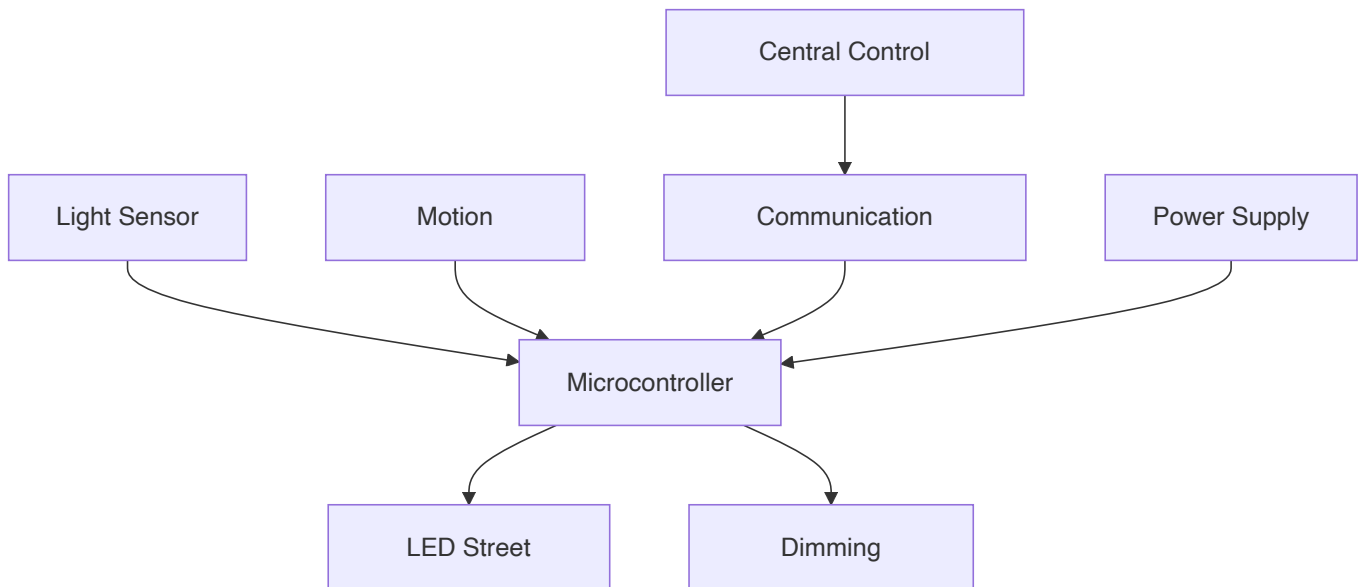- **Health Monitors**: Heart rate, blood pressure monitoring

Mnemonic: "WSH" - Watches, Smart glasses, Health monitors

Question 2(c) OR [7 marks]

Explain with the help of Block diagram Smart Street light control and monitoring.

Answer:

Block Diagram:

Components:

- **Light Sensor**: Detects ambient light levels

- **Motion Sensor**: Detects pedestrian/vehicle movement

- **Microcontroller**: Processes sensor data and controls lighting

- **Communication Module**: Wireless connection to control center

- **LED Street Light**: Energy-efficient lighting

- **Dimming Control**: Adjusts brightness based on need

Working:

- **Auto ON/OFF**: Lights turn on at dusk, off at dawn

- **Motion Detection**: Increases brightness when movement detected

- **Remote Monitoring**: Central system monitors all lights

- **Energy Saving**: Dims lights when no activity detected

Mnemonic: "LMCL" - Light sensor, Motion sensor, Controller, LED

Question 3(a) [3 marks]

Compare Organic and Inorganic electronics.

Answer:

Table: Organic vs Inorganic Electronics

Parameter	Organic Electronics	Inorganic Electronics
Material	Carbon-based compounds	Silicon, metals
Cost	Lower manufacturing cost	Higher cost
Flexibility	Flexible, bendable	Rigid structure
Processing	Low temperature	High temperature

Mnemonic: "MCFP" - Material, Cost, Flexibility, Processing

Question 3(b) [4 marks]

Write a short note on OPVD.

Answer:

OPVD (Organic Photovoltaic Devices) are solar cells made from organic semiconducting materials.

Characteristics:

- **Flexible**: Can be made on flexible substrates
- **Low-cost**: Cheaper manufacturing process
- **Lightweight**: Suitable for portable applications
- **Semi-transparent**: Can be integrated into windows

Applications:

- **Building Integration**: Solar windows
- **Portable Devices**: Flexible solar chargers
- **Wearable Electronics**: Solar-powered gadgets

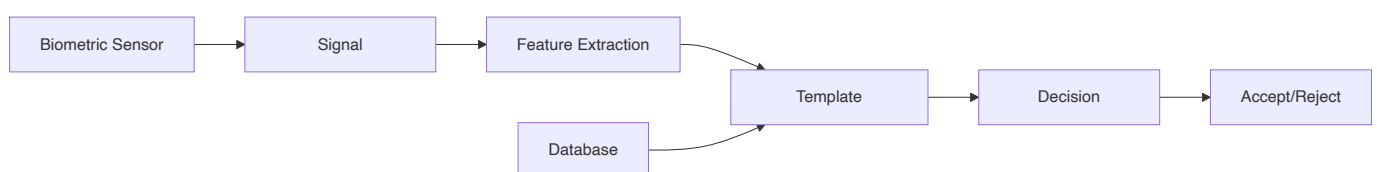**Mnemonic:** "FLLW" - Flexible, Low-cost, Lightweight, Windows

Question 3(c) [7 marks]

Explain Biometric systems and their basic block diagram.

Answer:

Biometric System identifies individuals based on unique biological characteristics.

Block Diagram:

Components:

- **Sensor Module**: Captures biometric data (fingerprint, iris, face)

- **Signal Processing**: Enhances and cleans captured signal

- **Feature Extraction**: Identifies unique characteristics

- **Database Module**: Stores biometric templates

- **Matching Module**: Compares captured data with stored templates

- **Decision Module**: Makes final accept/reject decision

Types of Biometrics:

- **Fingerprint**: Ridge patterns on fingers

- **Iris**: Eye iris patterns

- **Face Recognition**: Facial features

- **Voice**: Voice patterns and characteristics

Applications:

- **Security**: Access control systems

- **Banking**: ATM authentication

- **Mobile**: Phone unlocking

- **Border Control**: Immigration systems

Mnemonic: "SFEMD" - Sensor, Feature extraction, Matching, Database, Decision

Question 3(a) OR [3 marks]

List the advantages and applications of organic electronics.

Answer:

Advantages:

- **Flexible**: Bendable electronic devices

- **Low-cost**: Cheaper manufacturing

- **Large-area**: Can cover large surfaces

Applications:

- **OLED Displays**: Flexible screens

- **Solar Cells**: Lightweight panels

- **RFID Tags**: Flexible identification

Mnemonic: "FLL-OSR" - Flexible, Low-cost, Large-area - OLED, Solar, RFID

Question 3(b) OR [4 marks]

Write a short note on OLED.

Answer:

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

Advantages:

- **Self-illuminating**: No backlight needed
- **High contrast**: True black colors
- **Flexible**: Can be bent and curved
- **Energy efficient**: Lower power consumption

Applications:

- **Smartphones**: OLED screens
- **TVs**: Ultra-thin displays
- **Wearables**: Smartwatch displays

Mnemonic: "SHFE" - Self-illuminating, High contrast, Flexible, Efficient

Question 3(c) OR [7 marks]

Explain AR/VR core technology and discuss its applications.

Answer:

AR (Augmented Reality) overlays digital information on real world, while **VR (Virtual Reality)** creates completely immersive digital environment.

Core Technologies:

- **Display Systems**: Head-mounted displays, screens
- **Tracking Systems**: Motion sensors, cameras
- **Processing Units**: GPU, specialized chips
- **Input Methods**: Controllers, gesture recognition

AR Applications:

- **Gaming**: Pokemon Go, mobile AR games
- **Education**: Interactive learning experiences
- **Navigation**: GPS overlays on real roads
- **Shopping**: Virtual try-on experiences

VR Applications:

- **Entertainment**: Immersive gaming, movies
- **Training**: Flight simulators, medical training
- **Architecture**: Virtual building walkthroughs

- **Therapy**: Treatment of phobias, PTSD

Table: AR vs VR Comparison

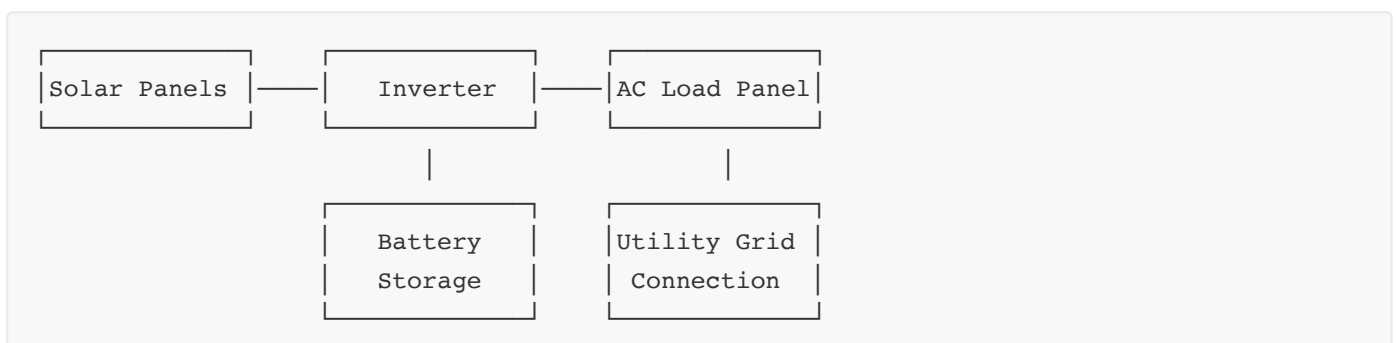| Aspect	AR	VR
Reality	Mixed with real world	Completely virtual
Equipment	Smartphone, AR glasses	VR headset, controllers
Immersion	Partial	Complete
Mobility	Mobile friendly	Stationary setup

Mnemonic: "DTPI-GENT" - Display, Tracking, Processing, Input - Gaming, Education, Navigation, Training

Question 4(a) [3 marks]

Draw Block Diagram of a Home Solar rooftop system.

Answer:

Block Diagram:

```
 ┌─────────────┐     ┌─────────────┐   ┌─────────────┐
 │Solar Panels │─────│  Inverter   │───│AC Load Panel│
 └─────────────┘     └─────────────┘   └─────────────┘
                            │                 │
                     ┌─────────────┐   ┌─────────────┐
                     │  Battery    │   │Utility Grid │
                     │  Storage    │   │ Connection  │
                     └─────────────┘   └─────────────┘
```

Components:

- **Solar Panels**: Convert sunlight to DC electricity
- **Inverter**: Converts DC to AC power
- **Battery Storage**: Stores excess energy

Mnemonic: "SIB" - Solar panels, Inverter, Battery

Question 4(b) [4 marks]

Explain working principle of OFET.

Answer:

OFET (Organic Field Effect Transistor) uses organic semiconductors to control current flow.

Working Principle:

- **Gate Voltage**: Applied voltage creates electric field

- **Channel Formation**: Electric field modulates conductivity
- **Current Control**: Source-drain current controlled by gate
- **Switching**: ON/OFF states for digital applications

Structure:

- **Source/Drain**: Current injection points
- **Gate**: Control electrode
- **Organic Layer**: Active semiconductor material

Mnemonic: "GCCS" - Gate voltage, Channel, Current, Switching

Question 4(c) [7 marks]

List various Machine learning tools. Discuss any two in brief.

Answer:

Machine Learning Tools:

- **TensorFlow**: Google's ML framework
- **PyTorch**: Facebook's deep learning library
- **Scikit-learn**: Python ML library
- **Keras**: High-level neural network API
- **Machine Learning for Kids**: Educational platform
- **Scratch**: Visual programming for ML

TensorFlow:

- **Purpose**: Deep learning and neural networks
- **Features**: Large-scale ML, production deployment
- **Applications**: Image recognition, NLP, recommendation systems
- **Advantages**: Scalable, extensive documentation

Scikit-learn:

- **Purpose**: General machine learning algorithms
- **Features**: Classification, regression, clustering
- **Applications**: Data analysis, predictive modeling
- **Advantages**: Easy to use, well-documented

Table: ML Tools Comparison

Tool	Type	Best For	Difficulty
TensorFlow	Deep Learning	Complex models	Advanced
Scikit-learn	General ML	Beginners	Easy

Mnemonic: "TPSKMS-TF.SL" - TensorFlow, PyTorch, Scikit, Keras, ML4Kids, Scratch - TensorFlow, Scikit-learn

Question 4(a) OR [3 marks]

Briefly explain Emerging Trends in Renewable Energy.

Answer:

Emerging Trends:

- **Floating Solar**: Solar panels on water bodies
- **Perovskite Cells**: Next-generation solar technology
- **Green Hydrogen**: Clean fuel from renewable sources

Benefits:

- **Higher efficiency**: Better energy conversion
- **Cost reduction**: Cheaper renewable energy

Mnemonic: "FPG" - Floating solar, Perovskite, Green hydrogen

Question 4(b) OR [4 marks]

Give Full forms of: AR, OLED, OPVD, OFET

Answer:

Table: Technology Full Forms

Abbreviation	Full Form	Technology Area
AR	Augmented Reality	Mixed reality
OLED	Organic Light Emitting Diode	Display technology
OPVD	Organic Photovoltaic Device	Solar cells
OFET	Organic Field Effect Transistor	Electronics

Mnemonic: "AOOO" - AR, OLED, OPVD, OFET

Question 4(c) OR [7 marks]

Explain Block diagram of Raspberry Pi.

Answer:

Block Diagram:
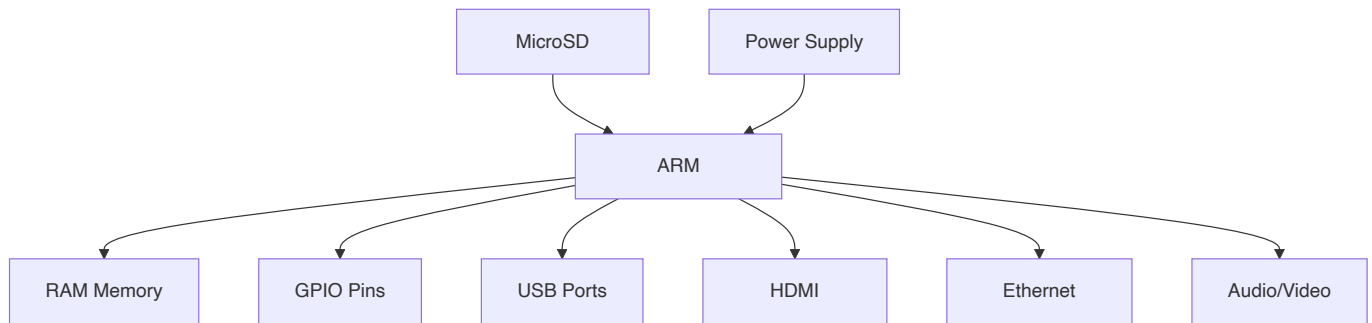
Components:

- **ARM Processor**: Central processing unit (Quad-core)

- **RAM Memory**: System memory (1GB-8GB)

- **GPIO Pins**: 40 pins for interfacing sensors/devices

- **USB Ports**: Connect peripherals

- **HDMI Output**: Video display connection

- **Ethernet Port**: Network connectivity

- **MicroSD Card**: Storage for OS and data

- **Power Supply**: 5V micro-USB or USB-C

Features:

- **Operating System**: Raspberry Pi OS (Linux-based)

- **Programming**: Python, C++, Scratch support

- **Connectivity**: Wi-Fi, Bluetooth built-in

- **Expandability**: Camera, display connectors

Applications:

- **IoT Projects**: Home automation

- **Education**: Learning programming

- **Robotics**: Robot control systems
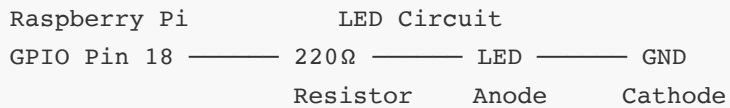
- **Media Center**: Home entertainment

Mnemonic: "ARGC-EPMS" - ARM, RAM, GPIO, Connectivity - Ethernet, Power, MicroSD, Storage

Question 5(a) [3 marks]

Interface LED with Raspberry Pi.

Answer:

Circuit Connection:

```
Raspberry Pi           LED Circuit
GPIO Pin 18 ———— 220Ω ———— LED ———— GND
                  Resistor   Anode    Cathode
```

Python Code:

```python
import RPi.GPIO as GPIO
import time

GPIO.setmode(GPIO.BCM)
GPIO.setup(18, GPIO.OUT)

while True:
    GPIO.output(18, GPIO.HIGH)  # LED ON
    time.sleep(1)
    GPIO.output(18, GPIO.LOW)   # LED OFF
    time.sleep(1)
```

Mnemonic: "GPIO-RC" - GPIO pin, Resistor, Code

Question 5(b) [4 marks]

Explain Pandas python library For Machine Learning.

Answer:

Pandas is a Python library for data manipulation and analysis, essential for ML data preprocessing.

Key Features:

- **DataFrame**: Tabular data structure
- **Data Cleaning**: Handle missing values, duplicates
- **Data Import**: Read CSV, Excel, JSON files
- **Data Analysis**: Statistical operations, grouping

ML Applications:

- **Data Preprocessing**: Clean and prepare datasets
- **Feature Engineering**: Create new features from data
- **Data Exploration**: Understand data patterns
- **Data Transformation**: Normalize, scale data

Common Functions:

```python
import pandas as pd
df = pd.read_csv('data.csv')    # Load data
df.info()                        # Data info
df.describe()                    # Statistics
```

Mnemonic: "DCIF" - DataFrame, Cleaning, Import, Functions

Question 5(c) [7 marks]

Explain types of machine learning techniques: supervised, unsupervised and reinforcement learning.

Answer:

Table: Machine Learning Types

Type	Data Required	Goal	Examples
Supervised	Labeled data	Predict outcomes	Classification, Regression
Unsupervised	Unlabeled data	Find patterns	Clustering, Dimensionality reduction
Reinforcement	Reward signals	Learn optimal actions	Game playing, Robotics

Supervised Learning:

- **Definition**: Learns from input-output pairs
- **Process**: Training with known answers
- **Applications**: Email spam detection, image recognition
- **Algorithms**: Linear regression, decision trees, neural networks

Unsupervised Learning:

- **Definition**: Finds hidden patterns in data
- **Process**: No target variable provided
- **Applications**: Customer segmentation, anomaly detection
- **Algorithms**: K-means clustering, PCA, hierarchical clustering

Reinforcement Learning:

- **Definition**: Learns through trial and error
- **Process**: Agent interacts with environment
- **Applications**: Game AI, autonomous vehicles, robotics
- **Components**: Agent, environment, rewards, actions

Diagram: ML Learning Process
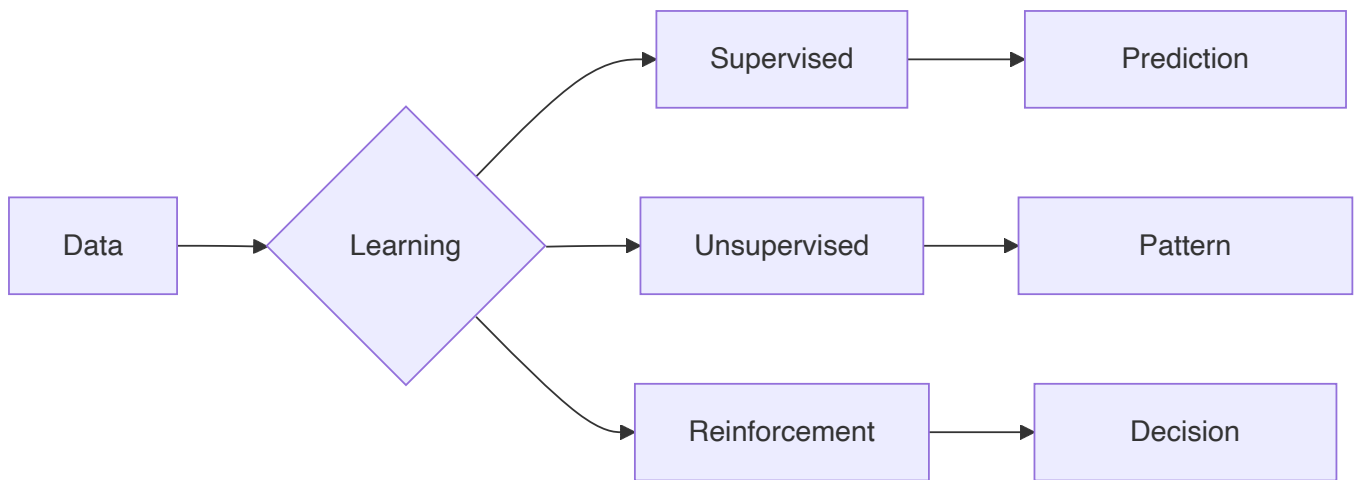
Mnemonic: "SUR-PLR-CPD" - Supervised, Unsupervised, Reinforcement - Prediction, Learning, Rewards - Classification, Patterns, Decisions

Question 5(a) OR [3 marks]

Explain NumPy python library For Machine Learning.

Answer:

NumPy is fundamental library for numerical computing in Python, essential for ML operations.

Key Features:

- **Arrays**: Multi-dimensional array objects
- **Mathematical Functions**: Linear algebra operations
- **Broadcasting**: Operations on different sized arrays

ML Applications:

- **Data Storage**: Efficient numerical data storage
- **Matrix Operations**: Neural network computations
- **Mathematical Computations**: Statistical operations

Mnemonic: "AMB" - Arrays, Mathematical functions, Broadcasting

Question 5(b) OR [4 marks]

Write Installation steps of Raspberry Pi OS on SD card using Raspberry Pi Imager.

Answer:

Installation Steps:

1. **Download**: Install Raspberry Pi Imager from official website
2. **Insert SD Card**: Connect SD card (16GB+) to computer
3. **Select OS**: Choose Raspberry Pi OS from list

4. **Select Storage**: Choose SD card as target

5. **Write**: Click "Write" to flash OS to SD card

6. **Eject**: Safely remove SD card after completion

Pre-configuration Options:

- **Enable SSH**: For remote access

- **Set Username/Password**: Security credentials

- **Configure Wi-Fi**: Network settings

Mnemonic: "DISWS-ESP" - Download, Insert, Select OS, Write, Storage - Enable SSH, Set credentials, Pre-configure

Question 5(c) OR [7 marks]

Interface Temperature and humidity sensors with Raspberry Pi and write Python Program for it.

Answer:

Circuit Connection:

```
DHT22 Sensor           Raspberry Pi
VCC  ──────────────    3.3V (Pin 1)
DATA ──────────────    GPIO 4 (Pin 7)
GND  ──────────────    GND (Pin 6)
```

Python Program:

```python
import Adafruit_DHT
import time

# Sensor type and GPIO pin
sensor = Adafruit_DHT.DHT22
pin = 4

while True:
    try:
        # Read sensor data
        humidity, temperature = Adafruit_DHT.read_retry(sensor, pin)

        if humidity is not None and temperature is not None:
            print(f'Temperature: {temperature:.1f}°C')
            print(f'Humidity: {humidity:.1f}%')
        else:
            print('Failed to read sensor data')

        time.sleep(2)  # Wait 2 seconds

    except KeyboardInterrupt:
        print("\nProgram stopped")
```

```
        break
```

Required Library:

```
pip install Adafruit_DHT
```

Components Used:

- **DHT22**: Temperature and humidity sensor
- **Raspberry Pi**: Processing unit
- **Python**: Programming language
- **Adafruit Library**: Sensor interface library

Features:

- **Real-time Reading**: Continuous monitoring
- **Error Handling**: Handles sensor read failures
- **Data Display**: Shows temperature and humidity values
- **User Control**: Keyboard interrupt to stop program

Applications:

- **Weather Station**: Local weather monitoring
- **Home Automation**: Climate control systems
- **Agriculture**: Greenhouse monitoring
- **Industrial**: Environmental monitoring

Mnemonic: "DHT-RPL" - DHT sensor, Raspberry Pi, Python, Library