Renewable Energy & Emerging Trends in Electronics (4361106) - Summer 2025 Solution

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Question 1(a) [3 marks]

Define Renewable Energy and explain its importance.

> **Solution**
>
> **Answer**: **Renewable Energy** is energy derived from natural sources that are continuously replenished, such as solar, wind, hydroelectric, biomass, and geothermal energy.
>
> **Table 1.** 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.

> **Solution**
>
> **Answer**: **Photovoltaic Effect** is the generation of electric current when light strikes a semiconductor material.
> **Working Principle:**
> 1. **Photon absorption**: Light photons hit solar cell surface
> 2. **Electron excitation**: Electrons gain energy and move to conduction band
> 3. **Charge separation**: Built-in electric field separates positive and negative charges
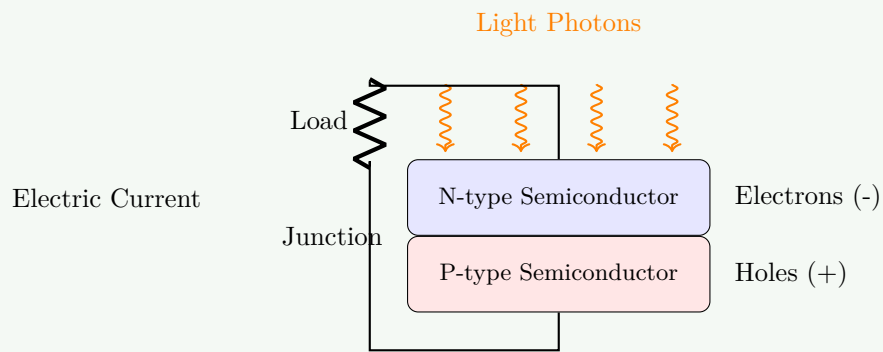> 4. **Current generation**: Flow of electrons creates DC electricity
> **Diagram:**

Figure 1. Photovoltaic Conversion Principle

Question 1(c) [7 marks]

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

Solution

Answer:

Table 2. 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
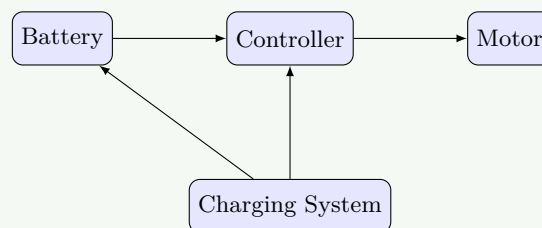- **Hybrid Sources**: Combination of multiple energy sources

Diagram: EV Architecture

Figure 2. Basic EV Architecture

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

Question 1(c) OR [7 marks]

Discuss different types of Renewable Energy Sources.

> **Solution**
>
> **Answer**:
>
> **Table 3.** 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.

> **Solution**
>
> **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

> **Solution**
>
> **Answer**:
>
> **Table 4.** 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.

> **Solution**
>
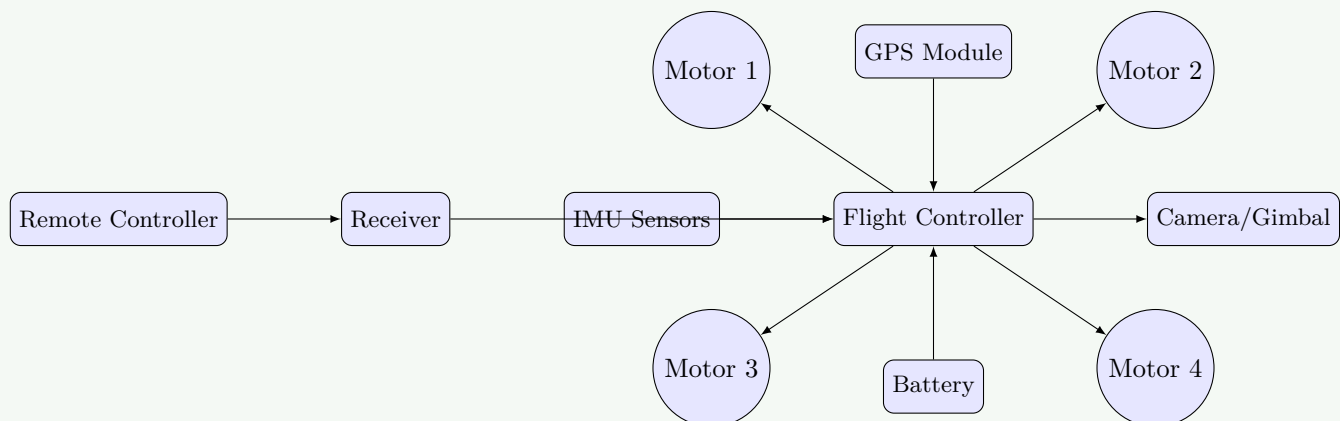> **Answer**:
> **Block Diagram:**

Figure 3. Drone 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.

Solution

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.

Solution

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.
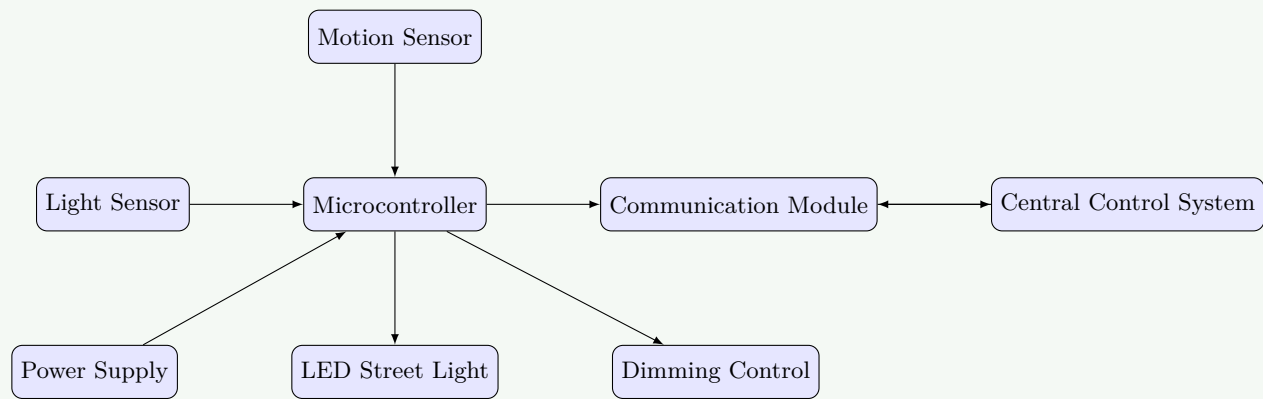
Solution

Answer:
Block Diagram:

Figure 4. Smart Street Light Control System

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.

Solution

Answer:

Table 5. 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.

Solution

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.

Solution

Answer: **Biometric System** identifies individuals based on unique biological characteristics.
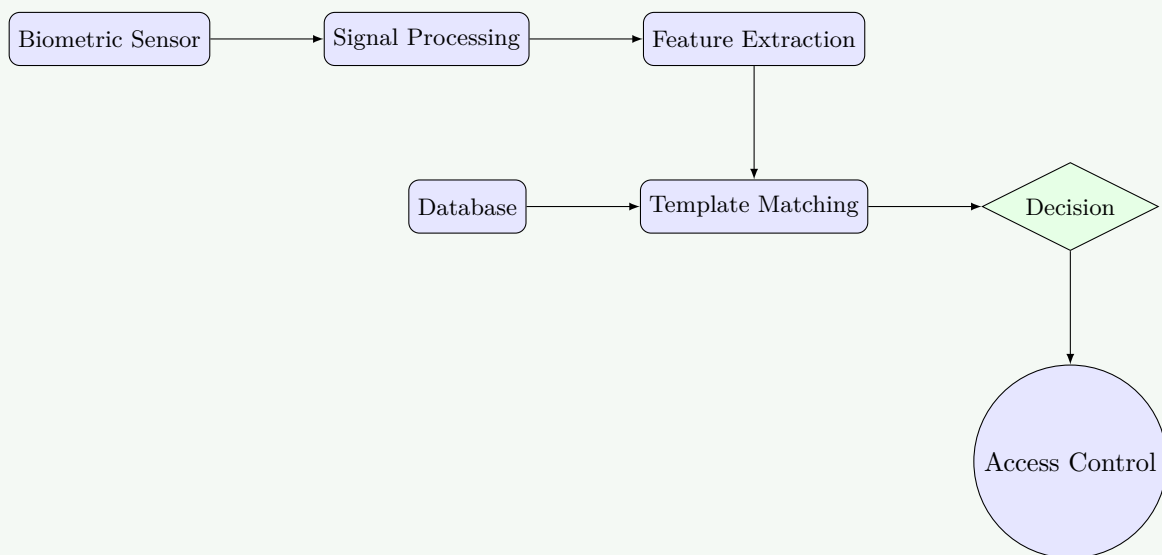**Block Diagram:**

Figure 5. Biometric System Components

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

Mnemonic

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

Question 3(a) OR [3 marks]

List the advantages and applications of organic electronics.

Solution

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.

Solution

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.

Solution

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

Table: AR vs VR Comparison

Table 6. 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

Applications:
- **AR**: Gaming (Pokemon Go), Education, Navigation, Shopping
- **VR**: Entertainment, Training, Architecture, Therapy

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.

Solution
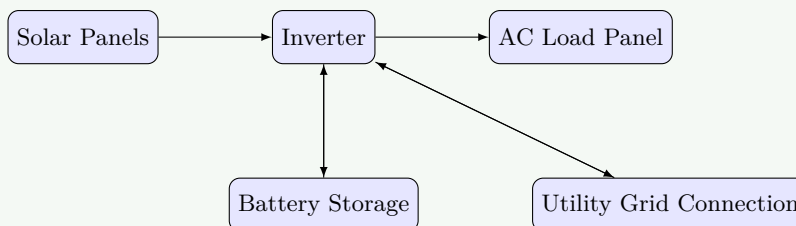
Answer:
Block Diagram:

Figure 6. Home Solar Rooftop System

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

Question 4(b) [4 marks]

Explain working principle of OFET.

Solution

Answer: **OFET (Organic Field Effect Transistor)** uses organic semiconductors to control current flow.
Working Principle:
1. **Gate Voltage**: Applied voltage creates electric field
2. **Channel Formation**: Electric field modulates conductivity
3. **Current Control**: Source-drain current controlled by gate
4. **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.

Solution

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
Table: ML Tools Comparison

Table 7. ML Tools Comparison

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

Detailed Discussion:
- **TensorFlow**: Deep learning and neural networks. Good for large-scale ML and production.
- **Scikit-learn**: General algorithms like classification, regression. Easy to use and well-documented.

Mnemonic

""TPSKMS" - TensorFlow, PyTorch, Scikit, Keras, ML4Kids, Scratch"

Question 4(a) OR [3 marks]

Briefly explain Emerging Trends in Renewable Energy.

Solution

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

Solution

Answer:

Table 8. 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.

Solution
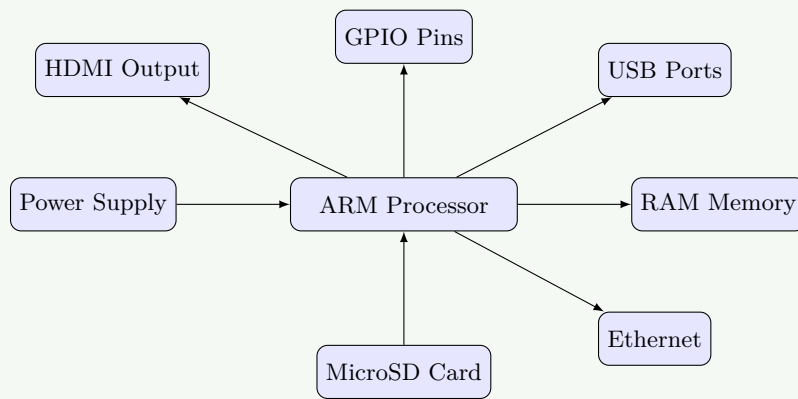
Answer:
Block Diagram:

Figure 7. Raspberry Pi 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

Mnemonic

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

Question 5(a) [3 marks]

Interface LED with Raspberry Pi.

Solution

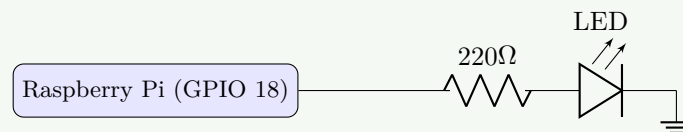**Answer**:
Circuit Connection:

Figure 8. LED Interfacing with Raspberry Pi

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)
```

Question 5(b) [4 marks]

Explain Pandas python library For Machine Learning.

Solution

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

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.

Solution

Answer:

Table 9. Machine Learning Types

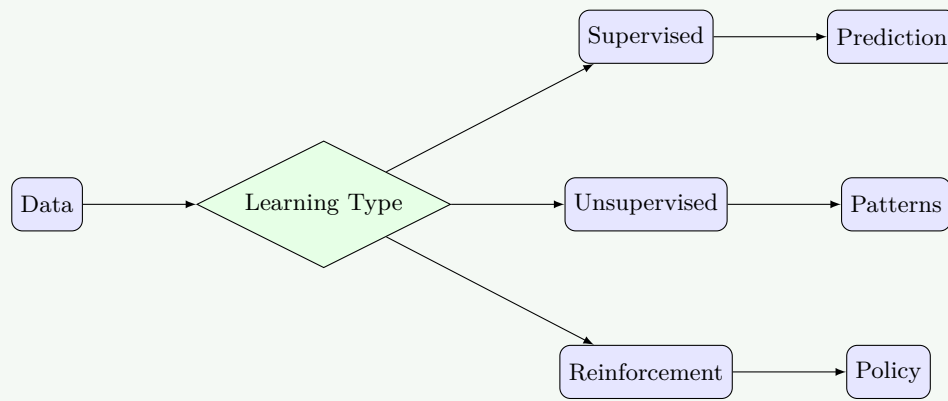| Type	Data Required	Goal	Examples
Supervised	Labeled data	Predict outcomes	Classification, Regression
Unsupervised	Unlabeled data	Find patterns	Clustering, Dimensionality reduction
Reinforcement	Reward signals	Learn optimal actions	Game playing, Robotics

Diagram: ML Learning Process

Figure 9. Machine Learning Types Flow

Descriptions:
- **Supervised Learning**: Learns from input-output pairs. Process involves training with known answers. Applications: Email spam detection.
- **Unsupervised Learning**: Finds hidden patterns in data without target variables. Applications: Customer segmentation.
- **Reinforcement Learning**: Learns through trial and error interacting with an environment. Applications: Game AI.

Mnemonic

""SUR-PLR-CPD" - Supervised, Unsupervised, Reinforcement - Prediction, Learning, Rewards"

Question 5(a) OR [3 marks]

Explain NumPy python library For Machine Learning.

Solution

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

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.

Solution

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.

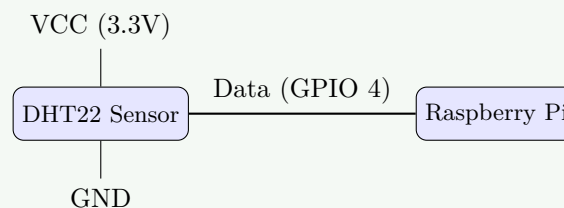**Solution**

Answer:

Circuit Connection:

Figure 10. DHT22 Sensor Interfacing

Python Program:

```python
import Adafruit_DHT
import time

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

while True:
    humidity, temperature = Adafruit_DHT.read_retry(sensor, pin)
    if humidity is not None and temperature is not None:
        print(f'Temp={temperature:0.1f}*C  Humidity={humidity:0.1f}%')
    else:
        print('Failed to get reading. Try again!')
    time.sleep(2)
```

Mnemonic

""DHT-Code" - Sensor, Pin, Read loop"