

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

Milav Dabgar

May 14, 2025

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:

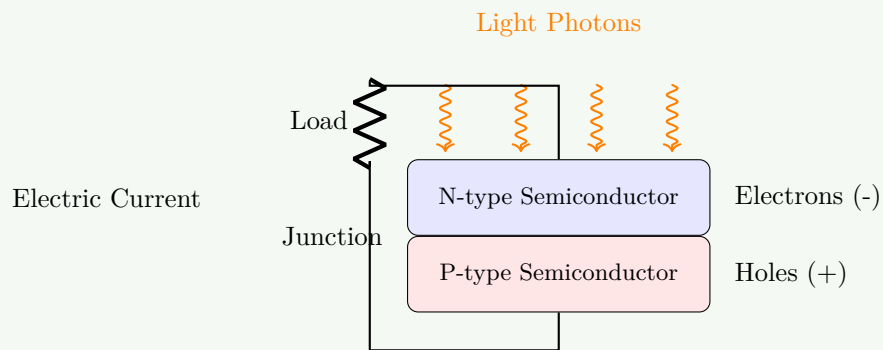


Figure 1. Photovoltaic Conversion Principle

Mnemonic

“PACE” - Photons, Absorption, Charge, Electricity”

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

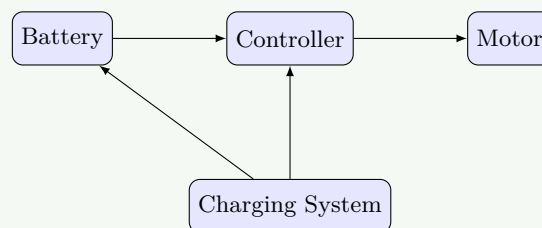
Diagram: EV Architecture

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:

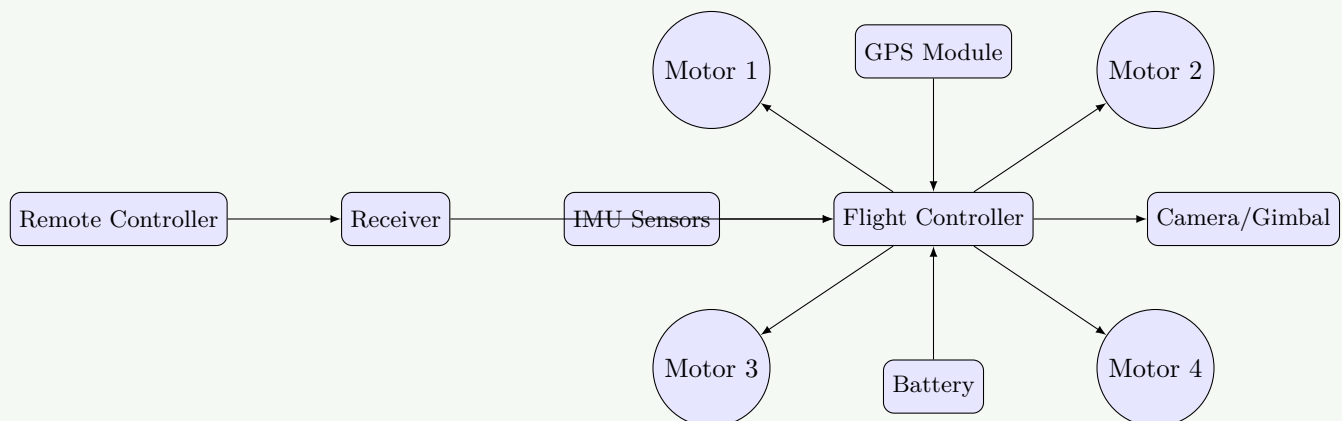


Figure 3. Drone Block Diagram

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:

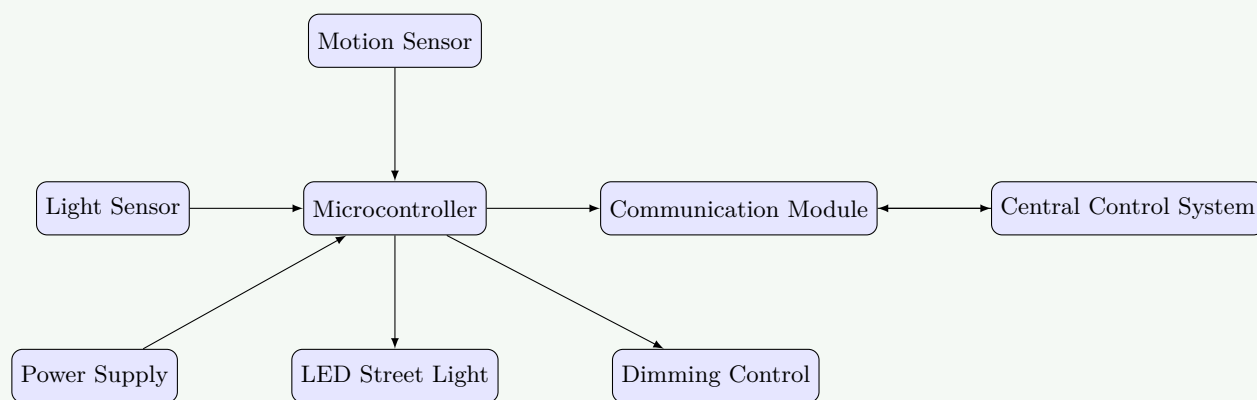


Figure 4. Smart Street Light Control System

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:

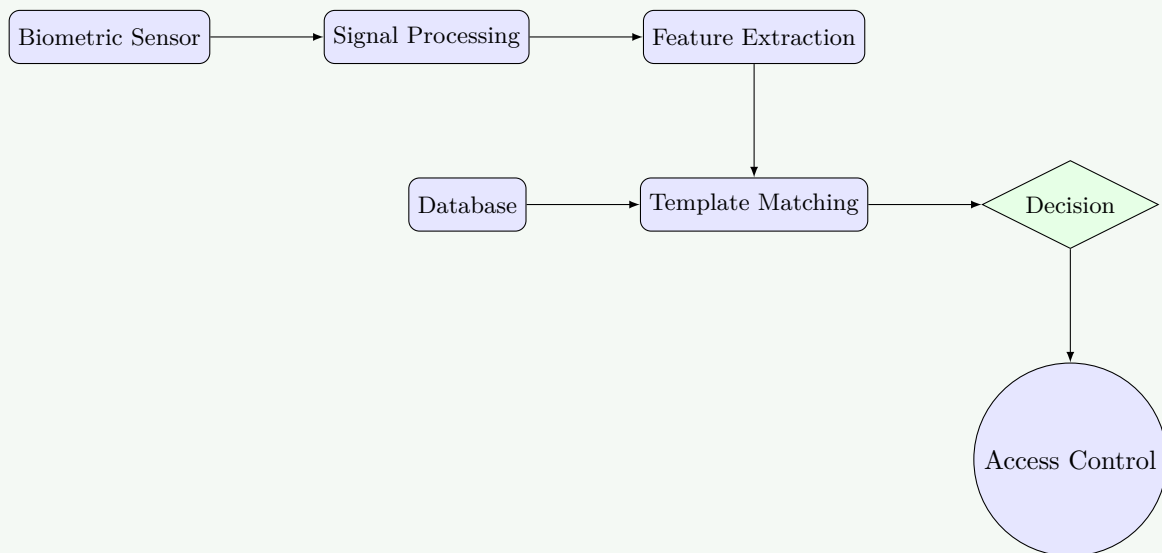


Figure 5. Biometric System Components

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:

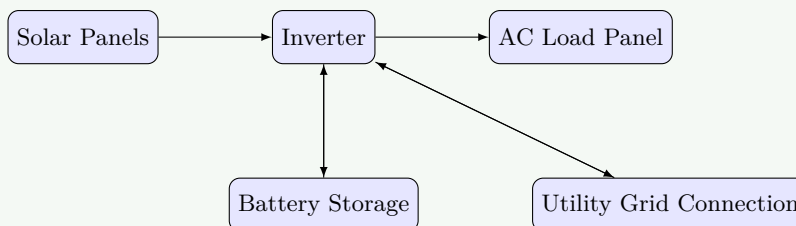


Figure 6. Home Solar Rooftop System

Components:

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

Mnemonic

“SIB” - Solar panels, Inverter, Battery”

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:

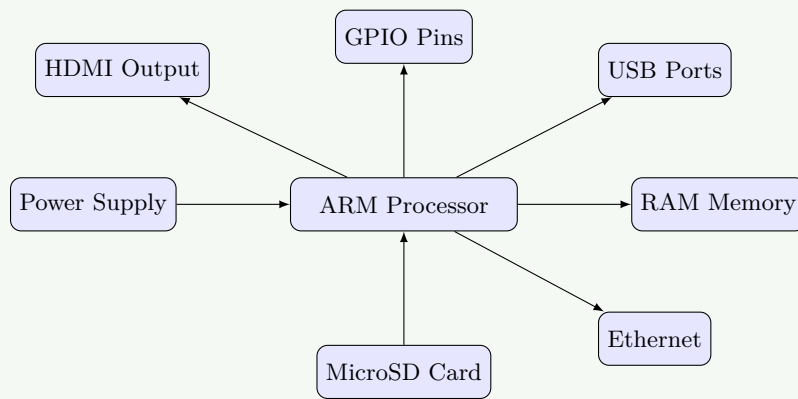


Figure 7. Raspberry Pi Block Diagram

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:

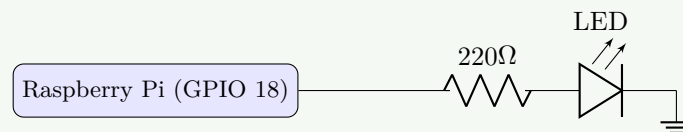


Figure 8. LED Interfacing with Raspberry Pi

Python Code:

```

1 import RPi.GPIO as GPIO
2 import time
3
4 GPIO.setmode(GPIO.BCM)
5 GPIO.setup(18, GPIO.OUT)
6
7 while True:
8     GPIO.output(18, GPIO.HIGH) # LED ON
9     time.sleep(1)
10    GPIO.output(18, GPIO.LOW)  # LED OFF
11    time.sleep(1)
  
```

Mnemonic

“GPIO-RC” - GPIO pin, Resistor, Code”

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:

```
1 import pandas as pd
2 df = pd.read_csv('data.csv')    # Load data
3 df.info()                       # Data info
4 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

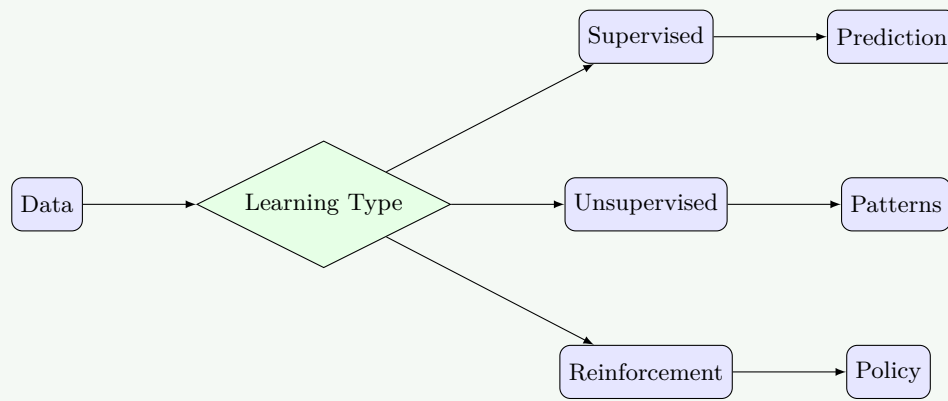


Figure 9. Machine Learning Types Flow

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:

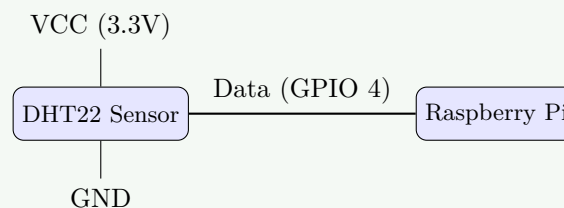


Figure 10. DHT22 Sensor Interfacing

Python Program:

```

1  import Adafruit_DHT
2  import time
3
4  # Sensor type and GPIO pin
5  sensor = Adafruit_DHT.DHT22
6  pin = 4
7
8  while True:
9      humidity, temperature = Adafruit_DHT.read_retry(sensor, pin)
10     if humidity is not None and temperature is not None:
11         print(f'Temp={temperature:0.1f}*C Humidity={humidity:0.1f}%')
12     else:
13         print('Failed to get reading. Try again!')
14     time.sleep(2)
  
```

Mnemonic

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