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

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November 25, 2024

Question 1(a) [3 marks]

List different types of Renewable Energy Sources and explain any one in detail.

> **Solution**
>
> **Table: Types of Renewable Energy Sources**
>
> **Table 1.** Types of Renewable Energy Sources
>
> | Type | Source | Application |
> |------|--------|-------------|
> | Solar | Sun's radiation | Solar panels, heating |
> | Wind | Moving air | Wind turbines |
> | Hydroelectric | Flowing water | Dams, turbines |
> | Biomass | Organic matter | Biofuels, heating |
> | Geothermal | Earth's heat | Power plants, heating |
>
> **Solar Energy Explanation**:
> - **Photovoltaic Effect**: Converts sunlight directly into electricity using silicon cells.
> - **Advantages**: Clean, abundant, renewable.
> - **Applications**: Rooftop systems, solar farms.

> **Mnemonic**
>
> "SWHBG - Sun Wins Hearts By Going"

Question 1(b) [4 marks]

List the different types of Solar Cells and explain any two.

> **Solution**
>
> **Table: Types of Solar Cells**
>
> **Table 2.** Types of Solar Cells

Type	Efficiency	Cost	Application
Silicon	15-20%	Medium	Residential
Monocrystalline	18-22%	High	Premium systems
Polycrystalline	15-17%	Low	Budget systems
Thin Film	10-12%	Very Low	Large installations
Amorphous Silicon	6-8%	Low	Small devices

Monocrystalline Silicon:
- **Structure**: Single crystal structure with uniform appearance.
- **Efficiency**: Highest among silicon cells (18-22%).

Polycrystalline Silicon:
- **Structure**: Multiple crystals with blue speckled appearance.
- **Cost**: Lower manufacturing cost than monocrystalline.

Mnemonic

"My Poly Thin Amp - Most Popular Types Available"

Question 1(c) [7 marks]

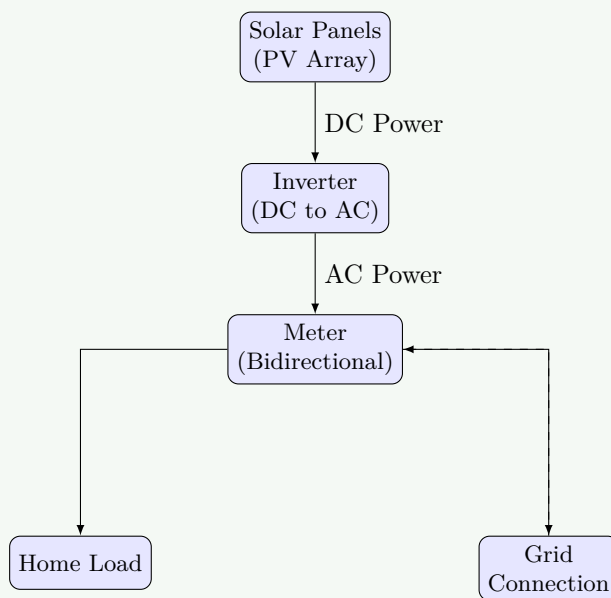**Draw and explain Block Diagram of a Home Solar rooftop system.**

Solution

Figure 1. Home Solar Rooftop System

Components Explanation:
- **Solar Panels**: Convert sunlight to DC electricity using photovoltaic effect.
- **Inverter**: Converts DC power to AC power for home use.
- **Bidirectional Meter**: Measures power consumption and excess power fed to grid.
- **Home Load**: Electrical appliances and devices.
- **Grid Connection**: Connects to utility grid for backup and selling excess power.

Working Principle:
- **Day Operation**: Solar panels generate electricity, inverter converts to AC.
- **Excess Power**: Fed back to grid through net metering.

- **Night Operation**: Power drawn from grid when solar not available.

Question 1(c OR) [7 marks]

Explain with diagram Solar Photovoltaic effect & Principle of photovoltaic conversion.
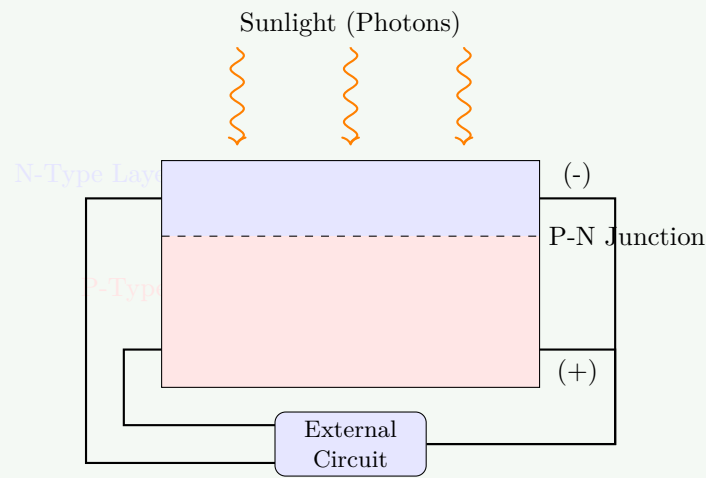
Solution

Figure 2. Solar Photovoltaic Effect

Photovoltaic Effect Process:
- **Photon Absorption**: Solar photons hit silicon atoms.
- **Electron Excitation**: Electrons gain energy and move to conduction band.
- **Charge Separation**: P-N junction creates electric field.
- **Current Flow**: Electrons flow through external circuit.

Key Parameters:
- **Band Gap**: Energy difference between valence and conduction bands.
- **Open Circuit Voltage**: Maximum voltage when no current flows.
- **Short Circuit Current**: Maximum current when terminals are shorted.

Conversion Efficiency:
- **Theoretical Maximum**: 33% for single junction cells.
- **Practical Efficiency**: 15-22% for commercial cells.

Question 2(a) [3 marks]

What is Nanotechnology? List its applications.

Solution

Definition: Nanotechnology is the manipulation of matter at atomic and molecular scale (1-100 nanometers).
Table: Applications of Nanotechnology

Table 3. Applications of Nanotechnology

Field	Application	Benefit
Electronics	Transistors, Memory	Miniaturization
Medicine	Drug delivery, Imaging	Targeted treatment
Energy	Solar cells, Batteries	Higher efficiency
Materials	Composites, Coatings	Enhanced properties
Environment	Water purification	Clean technology

Key Features:
- **Scale**: 1 nanometer $= 10^{-9}$ meters.
- **Properties**: Different properties at nanoscale.
- **Applications**: Cross-disciplinary technology.

Mnemonic

"Nano Makes Everything More Efficient"

Question 2(b) [4 marks]

List the different types of EV technologies and explain any two.

Solution

Table: Types of EV Technologies

Table 4. Types of EV Technologies

Type	Full Form	Power Source	Range
BEV	Battery Electric Vehicle	Battery only	150-400 km
HEV	Hybrid Electric Vehicle	Engine + Battery	600+ km
PHEV	Plug-in Hybrid Electric	Engine + Battery	50-80 km electric
FCEV	Fuel Cell Electric Vehicle	Hydrogen fuel cell	400-600 km

Battery Electric Vehicle (BEV):
- **Power Source**: Rechargeable battery pack only.
- **Operation**: Pure electric drive with zero emissions.
- **Charging**: External charging from grid required.
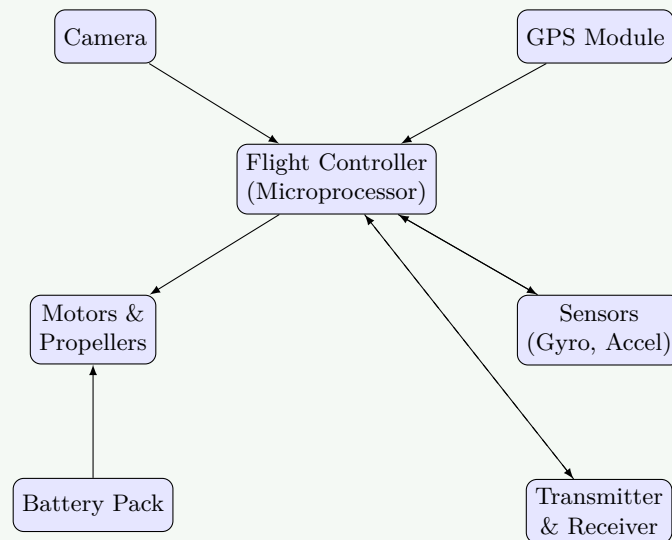
Hybrid Electric Vehicle (HEV):
- **Power Source**: Internal combustion engine + electric motor.
- **Operation**: Automatic switching between power sources.
- **Efficiency**: Regenerative braking recovers energy.

Mnemonic

"Big Hybrid Plug Fuel - Better Transportation Options"

Question 2(c) [7 marks]

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

Solution

Figure 3. Drone Block Diagram

Major Components:
- **Flight Controller**: Central processing unit controlling all operations; provides stabilization, navigation, autopilot functions.
- **Motors and Propellers**: Brushless motors for high efficiency; propellers generate thrust.
- **Sensors Package**: Gyroscope (angular velocity), Accelerometer (acceleration/tilt), Barometer (altitude).
- **Power System**: LiPo Battery for high power density; ESC (Electronic Speed Controllers).
- **Communication**: Transmitter/Receiver for remote control; GPS for position tracking.

Mnemonic

"Flying Controllers Motor Sensors Power Communication - Drones Fly Perfectly"

Question 2(a OR) [3 marks]

What is UAV? List its applications.

Solution

Definition: UAV (Unmanned Aerial Vehicle) is an aircraft operated without human pilot onboard.
Table: UAV Applications

Table 5. UAV Applications

Sector	Application	Benefit
Agriculture	Crop monitoring, Spraying	Precision farming
Security	Surveillance, Border patrol	Enhanced monitoring
Delivery	Package delivery	Fast transportation
Photography	Aerial photography	New perspectives
Inspection	Infrastructure inspection	Safe access

Mnemonic

"Unmanned Aircraft Versatile - Applications Are Vast"

Question 2(b OR) [4 marks]

List the different types of EV energy sources and explain any two.

Solution

Table: EV Energy Sources

Table 6. EV Energy Sources

Type	Technology	Storage	Efficiency
Battery	Lithium-ion	Chemical	90-95%
Fuel Cell	Hydrogen	Chemical	50-60%
Ultracapacitor	Electric field	Electrical	95%+
Flywheel	Kinetic energy	Mechanical	85-90%
Regenerative Braking	Motor generator	Kinetic to electrical	70-80%

Battery System: Lithium-ion cells with high energy density; mature technology.
Fuel Cell System: Hydrogen combines with oxygen to produce electricity; quick refueling, long range.

Mnemonic

"Battery Fuel Ultra Fly Regen - Energy Sources Enable Vehicles"

Question 2(c OR) [7 marks]

List the different types of Smart Systems. Explain with a diagram any 2 smart systems.

Solution

Types of Smart Systems: Smart Homes, Smart Cars, Smart City, Smart Grid, Smart Health.
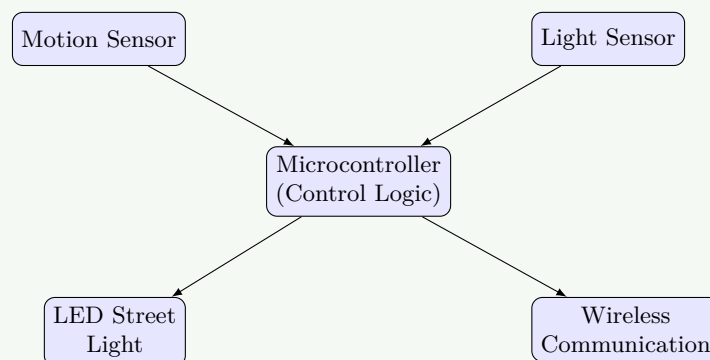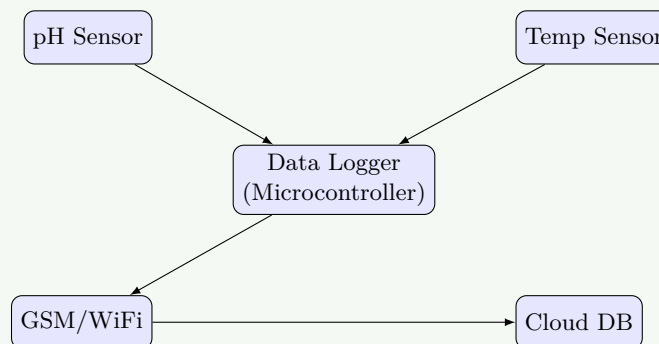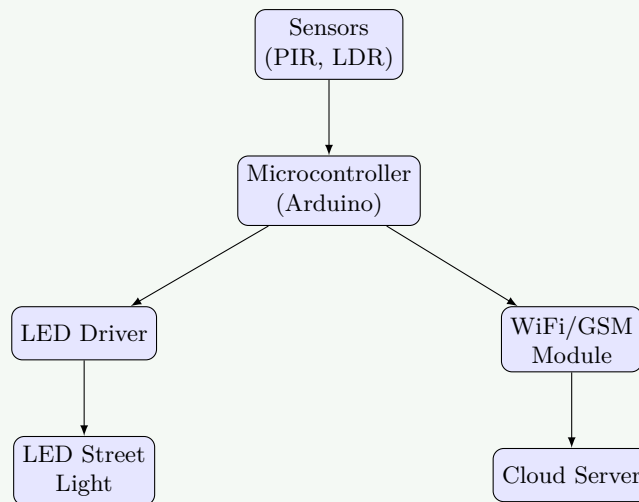

Figure 4. Smart Street Light System

Figure 5. Smart Water Pollution Monitoring

Features: Automation, energy efficiency, remote monitoring.

Question 3(a) [3 marks]

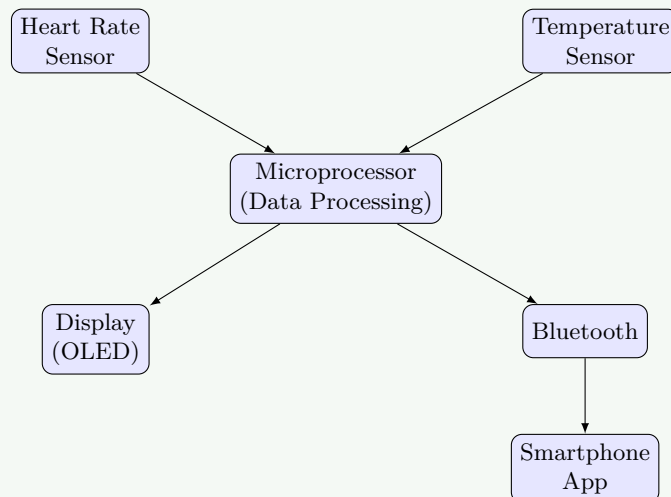**Draw the Block diagram of a Smart Street light control and monitoring system.**

Solution

Figure 6. Smart Street Light Control

Question 3(b) [4 marks]

Draw and explain the block diagram of a wearable health monitoring system.

Solution

Figure 7. Wearable Health Monitoring System

Explanation: Sensors monitor vital signs; processor analyzes data; Bluetooth sends data to smartphone; triggers alerts if needed.

Question 3(c) [7 marks]
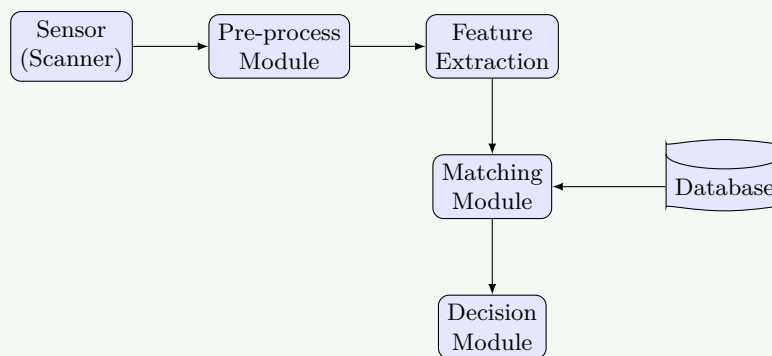
Explain Biometric systems and their basic block diagram.

Solution

Figure 8. Biometric System Block Diagram

Components:
- **Sensor Module**: Captures raw biometric data.
- **Pre-processing**: Noise removal and enhancement.
- **Feature Extraction**: Extracts unique characteristics (template).
- **Matching Module**: Compares template with database.
- **Database**: Stores enrolled templates securely.
- **Decision Module**: Accepts/Rejects based on score.

Question 3(a OR) [3 marks]

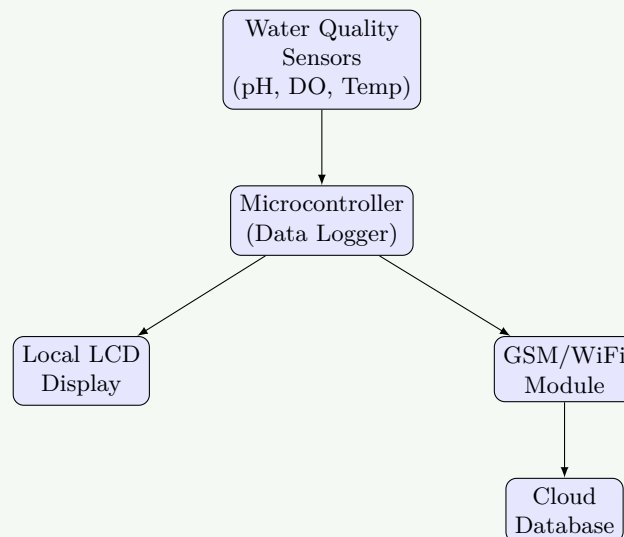**Draw the Block diagram of a Water pollution monitoring system.**

Solution

Figure 9. Water Pollution Monitoring System

Question 3(b OR) [4 marks]

Draw and explain the block diagram of a Smart Watch.
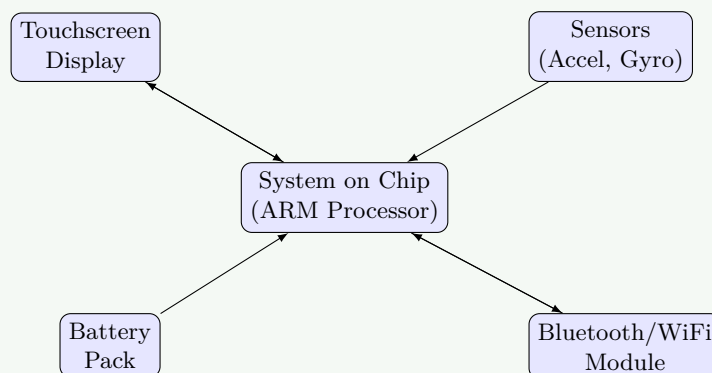
Solution

Figure 10. Smart Watch Block Diagram

Question 3(c OR) [7 marks]

Explain AR/VR core technology and discuss its applications.

Solution

Core Components: Display Technology (See-through vs OLED), Tracking Systems (Motion, Eye, Hand), Processing Power (GPU, CV, AI/ML).

Applications:

- **Education**: Interactive textbooks, virtual classrooms.
- **Healthcare**: Surgery assistance, therapy.
- **Entertainment**: Gaming, virtual concerts.
- **Industry**: Maintenance, training.

Question 4(a) [3 marks]

Differentiate between Inorganic and Organic electronics.

Solution

Table: Inorganic vs Organic Electronics

Table 7. Inorganic vs Organic Electronics

Parameter	Inorganic Electronics	Organic Electronics
Materials	Silicon, Germanium	Carbon-based compounds
Processing	High temperature	Low temperature
Flexibility	Rigid	Flexible
Cost	High	Low
Performance	High speed, stable	Lower speed, improving

Question 4(b) [4 marks]

List different types of organic components and explain any two.

Solution

Table: Types of Organic Components

Table 8. Types of Organic Components

Component	Full Form	Application
OLED	Organic Light Emitting Diode	Displays
OFET	Organic Field Effect Transistor	Switching
OPVD	Organic Photovoltaic Device	Solar cells
OECT	Organic Electrochemical Transistor	Biosensors

OLED: Self-illuminating, flexible, wide viewing angle. **OFET**: Organic semiconductor channel, current controlled by gate.

Question 4(c) [7 marks]

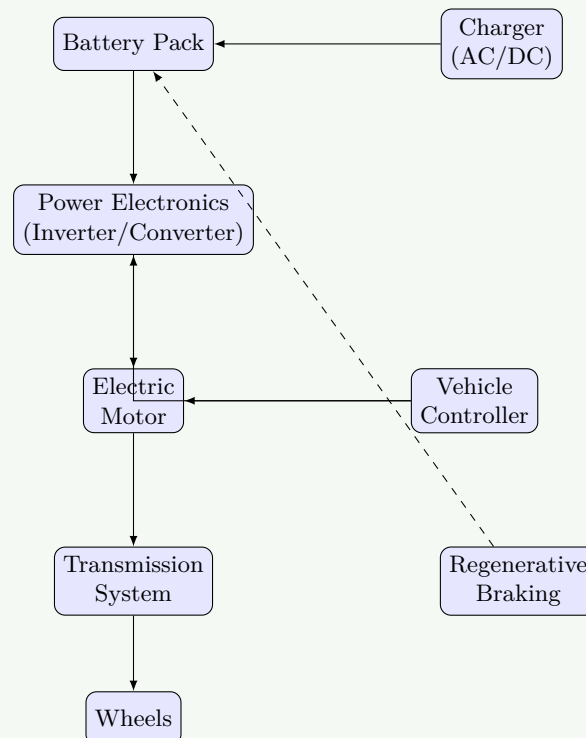**Draw and explain the block diagram of an electric vehicle.**

Solution

Figure 11. Electric Vehicle Block Diagram

Question 4(a OR) [3 marks]

Write the Advantages of Organic Electronics.

> **Solution**
>
> - **Flexibility**: Bendable, rollable.
> - **Low Cost**: Cheap materials, printing.
> - **Large Area**: Easy scaling.
> - **Light Weight**: Thin, lightweight.
> - **Transparency**: See-through devices.

Question 4(b OR) [4 marks]

Write about AR/VR Industry perspectives and opportunities.

> **Solution**
>
> **Market Segments**: Gaming, Enterprise, Healthcare, Education. **Opportunities**: 5G Networks, AI Integration, Hardware Miniaturization. **Challenges**: Motion Sickness, Battery Life, Content Creation.

Question 4(c OR) [7 marks]
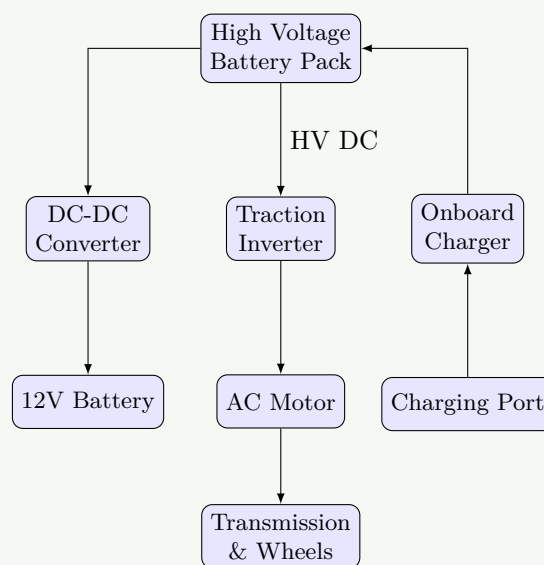
Draw and explain the EV architecture.

> **Solution**
>
>
>
> **Figure 12.** EV Architecture

Question 5(a) [3 marks]

Write briefly about Monocrystalline Silicon solar cells.

> **Solution**
>
> **Characteristics**:
> - **Efficiency**: 18-22% (Highest).
> - **Structure**: Single crystal, uniform dark blue/black color.

- **Lifespan**: 25+ years.
Manufacturing: Czochralski Method.

Question 5(b) [4 marks]

Describe the working principle of a drone.

Solution

Basic Physics: Lift generation via propellers, thrust control by speed variation, stability via gyroscope. **Control**:
- **Ascend/Descend**: Increase/Decrease speed of all motors.
- **Forward/Backward/Left/Right**: Tilt by varying speed of specific motors.
- **Rotation**: Torque differential.

Question 5(c) [7 marks]

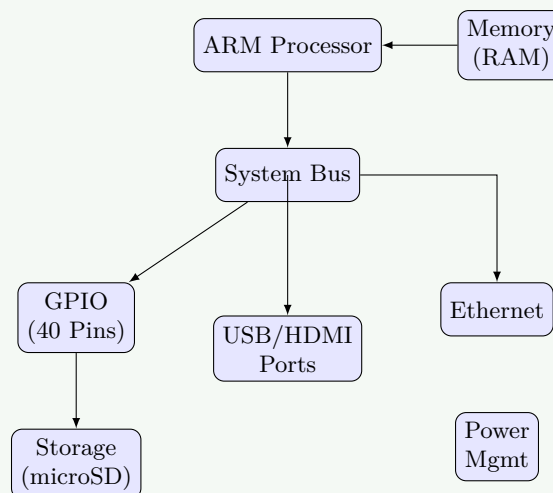**Explain the Block diagram of Raspberry Pi.**

Solution

Figure 13. Raspberry Pi Block Diagram

Core Components: ARM Processor (SoC), RAM, GPIO (General Purpose Input/Output), Connectivity (USB, HDMI, Ethernet, WiFi), Storage (microSD).

Question 5(a OR) [3 marks]

Write briefly about Polycrystalline Silicon solar cells.

Solution

Characteristics:
- **Efficiency**: 15-17%.
- **Structure**: Multiple crystals, blue speckled appearance.
- **Cost**: Medium (Lower than Mono).
Manufacturing: Casting Method.

Question 5(b OR) [4 marks]

Compare Types of machine learning techniques: supervised and unsupervised.

> **Solution**
>
> **Table: Supervised vs Unsupervised Learning**
>
> **Table 9.** Supervised vs Unsupervised Learning
>
> | Aspect | Supervised Learning | Unsupervised Learning |
> |---|---|---|
> | Data Type | Labeled data | Unlabeled data |
> | Goal | Prediction | Pattern discovery |
> | Examples | Classification, Regression | Clustering, Association |
> | Algorithms | SVM, Decision Trees | K-means, PCA |

Question 5(c OR) [7 marks]
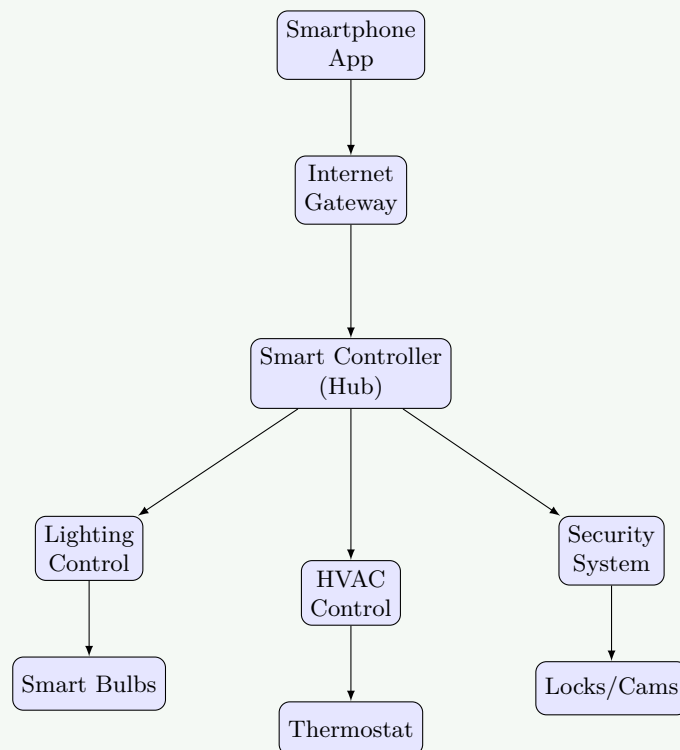
Draw and explain the block diagram of a Smart Home.

> **Solution**
>
>
>
> **Figure 14.** Smart Home System
>
> **Components**: Smart Controller (ZigBee/Z-Wave), Lighting (Smart Bulbs), HVAC (Thermostat), Security (Locks, Cameras), Internet Gateway, Smartphone App.