PLUMULE RESEARCH IOT DEVICE & SOLUTION CATALOGUE

Plumule Research®

Give every student a dream

Contents

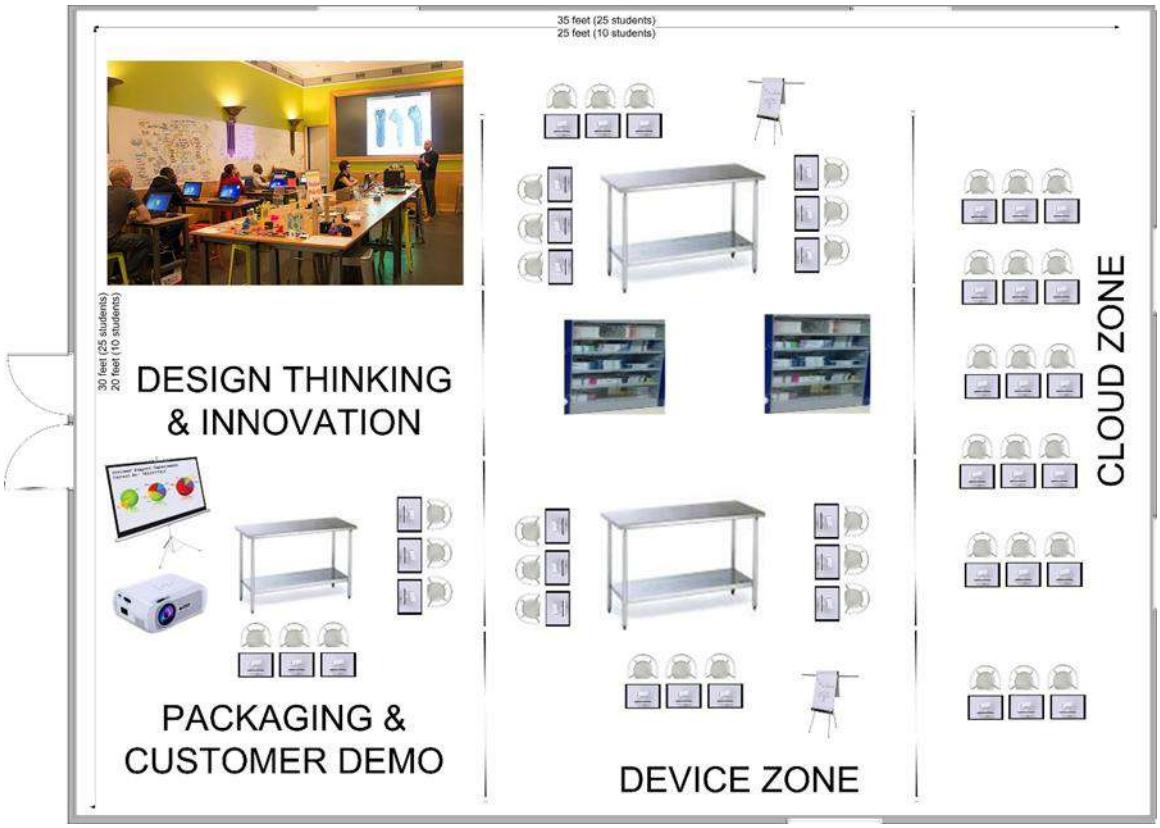
ABOUT PLUMULE RESEARCH DEVICES

Plumule Research LLP delivers solutions to industrial and residential problems by innovative assembly of IOT devices with embedded and cloud-based AI.

PLUMULE RESEARCH DEVICE & SOLUTIONS

IOT/AI/ML Center of Excellence

Industrial design thinking and device assembly labs delivered to Techno India Batanagar, TICT Newtown, JIS-BCCI Center of Industrial Innovation, Dr. Sudhir Chandra Sur Degree Engineering College, Dumdum, Webel FujisoftVara Industry 4.0 CoE, India Power Corporation Limited, Central warehousing Corporation.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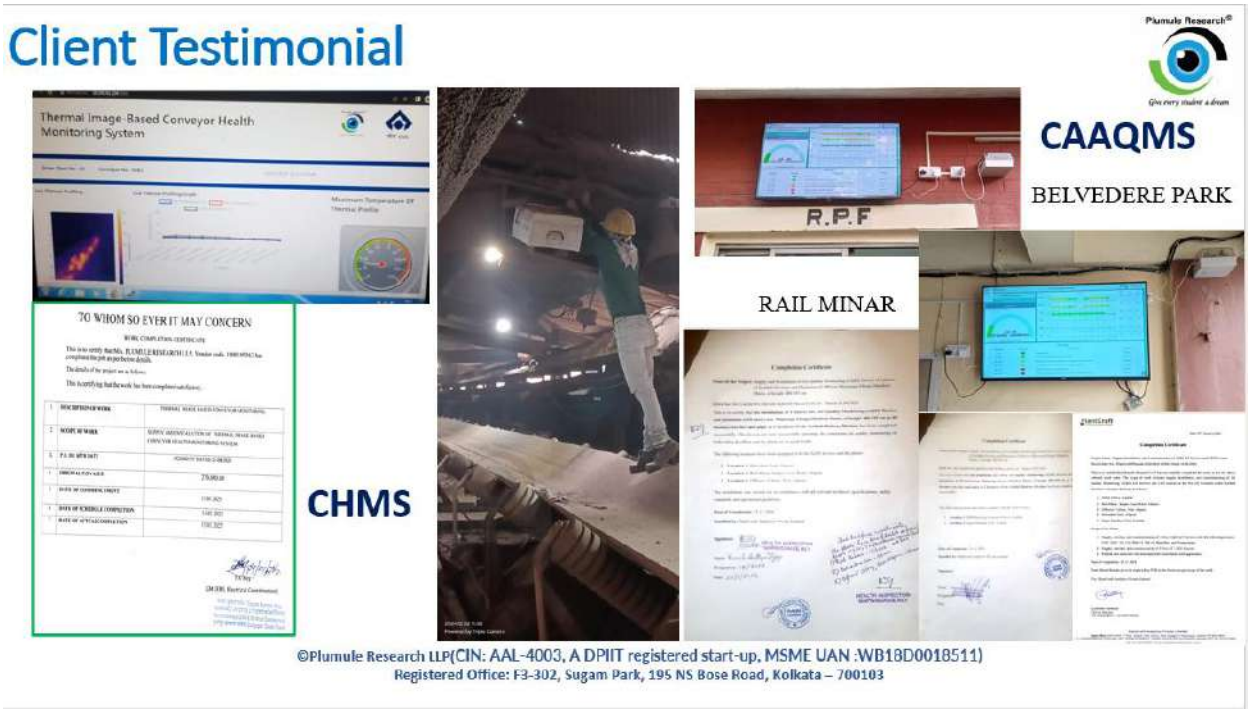
25 feet (10 students)
30 feet (25 students)
20 feet (10 students)
DESIGN THINKING
& INNOVATION
PACKAGING &
CUSTOMER DEMO
DEVICE ZONE
CLOUD ZONE

Industrial Solutions



Continuous Ambient Air Quality Monitoring Systems

Product 1 : RealTime Air Quality Monitoring System

Indian Railways, Sealdah

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https://aqidev.plantcraftanalytics.com/airmain/Dashboard/realtime/index.php?id=2
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https://aqidev.plantcraftanalytics.com/airmain/Dashboard/realtime/index.php?id=5

SCOPE OF THE PROJECT

Measuring concentration of the following polluting components in ambient air
- CO, CO2, PM2.5, PM10, O2, VOC, Humidity, Temperature

Communicating the data in real time to the cloud
Computing the Air Quality & Prominent Pollutant in the cloud
Displaying the real time trending of pollutant ppm and the AQI and primary pollutants on an unmanned 43 inch monitor
Do this at 5 locations namely : Belevedere Park, Alipore, Rail Minar, Alipore, Officers Colony, New Alipore, DRM Building Entrance Portico, Sealdah, Sagar Manthan Club, Sealdah

OUR SOLUTION

Design & engineering of the integrated gas sensor cum microcontroller and battery assembly in a FRP IP65 enclosure
Collation of sensor data in a microcontroller and sending the data to the cloud over wi-fi
Self booting 43 inch TV displaying the computed AQI, Prominent Pollutant and real time trend of all the polluting elements
Installation and commissioning of the entire system

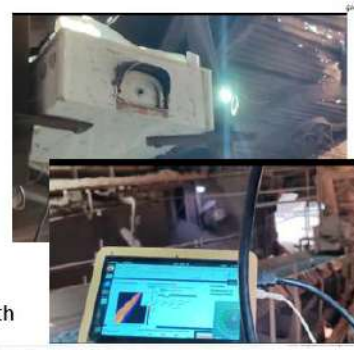
Conveyor Health Monitoring System

Product 2 : Conveyor Health Monitoring System

Durgapur Steel Plant Sinter Plant 2 SSB1

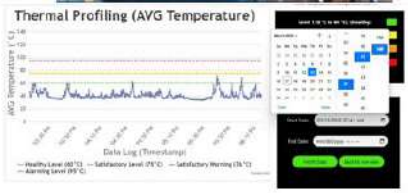
SCOPE OF THE PROJECT

Detection of temperature hotspots on a sinter carrying conveyor using a thermal camera
The conveyor is running at a high speed 1.2 m/s
Hot sinters in cluster damage underlying rubber belt and can even cause fires
Temperature profiling over rectangular frames to understand if it is crossing alert zone of > 98°C
Remote viewing, data transmission to a central server for further analytics
JIT arrest of any fire hazard by operating a relay to alert / start water sprinklers
Prediction of conveyor fire well in advance and life cycle analysis of conveyor health



OUR SOLUTION

Design & engineering of a thermal imaging assembly
Use of high end GPU displaying spatiotemporal thermal data in real time
Fiber Optic Transmission and display of image and data in real time over the plant LAN
Relay terminals to operate sprinklers based on temperature setting
Temperature profiling & impact analysis of the EP conveyor belt



Unmanned Train Detection & Alert Systems

Product 3 : Unmanned Train Detection & Alert System

Matix Fertilizer, Panagarh Industrial Estate

PROBLEM

At Matix, freight trains come empty into the plant from Panagarh offtake / virtual junction, enter int the urea and ammonia manufacturing premises at unpredictable times

Matix was looking for an automated solution that could ring the buzzer and the siren and light the flasher to safeguard the passerby and the labourers who load the bags from conveyors on the 750m long platform

They wanted a flawless automated system for detecting a train and alerting everyone

OUR SOLUTION

Design & engineering of autonomous detection system using radar and camera and deep learning at the edge
Communication to the platform using M2M SIM
Alert to a series of flashers and sirens spanning the entire platform, so that everyone in and around the area was on alert
Tuning of the system at site to remove the JCBs, the trucks, the bikes and any other irrelevant obstacle
Manual override if the communication failed or the relay failed
System robust to handle storm , rain, fog and extreme heat at Panagarh
Assembled to order from elemental components

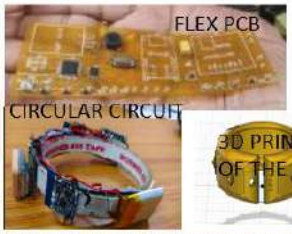
SOS Devices

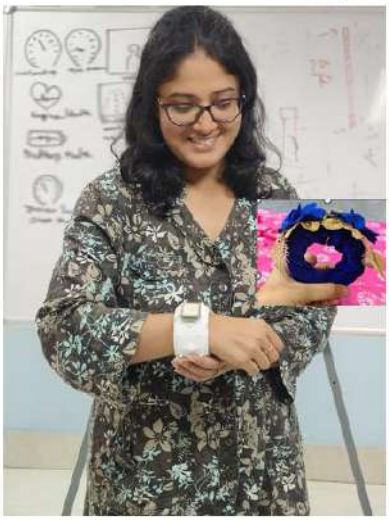
Product 4 : SOS Bangle / Amulet

Project Concern International

The Need:
Domestic violences for women can be restricted or reduced or stopped if there is timely help.
Similarly in the event of sudden attack by a miscreant or health issues, communication for urgent help is the need

Our Solution:
Design and development of a GPS based location tracking system with a M2M SIM communicator and a push button to trigger the SMS from the device. The SMS will contain the coordinates of the hazard / danger and alert the police / control force in a few minutes so that the help can come in time .To fit into a bangle flexible PCB and later flexible wires on a silicone base was used.to enable a 2A SMS to go.





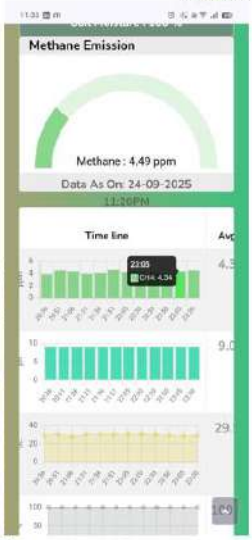
Soil Analysis

Product 5 : GHG Monitoring, The Green Project

Project Concern International

The Need:
Track methane and soil parameters like pH, conductivity, moisture and temperature monitoring solution capable of transmitting real-time, accurate data from remote paddy fields in Bihar to a centralized cloud-based dashboard using MQTT protocol.

Our Solution:
Solar and battery powered freewheeling soil monitoring device measuring accurate methane ppm in air, soil moisture , pH, conductivity and temperature with warranty for 3 years. Use of sensor arrays and intelligent algorithms to perform real time sensor fusion and edge analytics. Alarm using GPS for pilferage. Alerts for battery and other conditions with LED panels. Use of M2M SIM based communications to send data to cloud for dashboarding and other analytics.



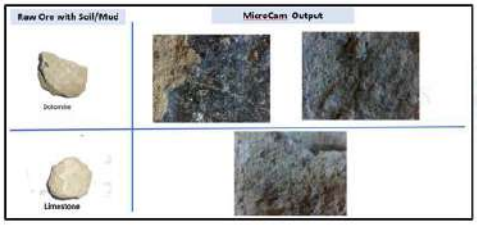
Micro Imaging

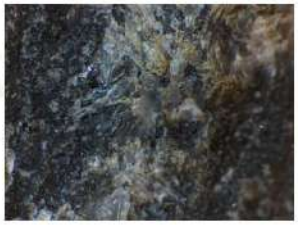
Product 6 : Microscopic Analysis of Materials (In Research)

Bokaro Steel Plant, Durgapur Steel Plant

The Need:
Dolomite and limestone are apparently similar and can be mistaken for each other by field personnel when loaded on the conveyor. The cost and purpose of dolomite and limestone are different. This document proposes a solution to the problem by a physical, non-invasive detection method using IoT and AI
Inline assessment of sinter quality to control the sintering process for better productivity of the blast furnace, less energy requirement

Our Solution:
Invention of the Plumule MicroCam using petrographic image analysis techniques and AI to detect the large rhombohedral crystalline structure of Dolomite vs. grainy microcrystalline structure of Limestone. Similar texture , hardness, porosity, colorimetry and homogeneity analysis of iron ore sinters

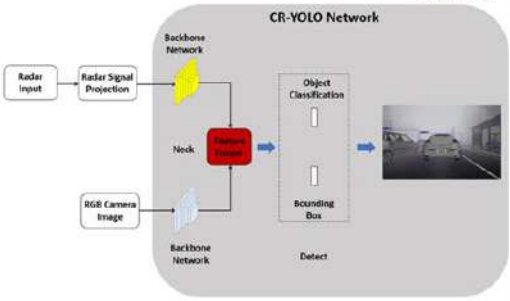




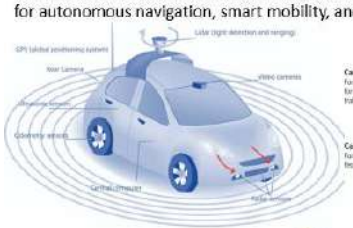
Driver Performance System

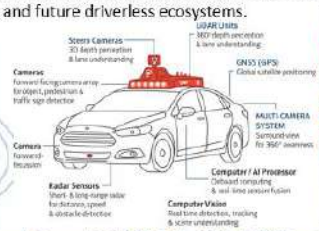
Computer Vision & Radar-Based Driver Safety System

The Need:
Modern mobility is moving toward **self-driving cars and autonomous fleets**, which require reliable real-time perception of the road, surroundings, and traffic environment. This demands strong **camera vision, radar sensing, and AI-based sensor fusion** to ensure accurate navigation and decision-making.



Our Solution:
Plumule Research provides an advanced Autonomous Systems platform for next-generation self-driving cars, combining **computer vision, multi-camera perception, radar sensing, and AI-based sensor fusion.** The system delivers real-time environment understanding with 360° camera coverage, object detection, lane and road-edge recognition, traffic-sign interpretation, and full situational awareness. Integrated short- and long-range radar improves depth, speed, and obstacle detection in any weather, forming a strong, autonomous-grade perception stack. Built on scalable AI pipelines, the platform supports reliable detection, tracking, and decision-making for autonomous navigation, smart mobility, and future driverless ecosystems.



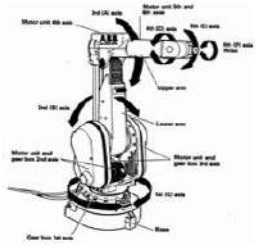


Smart Manufacturing

Next-Generation Robotic Systems for Smart Manufacturing

The Need:
Modern industries demand reliable robotic systems for inspection, material handling, automation, and operations in hazardous, high-precision, and repetitive environments. Robotics is now central to smart factories, autonomous mobility, and industrial automation.

Our Solution:
Plumule Research develops **production-grade robotic systems** including multi-DOF robotic arms, autonomous ground robots, quadruped/spider robots, AI vision-enabled robots, conveyor and factory robots, collaborative cobots, and modular robotic platforms—built for high precision, industrial reliability, harsh environments, and flexible automation across smart factories and industrial operations.



KEY FEATURES:
- 4 DOF robotic manipulator with servo/industrial actuator compatibility
- High accuracy for pick-and-place operations
- Custom-designed gripper with 2–5 kg payload capacity
- Built-in wiring channels for safe operation in dusty industrial environments
- Programmable via microcontroller or PLC interface
- Ready for camera-based automation and AI-guided tasks
- Can be scaled to a full robotic workstation

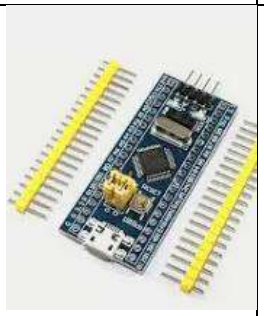
APPLICATIONS:
Sinter plants, conveyor inspection, industrial labs, material sorting, robotic training labs, and R&D automation.

COMPONENT CATALOGUE

Main Suppliers : Robu, Melexis, DigiKey, FlyRobo, Evelta

MICROCONTROLLER BOARDS			
Microcontroller	**Picture**	**Specification**	**Justification / Reason**
Arduino Uno R3		Arduino UNO R3 ATMega328P Processor Memory AVR CPU at up to 16 MHz 32 kB Flash 2 kB SRAM 1 kB EEPROM	Enables robust industrial automation and sensor control for real-time IoT deployments across smart infrastructure applications.
NodeMCU (ESP8266/ESP32) *(Ai Thinker NodeMCU-32S – IPEX Version)*		Ai Thinker NodeMCU-32S-ESP32 Development Board – IPEX Version Built-in Flash: 32Mbit Power supply: 5V Wi-Fi protocol: IEEE 802.11 b/g/n Peripheral interface: UART/GPIO/ADC/DAC/ SDIO/PWM/I2C/I2S Logic level: 3.3V	Provides high-performance wireless connectivity and cloud-ready IoT capabilities for scalable intelligent automation and AI-driven analytics.
Arduino Mega 2560		Programmer: CH340 Operating Voltage 5V Input Voltage (recommended) 7-12V Input Voltage (limits) 6-20V Digital I/O Pins 54 (of which 15 provide PWM output) Analog Input Pins 16 DC Current per I/O Pin 40 mA DC Current for 3.3V Pin 50 mA Flash Memory 256 KB of which 8 KB used by bootloader	Supports complex automation projects requiring extensive sensor/actuator networks in advanced industrial control environments.
Arduino Nano		Operating Voltage (logic level): 5V With USB cable and Soldered Connector 8 analog inputs ports: A0 ~ A7 14 Digital input / output ports: TX, RX, D2 ~ D13 1 pair of TTL level serial transceiver ports RX / TX Using Atmel Atmega328P-AU MCU There is a bootloader installed in it Standard 0.1" spacing DIP (breadboard friendly). Manual reset switch.	Designed for integration into miniaturized commercial IoT products, enabling embedded intelligence in field-deployable devices.

Raspberry Pi 4B		Raspberry Pi 4 Model B with 8GB RAM: Offers high performance for advanced projects and multitasking. 32GB A2 Class MicroSD Card: Fast, reliable storage for your OS and data. 5.1V 3A Power Adapter: Ensures stable power for the Raspberry Pi 4. 1.5m HDMI to Micro HDMI Cable: Connects your Pi to a monitor or TV. Red-White Plastic Case: Protects the Pi while providing easy access to all ports.	Delivers powerful edge AI computing with ML, computer vision, and real-time robotics processing supporting Industry 4.0 applications.
NVIDIA Jetson Nano		Nvidia Jetson Nano Development Kit (128 Cuda Cores, Cortex®-A57, 4 GB 64-Bit LPDDR4) Brand: Waveshare	Accelerates on-device deep learning inference using GPU cores for autonomous robotics, intelligent surveillance, and predictive automation.
C2000 Board – Texas Instruments		TMS320F28379D controlCARD C2000™, Delfino™ MCU 32-Bit Embedded Evaluation Board Real-time deterministic control Low-latency interrupts High-speed PWM Fast ADC conversions Industrial-grade peripherals High-resolution PWM (up to picosecond levels) Multi-channel ADC synchronized with PWM On-chip comparators for protection CAN, SPI, I2C, UART communications Digital Power & Motor Control IP	Ensures high-precision real-time control for motor drives, smart grid systems, and power electronics widely used in manufacturing automation.

		Sensorless FOC (Field Oriented Control) libraries MotorWare & PowerSuite Digital control loop acceleration	
Google Coral Development Board		AM335x 1GHz ARM Cortex-A8 SGX530 Graphics accelerator NEON floating-point accelerator 2x PRU 32-bit 200MHz PRUs 512MB DDR3 800MHZ RAM 4GB Embedded eMMC flash storage	Offers ultra-fast edge AI inference with dedicated TPU for secure, low-latency decision-making in industrial automation and smart city solutions. Industrial-grade deterministic processing for mission-critical automation systems such as CNC machines, robotics, and factory controls.
STM32		Architecture ARM Cortex-M Series (M0/M3/M4/M7/H7) Clock Speed 48 MHz → 600 MHz (depending on series) Flash Memory Up to 2 MB RAM Up to 1 MB AI Processing Support STM32Cube.AI, DSP, SIMD, FPU ADC 12–16 bit high precision Interfaces I2C, SPI, UART, CAN, USB, Ethernet, SDIO, PCI Operating Voltage 1.8V–3.6V Power Consumption Ultra-low-power modes < 1 µA Real-Time Performance Interrupt latency < 50ns (M7 cores) Industrial Reliability AEC-Q100 automotive certified variants Security Features AES-256, Secure Boot, TrustZone, Tamper Pins	STM32 meets key requirements for high-end AI/IoT systems by enabling Edge AI with low-latency processing through STM32Cube.AI and Cortex-M DSP acceleration; offering industrial robustness with AEC-Q100 certified variants supporting wide temperature, dust, and metal-harsh environments; supporting multi-sensor fusion via high-precision ADCs and extensive communication interfaces ideal for environmental and gas sensing; ensuring ultra-low-power performance for solar IoT through deep-sleep operating modes; delivering real-time decision-making using hardware timers and RTOS support such as FreeRTOS; maintaining strong cybersecurity with hardware encryption and secure boot firmware protection suitable for Industry 4.0; and providing excellent scalability so the same STM32 ecosystem grows from basic MCUs to high-performance AI-enabled devices.

ON BOARD SENSORS			
Sensor Name	**Picture**	**Specification**	**Justification / Reason**
PIR Sensor		HC-SR501 PIR with Jumper at back for trigger Wide Working Voltage Range: DC 4.5V- 20V Current Drain: <60uA Detection Angle: <140° Detection Distance: 3 to 7m (can be adjusted) Blockade time: 2.5s (Default) Work temperature: -20-+80°C Jumper for trigger	Enables intelligent motion-triggered automation and smart surveillance systems for energy-efficient security and monitoring applications.
Ultrasonic Sensor		HC-SR04-Ultrasonic Range Finder Operating Voltage: 5 V Sonar Sensing Range: 2-400 cm Max. Sensing Range: 450 cm Frequency: 40 kHz	Supports precise distance measurement for robotics navigation, collision avoidance, and industrial object-detection systems.
DHT11 Sensor		DHT-11 Digital Temperature And Humidity Sensor	Monitors environmental temperature and humidity conditions for smart infrastructure, precision storage systems, and health-focused IoT devices.
Joystick Module		Dimensions: 34 x 34 x 15 (LxWxH) mm. Weight: 10gm (without Hat). 2.54mm pin interface leads. Operating Voltage: 5V. Long service life and stable performance.	Provides multi-axis interactive control for robotics, automation interfaces, and real-time human-machine input applications.
ESP-01		802.11 b/g/n Standards Wi-Fi Direct (P2P), soft-AP 1MB Flash Memory Integrated low power 32-bit CPU could be used as an application processor A-MPDU & A-MSDU aggregation & 0.4ms guard interval	Adds reliable Wi-Fi connectivity to embedded systems enabling cloud data access, smart control, and wide-area IoT communication.

		Wake up and transmit packets in < 2ms Standby power consumption of < 1.0mW (DTIM3)	
Bluetooth Module		Voltage Rating (VDC):3.6 to 6 Switch/Button Yes Input Supply Voltage (V) 3.6 ~ 6 Input current (mA) 50 Max. Operating Range (m):10 Operating Frequency (Hz):2.4GHz ISM band Modulation Type: GFSK (Gaussian Frequency Shift Keying) Emission power 4dBm, Class 2 Sensitivity (dBm): -84dBm at 0.1% BER	Enables seamless short-range data exchange for wearable devices, access control, smart appliances, and mobile-connected IoT products.
Buzzer 5V		Input Voltage(Max.) : 5V Resistance: 90 Ω Resonance Frequency: 2048 Hz Sound pressure(dB(A)/10cm)min.: 80 Body Size : 12 x 9.5mm Pin Pitch: 6mm External Material: Plastic; Color: Black	Offers real-time audio indication and alerting solutions for automated safety, equipment status, and process notifications in industrial systems.

ACTUATORS			
Actuator	**Picture**	**specification**	**Justification / Reason**
Servo Motor (SG90) with Motor Driver		Chipset NXP PCA9685 Number of Outputs 16 independent PWM channels Communication Interface I²C (up to 1 MHz Fast-Mode) PWM Frequency Range 40 Hz → 1000 Hz Resolution 12-bit (4096 steps per channel) Output Voltage Logic Level 3.3V / 5V compatible Operating Voltage (power input) 5V – 6V typical for servos Servo Power Input Connector 2-pin screw terminal On-board Power Filtering Large electrolytic capacitor for stable servo power Address Select Pins Up to 62 drivers on same bus → control 992 servos Size Approx. 62 mm × 25 mm MountingMultiple mounting holes Additional Feature Built-in 5V regulator on some versions for logic Compatibility Works with Arduino, ESP32, Raspberry Pi, Jetson Nano, etc.	Enables precise angular positioning and automated motion control for robotics, smart mechanisms, and embedded electromechanical systems.
Stepper Motor with Motor Driver		his kit includes a 28BYJ-48 unipolar stepper motor and a ULN2003 driver board. The motor operates typically at 5V DC. It is a 4-phase stepper motor suitable for low-power applications.	Supports accurate stepwise rotation for CNC machines, industrial positioning systems, and autonomous robotics requiring high precision.

		The motor has a gear reduction ratio of about 1:64. Step angle is 5.625° per step before gearing, resulting in ~2048 steps per full rotation. Motor torque is around 300 gf·cm, ideal for light mechanical loads. Current consumption per phase is up to 240 mA. The ULN2003 module uses a Darlington transistor array driver IC. The driver supports 4-channel control of the stepper phases. The module input voltage is 5V, matching the stepper motor requirement. The driver board includes LED indicators for each active step coil. The board has a 5-pin JST-XH connector to directly plug the motor cable. It supports common controllers: Arduino, ESP32, ESP8266, Raspberry Pi, STM32, etc. It allows bidirectional control and stepping modes such as full-step and half-step. Designed for slow speed, precise positioning, and low-noise movement. Common uses: small robots, camera sliders, automatic curtains, toys, 3D printer mechanisms (light loads), and DIY automation.	

DC Motors with Motor Driver		Motor type: Small DC brushed motor for robotics projects. Operating voltage range: Typically 3V to 6V DC. Speed: Depends on supply voltage; higher voltage → higher RPM. Direction control: Supports Forward and Reverse rotation. Control interface: Simple switch/button or control pins provided. Current drive capability: Suitable for low-power DC motors used in hobby kits. Motor driver technology: Transistor-based / Integrated driver circuit. Connections: Plug-and-play 2-pin motor connector. On-board direction toggle switch for manual direction change. Compact size for easy fit in small robots and mechanisms. Used for: Wheels, mini-robots, toys, sliders, and simple mechanisms. Ideal for educational STEM projects and prototyping. Compatible with WitBlox electronic blocks system. Lightweight and safe for students and beginners.	Provides dynamic rotational force for automation, smart mobility systems, and industrial motion solutions with customizable control.
Relay Modules with Motor Driver		Type: 2-channel industrial relay board mounted on a DIN-rail enclosure. Relay type: Electromechanical relays for switching AC or DC loads.	Automates switching of high-voltage industrial loads and machinery using low-power logic signals, enabling safe and reliable control in IoT and smart factory applications.

		Mounting style: DIN rail (standard 35 mm rail for control panels). Input voltage: Usually 24V DC for coil operation (other variants may be 12V or 5V). Output switching voltage: Supports AC up to 250V or DC up to 30V (typical range). Output current rating: Around 10A per relay contact (varies by model). Isolation: Provides electrical isolation between control and load circuits. Terminals: Screw terminals for secure wiring of input and output lines. Indicators: LED indicators show relay activation status. Channels: 2 independent switching channels. Safety: Enclosed design reduces risk of accidental contact in industrial environments. Application: PLC automation, motor control, industrial machinery, home automation. Compatibility: Can be controlled by PLCs, microcontrollers, or automation controllers. Protection: Basic PCB-level protection, can support additional fuses externally.	

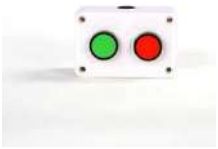
COMMUNICATION MODULES			
Communication Module	**Picture**	**specification**	**Justification / Reason**
Wi-Fi Module (ESP8266)		Microcontroller: ESP8266EX Wi-Fi SoC. Operating voltage: 3.3V (NOT 5V tolerant on I/O pins). Wi-Fi standard: 802.11 b/g/n (2.4 GHz band). Flash memory: Typically 512 KB to 1 MB (varies by version). Processor speed: Up to 80 MHz (can overclock to 160 MHz). GPIO pins: 2 digital I/O pins (GPIO0, GPIO2). Communication interface: UART (TX, RX). Network features: Supports TCP/IP stack, HTTP, MQTT. Operating modes: Station mode, Access Point mode, or both. Antenna: PCB onboard antenna (good range indoors). Power consumption: 70 mA average, peaks up to 300 mA during Wi-Fi transmit. Security: WPA/WPA2 encryption support. Programmable using: Arduino IDE, AT Commands, Lua (NodeMCU) and others. Application: IoT communication, wireless sensor modules, home	Enables seamless IoT connectivity for real-time cloud monitoring, smart automation, and scalable AI-enabled remote control systems.

		automation, web-controlled devices. Size: Ultra-compact for embedding into projects.	
Bluetooth Module (HC-05/HC-06)		Communication standard: Bluetooth V2.0 + EDR Frequency: 2.4 GHz ISM band Operating voltage: 3.3V to 5V input (3.3V internal regulation) Logic level: 3.3V (TX/RX pins) Communication interface: UART (Serial) Default baud rate: 9600 (configurable via AT commands) Operating modes: Master or Slave mode (can be switched) Range: Up to ~10 meters (open space) Antenna: Onboard PCB antenna Security: Supports PIN-based pairing (default PIN: 1234 or 0000) Two LEDs indicate power and connection status Current consumption: Typically 30–40 mA Modulation: GFSK Supports AT commands for configuration Applications: Wireless serial communication, robotic control, data logging, remote sensors Compact lightweight module for embedded IoT and DIY projects	Supports secure wireless pairing and control for wearable devices, smart appliances, and human-machine interaction in modern IoT ecosystems.

GSM Module (SIM900A)		Module type: Dual-band GSM/GPRS communication module. Supported frequency bands: 900 MHz and 1800 MHz (2G network). Communication protocols: GSM, GPRS Class 10. Functions supported: Voice call, SMS, GPRS data, DTMF, fax. Control interface: UART (TX/RX) with AT command support. Operating voltage: 3.4V to 4.4V, recommended 4.0V supply. Current consumption: Idle: ~20–30 mA During transmission: ~200–400 mA peaks SIM card support: Standard 2G SIM card slot needed on breakout board. Antenna: External antenna connection required (SMA / IPEX depending on version). Supported data protocols: TCP/IP, HTTP, FTP over GPRS. Baud rate: Configurable, default typically 9600 bps. Temperature range: -40°C to +85°C. Audio interface: Supports microphone and speaker for calls. SMS support: Text mode and PDU mode. Small form factor: Compact embedded module for IoT devices. Applications: IoT connectivity, remote monitoring, SMS alert systems, GPS trackers, home automation.	Facilitates mobile-network-based communication for mission-critical remote monitoring and telemetry applications where Wi-Fi is unavailable.

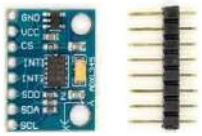
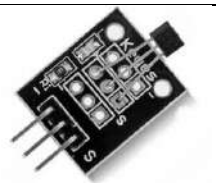
RF Module (433 MHz)		Transmitter Module (right side) Operating frequency: 433 MHz Operating voltage: 3V to 12V DC Output power: Up to 10 mW (varies with supply voltage) Range: Up to 100 meters (open area, with proper antenna) Modulation: ASK / OOK (Amplitude Shift Keying / On-Off Keying) Data rate: Up to 10 kbps Very low cost and low power consumption Requires external antenna wire for long range Suitable for one-way communication Receiver Module (left side) Operating frequency: 433 MHz Operating voltage: 5V DC Sensitivity: ≈ -105 dB to -110 dB Data rate: Up to 4.8 kbps reliable communication Output type: Digital signal output Range: Up to 100 meters (open line-of-sight) Uses super-heterodyne design for better reception stability	Delivers low-power, short-range wireless communication for reliable remote control and data transmission in embedded industrial systems.

INTERFACE DEVICE			
Interface Device	**Picture**	**Specification**	**Justification / Reason**
4x4 Membrane Keypad		• 16 Keys (4×4 Matrix)• Operating Voltage: 3.3–5V• Flexible Polyester Material• Adhesive Backing• Standard 8-Pin Interface	Enables secure multi-parameter access input for automation systems, access control, robotics navigation, and configuration interfaces in smart devices.
RGB LED – Common Cathode		• Red/Green/Blue LEDs in one package• Forward Voltage: R (1.8–2.2V), G/B (3.0–3.2V)• Common Cathode Pin• Independent color control via PWM	Provides dynamic multi-color visual signaling for status monitoring, alerts, and UI feedback in intelligent IoT environments.
400-pin Breadboard		• 400 Tie-Points• Standard 2.54 mm Pitch• Supports Jumpers & DIP ICs• Solderless Prototyping	Supports modular prototyping and rapid hardware integration for scalable development of AIoT and embedded automation solutions.
HDMI to Micro-HDMI Cable		• HDMI Type-A to Micro-HDMI Type-D• 1080p / 4K Compatible• Length: 1m (typ.)• High-speed Data Transmission	Delivers high-quality display output for edge AI systems, enabling visualization dashboards, process monitoring, and user interfaces.
HDMI to Micro Adapter		• Converts HDMI Type-A to Micro-HDMI• Compact Adapter• Supports Full HD / 4K Resolution	Allows flexible video connectivity for compact industrial controllers, enhancing device deployment in real-world digital infrastructure.

3x3 Channel Relay		• 3 Individual Relays• 5V/12V Operating Voltage (as applicable)• 10A @ 250VAC / 30VDC switching• Optocoupler isolation	Controls multiple industrial loads independently using isolated channels for high-reliability switching in smart automation.
3 RGB LED		• Discrete RGB LEDs (x3 units)• Forward Voltage: R (2V), G/B (3V)• Bright diffused lenses• Independent channel control	Enables vivid status indication for multi-signal monitoring, UI design, and intelligent alerting in connected systems.
2 Push Button		• Momentary Tactile Switches• NO Contact Operation• Operating Voltage: 3.3–5V• Durable Actuation Life	Supports tactile event inputs for various intelligent control applications in robotics, automation, and wearable technology.
Buzzer		• Active or Passive Type• Operating Voltage: 3–5V• Sound Output: 85–95 dB (typ.)• PCB Mountable	Provides real-time audible notifications for safety alerts, warnings, equipment status, and interactive device feedback.
LCD 16x2 or OLED Display		• 16×2 Character LCD (4/8-bit interface) **or** OLED (128×64)• Voltage: 3.3–5V• I2C/SPI Interface• High readability	Enables real-time data presentation and user interaction in intelligent systems, supporting dashboards, AI inference results, and device status insights.

EXTERNAL SENSOR			
External Sensor / Module	**Picture**	**Specification**	**Justification / Reason**
DC motor with Fan – small one		• Operating Voltage: 3–12V• Speed: ~10,000 RPM• Small plastic fan propeller	Provides efficient cooling and airflow control for automated systems, enabling thermal management in high-performance embedded applications.
RF Wireless Transceiver		• Frequency: 433MHz/2.4GHz (varies)• Range: Up to 100m• ASK/FSK Modulation	Enables reliable wireless data exchange for secure, remote machine-to-machine communication in industrial and IoT automation systems.
GPS Tracker Module Neo 6M		• GPS L1 frequency 1575.42MHz• UART Interface (9600bps default)• Accuracy: <2.5m CEP	Supports real-time geolocation tracking for autonomous vehicles, fleet management, and precision navigation in smart logistics.
Mini Pump		• Operating Voltage: 5–12V• Typical Flow Rate: 80–120 L/hr• Diaphragm or DC motor-based	Enables automated liquid movement and smart irrigation solutions for industrial process control and smart agriculture.
IR Sensor Module		• Range: 2–80 cm• Receiver & IR LED Pair• Digital/Analog Output	Detects proximity and object presence for automatic actuation, obstacle avoidance, and machine safety systems.

Sound Sensor		• Microphone + Amplifier• Digital & Analog Outputs• Sensitivity Adjustable	Enables acoustic event detection and sound-based monitoring for security, automation, and intelligent audio systems.
Touch Sensor		• Tactile push-sensitive input• Digital output• Operating Voltage: 3.3–5V	Provides direct human-device interaction for smart user interfaces in kiosks, appliances, and automation control panels.
Capacitive Touch Sensor		• IC: TTP223 (commonly)• No mechanical wear• Low power capacitive detection	Enables modern touch-controlled interfaces for sealed, durable HMI systems in industrial and consumer smart products.
MQ-2 Gas Sensor		• Detects: LPG, Smoke, Methane etc.• Output: Analog• Heating Element Required	Detects hazardous gases for industrial safety, smart monitoring, and environmental compliance applications.
Light Sensor		• LDR-based or ALS Sensor• Analog Output• Detects ambient brightness	Measures ambient light levels for automated illumination control and energy-efficient building systems.
Magnetic Switch – Reed Switch Module		• Magnetic proximity switch• Normally Open contact type• Digital Output	Provides magnetic field detection for asset monitoring, position sensing, and intrusion detection in secure environments.
Soil Moisture Sensor		• Capacitive or resistive type• Analog Output• 3.3–5V Operation	Enables precise irrigation automation and soil health monitoring in precision farming and green IoT solutions.

3-Axis Digital Accelerometer		• Common IC: ADXL345/MPU6050• I²C/SPI Interface• ±2g to ±16g Measurement Range	Measures motion, tilt, and vibration for robotics stability, vehicle safety, and industrial condition monitoring.
Magnetic Field Sensor + Shield		• Hall-effect Vector Sensing• I²C Output• Measures static/moving magnetic fields	Provides magnetic field vector measurement for navigation-grade orientation systems in robotics and smart mobility.
Turbidity Sensor		• Measures suspended particles• Analog/Digital Output• IR-based detection method	Monitors water quality by detecting suspended particles in environmental and industrial process applications.
pH Sensor Board (0–14 pH)		• Range: 0–14 pH• BNC Probe Input• Analog Output with pH Interface Board	Enables real-time chemical analysis for wastewater treatment, agriculture optimization, and industrial liquid monitoring.
Heartbeat Sensor – Pulse Sensor		• Measures SpO_2 & HR (PPG optical)• Operating Voltage: 3.3–5V• Analog/Digital Output	Provides real-time biometric pulse data for health analytics, wearable smart devices, and remote healthcare monitoring.
Water Flow Sensor (1–30 L/min)		• Hall-effect Turbine• Digital Pulse Output• Flow Range: 1–30 L/min	Measures liquid flow rate to support industrial metering, consumption analytics, and smart water management.
Water Level Sensor – Digital & Analog		• Resistive ladder or float type• Both digital and analog signals• Waterproof construction	Enables fluid-level monitoring in storage systems for industrial automation, resource management, and safety compliance.
Vibration Sensor		• Spring/vibration switch• Digital output• Trigger threshold adjustable	Detects vibration levels for predictive maintenance and machine-health diagnostics in industrial environments.

Accelerometer with ≥0.2g Sensitivity		• Motion sensing <0.2g• Low noise output• Digital I²C Interface	Measures small accelerations for impact detection, smart mobility analytics, and IoT motion-aware systems.
Oxygen Level Sensor Max 30100		• Measures HR & SpO_2 (Pulse Ox.)• I²C Interface• IR + Red LED sensing	Provides non-invasive health monitoring (SpO_2 + HR) for biomedical wearables and smart patient monitoring.
Blood Pressure Sensor		• Non-invasive BP measurement• Analog Output• Typically uses cuff + pressure transducer	Enables continuous blood pressure measurement in remote health diagnostics and medical IoT devices.
RFID RC522 Small Chip		• 13.56 MHz (NFC compatible)• SPI/I²C Interface• Range: 2–5 cm	Supports secure identity authentication and asset tracking systems within smart access and retail tech.
Weight Sensor		• Strain gauge technology• Weight ranges: 1–50 kg typical• Analog mV output	Measures load and force in smart industrial weighing, logistics automation, and precision monitoring systems.
Driver for Load Cell		• HX711 24-bit ADC (typ.)• High-precision amplification• Digital output to MCU	Provides accurate amplification for load-cell signals in weighing automation and industrial quality systems.
20A Current Sensor		• ACS712 / ACS758 series• Range: Up to 20A AC/DC• Analog proportional output	Enables high-current measurement for power monitoring, predictive maintenance, and intelligent energy systems.

Solenoid Valve		• 12V/24V DC Coil• Controlled ON/OFF fluid flow• Brass/Plastic body options	Provides automated control of fluid and gas routing in industrial machinery and smart irrigation.
OLED 0.96-inch Yellow-Blue Display		• Resolution: 128×64• I²C/SPI Interface• Low power consumption	Displays system status, alerts, and edge analytics in portable and embedded visual interfaces.
Hall Effect Sensor A44E		• Digital magnetic switch• 3.3–5V• Sensitive to magnetic field polarity	Detects magnetic field changes for rotation sensing in motor control and smart mechanical systems.
Camera Module		• CMOS camera (e.g., OV2640/OV5647)• Digital video output• Supports AI vision systems	Captures real-time image data enabling AI-powered vision analytics in industry automation and robotics.
Fingerprint Sensor 307		• UART Interface• Resolution: 500 dpi• Template storage: Up to 1000	Enables biometric identity authentication for secure access, attendance, and smart payment solutions.
Flame Sensor 4-Pin		• IR flame wavelength detection (760–1100 nm)• Analog/Digital Outputs• Adjustable sensitivity	Detects flame presence for fire-safety automation in industrial environments and smart buildings.

ENVIROMENTAL SENSOR			
Sensor Name	**Picture**	**Specification**	**Purpose**
BMP180/BME280 – Pressure, altitude, and temperature sensor.		BMP180: 300 – 1100 hPa BME280: 300 – 1100 hPa (±1 hPa accuracy) **Temperature Accuracy**: ±1°C **Humidity Accuracy**	High-quality environmental analytics → essential for weather prediction models

<table>
<tr>
<td></td>
<td></td>
<td>(BME280): ±3% RH
Communication: I2C/SPI
Operating Voltage: 1.8 – 3.6V
Altitude Resolution: ~1m</td>
<td>Pressure + humidity + temperature enable AI-driven forecasting

Used in air quality systems to normalize & calibrate gas sensor outputs

Compact, low-power → reliable for long-term smart city deployments</td>
</tr>
<tr>
<td>MQ Gas Sensors (MQ-3, MQ-4, MQ-5, MQ-7, MQ-9) – Detect gases like smoke, methane, carbon monoxide, etc.</td>
<td>  </td>
<td>
<table>
<tr><th>Sensor</th><th>Target Gas</th><th>Applications</th><th>Ra</th></tr>
<tr><td>MQ-3</td><td>Alcohol Vapor</td><td>Smart breath analyzer, industrial safety</td><td>0.05–10</td></tr>
<tr><td>MQ-4</td><td>Methane</td><td>Coal mines, pipelines, landfill monitoring</td><td>200–100</td></tr>
<tr><td>MQ-5</td><td>LPG, Natural Gas, H2</td><td>Refinery safety, leak detection</td><td>200–100</td></tr>
<tr><td>MQ-7</td><td>CO</td><td>Industrial combustion safety, boiler rooms</td><td>20–2000</td></tr>
<tr><td>MQ-9</td><td>CO + Flammable Gases</td><td>Dual safety monitoring</td><td>10–2000</td></tr>
</table>
</td>
<td>Enables AI-based leak detection and early warning systems

Highly sensitive → useful in predictive safety analytics

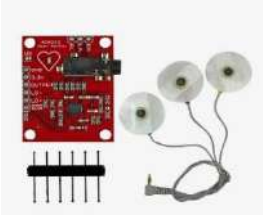
Supports data fusion with temperature/humidity sensors for improved accuracy

Cost-effective for distributed IoT networks in hazardous industries</td>
</tr>
</table>

Rain Drop Sensor – Detects the presence of rainwater.		Function: Detects raindrops through conductivity Output: Analog + Digital Voltage: 3.3V–5V	Useful for AI models in climate analytics and irrigation automation Supports autonomous decision-making (close windows, activate roof covers) Data improves crop protection, flood preparedness, and outdoor machine operation
UV Sensor (UV Index Sensor) – Measures UV radiation intensity.		Range: UVA/UVB Detection UV Index Output: 0–15 Accuracy: ±0.1–0.2 UVI Interface: Analog / I2C	Essential for AI-based human safety alerts (skin cancer risk, excessive UV exposure) Smart agriculture: controls sunlight exposure cycles Used in wildfire prediction models (UV & heat correlation)
Light Dependent Resistor (LDR) – Measures light intensity.		Function: Measures ambient light intensity Output: Analog voltage Response Time: <10ms Spectral Range: Visible light	Enables context-aware AI decision making: Auto-exposure adjustment for cameras (industrial vision systems)

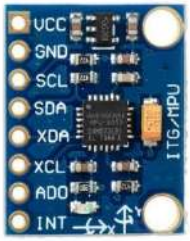
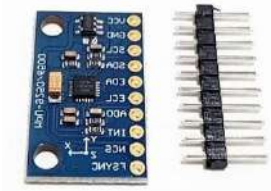
			Adaptive lighting in smart factories / greenhouses Cost-effective auxiliary data for deep-learning image pipelines
pH Sensor – Monitors acidity or alkalinity of liquids.		Measurement Range: pH 0–14 Accuracy: ±0.1 pH Temperature Compensation: Optional (required for high precision) Output: Analog or RS485 (for professional probes) Electrode Type: Glass / ISFET	Key parameter for AI process automation in: Water treatment plants Chemical & fertilizer industries Smart agriculture irrigation Input for predictive maintenance (corrosion, scaling, biomass growth) Works in digital twins of environmental systems

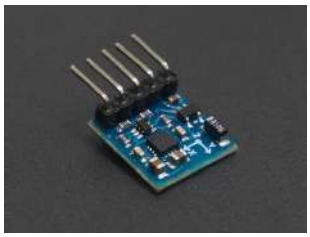
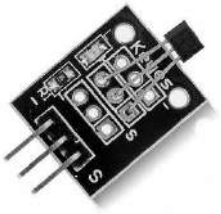
SMART AGRICULTURE SENSORS			
Sensor Name	**Picture**	**Specification**	**Purpose**
Leaf Wetness Sensor		• Sensing Principle: Resistive/Capacitive film• Output: Analog (0–3.0V / 0–5.0V)• Detection Range: Dry → Water film presence• Operating Voltage: 3.3V–5V• Weatherproof surface coating for outdoor use	Detects moisture on leaf surfaces to predict fungal disease risk and optimize irrigation.
NPK Sensor		• Measurement: Soil Nitrogen (N), Phosphorus (P), Potassium (K)• Interface: RS485 (Modbus RTU) / Analog• Supply Voltage: 5–30V• Waterproof Probe for soil insertion• Response Time: <1s	Measures essential soil nutrients (Nitrogen, Phosphorus, Potassium) to support precision fertilization.

HEALTH CARE & BIOMEDICAL SENSORS			
Sensor Name	**Picture**	**Specification**	**Justification / Reason**
ECG Sensor		• Type: Analog ECG acquisition module (e.g. AD8232 / ECG front-end) • Operating Voltage: 3.3V–5V • Output: Analog waveform + Heartbeat digital signal • Detection: Electrical activity of the heart • Electrode: 3-lead chest/limb patch connectors • Noise reduction with built-in filters • Mono-channel (single-lead) measurement	Provides high-fidelity cardiac electrical monitoring for medical IoT, tele-health, and AI-driven cardiovascular analysis in smart healthcare systems.

Body Temperature Sensor (MLX90614)		• Type: Infrared Thermometer Sensor • Measuring Range: −70°C to +380°C (object) • Accuracy: ±0.2°C (human body), typical clinical range • Interface: I2C digital output • Non-contact sensing technology • Supply Voltage: 3.3V–5V compatible • Built-in low-noise amplifier + 17-bit ADC	Enables precise, contactless human body temperature screening for clinical diagnostics, public safety, and intelligent health monitoring devices.

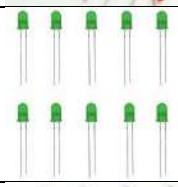
SENSORS FOR ENERGY MANAGEMENTS			
Sensor Name	**Picture**	**Specification**	**Justification / Reason**
Current Sensor (ACS712)		• Type: Hall-Effect Current Sensor • Measurement Range: ±5A / ±20A / ±30A variants • Output: Analog voltage proportional to current • Operating Voltage: 5V • Isolation: Yes (galvanic isolation from load) • Response Time: < 5 µs	Enables real-time current monitoring for intelligent load management, predictive maintenance, and electrical safety in smart energy systems.
Voltage Sensor		• Type: Resistive Divider Voltage Measurement Module • Operating Voltage: 3.3V–5V logic compatible • Measurement Range: Typically up to 25V DC • Output: Analog signal proportional to voltage • Compact module for system monitoring	Provides continuous voltage analysis for grid stability, equipment protection, and automated power regulation in industrial automation.
Power Meter Sensor (INA219)		• High-side current and voltage measurement • Interface: I2C Communication • Measures: Voltage + Current + Power + Energy • Operating Voltage: 3.0V–5.5V • Accuracy: 1% reading, factory calibrated • Max Bus Voltage: 26V	Measures voltage, current, and power consumption simultaneously, enabling precise energy analytics for Industry 4.0 and smart metering solutions.

SENSORS FOR AI-IOT CAPSTONE PROJECTS			
Sensor Name	**Picture**	**Specification**	**Justification / Reason**
Accelerometer (ADXL345)		• 3-Axis digital accelerometer • Range: ±2g/±4g/±8g/±16g • Interface: I2C or SPI • Resolution: 13-bit • Operating Voltage: 3.3V • Low power motion sensing	Enables multi-axis motion tracking for robotics, wearables, and smart mobility analytics, supporting intelligent control and real-world physical interaction.
Gyroscope (MPU6050)		• 3-Axis gyroscope + 3-Axis accelerometer (6-DoF) • Gyro Range: ±250/±500/±1000/±2000 °/s • Accel Range: ±2g/±4g/±8g/±16g • Interface: I2C • Built-in DMP motion processor • Operating Voltage: 3V–5V	Provides precise orientation and angular velocity tracking essential for autonomous navigation, self-balancing systems, and drone stabilization.
IMU Sensor (MPU9250)		• 9-Axis IMU (Accel + Gyro + Magnetometer) • Interface: I2C / SPI • Gyro Range: ±250 to ±2000 °/s • Accel Range: ±2g to ±16g • Magnetometer Range: ±4800 µT • Operating Voltage: 3.3V	Combines accelerometer, gyroscope, and magnetometer sensing to deliver full 9-DoF motion intelligence for advanced robotics and AR/VR applications.
Ultrasonic Sensor (HC-SR04)		• Distance Range: 2cm – 400cm • Accuracy: ±3mm • Ultrasonic Frequency: 40 kHz • Interface: Trigger + Echo pins • Operating Voltage: 5V • Non-contact sensing	Supports real-time distance measurement for object detection, autonomous navigation, and robotics obstacle avoidance in dynamic environments.

IR Proximity Sensor		• IR LED + IR receiver module • Adjustable range (potentiometer) • Output: Digital (Obstacle / No obstacle) • Operating Voltage: 3.3V–5V • Reflection-based detection	Enables proximity-based detection and automation for smart devices, industrial safety automation, and human-machine interaction.
TOF Sensor (Time-of-Flight)		• Laser-based distance measurement • Range: Up to ~200cm (model dependent) • Interface: I2C • High-accuracy short-range sensing • Low power optical system	Delivers high-accuracy distance mapping using light-based sensing for spatial awareness, gesture control, and precision robotics.
Magnetometer (HMC5883L)		• 3-Axis magnetic field sensor • Range: ±8 Gauss • Resolution: 12-bit • Interface: I2C • Operating Voltage: 3.3V–5V • Compass heading detection	Detects Earth's magnetic field direction for digital compass-like functionality in drones, robots, and autonomous vehicles.
Hall Effect Sensor		• Magnetic field detection • Output: Digital or Analog (model dependent) • Operating Voltage: 4.5V–24V • High-speed sensing • Non-contact rotation detection	Detects magnetic fields for rotation, speed, and positional sensing in motor control and smart electromechanical systems.

TOOLS AND ACCESSORIES			
Tools & Accessories	**Picture**	**Specification**	**Justification / Reason**

General Purpose PCB (6x4)		• Size: 6 inch × 4 inch (approx.) • Material: FR4 fiber sheet • Copper layer: Single-sided • Supports permanent soldered circuit assembly	Enables permanent soldered circuit development for deploying robust electronics in industrial-grade prototypes and field installations.
General Purpose PCB (4x4)		• Size: 4 inch × 4 inch • FR4 PCB board • Grid layout for soldered components • Suitable for compact electronic designs	Supports scalable circuit assembly for modular IoT hardware development and compact automation systems.
General Purpose PCB (3x2)		• Size: 3 inch × 2 inch • Single-side copper • Ideal for small embedded circuits • Prototype to product conversion	Provides compact prototyping capability for sensor modules and embedded system integration in real deployment scenarios.
Resistor Pack		• Multiple resistance values (Ω to MΩ range) • Tolerance: 1% or 5% depending on pack • Through-hole components • Used for current limiting and biasing	Offers essential components for precise current, voltage, and signal control enabling reliable operation of intelligent electronic systems.
Capacitor Pack		• Includes ceramic + electrolytic capacitors • Capacitance range: pF to µF • Through-hole type components • Used for filtering and timing circuits	Ensures stable power conditioning, filtering, and timing in advanced IoT and automation circuitry.
Connector (M2M)		• Male-to-Male jumper wires • Length: 10–30 cm (varies) • 2.54 mm pitch • Reusable prototyping wires	Enables secure interconnection of hardware modules for modular expandability and flexible circuit integration.
Connector (M2F)		• Male-to-Female jumper wires • Breadboard compatible • PVC insulation • 2.54 mm pitch	Provides versatile interfacing between PCB-mounted and breadboard components for fast prototyping transitions.

Connector (F2F)		• Female-to-Female jumper wires • Flexible stranded conductors • Standard 2.54 mm spacing • Suitable for module-to-module linking	Allows seamless connectivity between multiple embedded sub-systems without soldering constraints.
LED Pack (Red)		• 5mm through-hole LEDs • Forward Voltage: ~2V • High-brightness indicators • Current rating: 20 mA	Provides visual indication and UI feedback for process states, alerts, and real-time operational monitoring in embedded devices.
LED Pack (Green)		• 5mm LED indicators • Forward Voltage: ~2.1V • Standard 20 mA rating • Visual signaling applications	Enables system status signaling for automation states, communication activity, and control feedback in smart hardware.
LED Pack (Blue)		• 5mm blue LEDs • Forward Voltage: ~3V • Long life, high visibility • Current rating: 20 mA	Supports high-visibility system diagnostics for alerts, warnings, and advanced HMI design.
IC 555		• Timer/oscillator IC • Operating Voltage: 4.5–15V • Output drive: 200 mA • Used for PWM, delays, pulse generation	Provides precise timing and waveform generation functions essential for automation control and signal processing circuits.
IC 741		• General-purpose Op-Amp • Operating Voltage: ±5V to ±18V • Single or dual power supply • Analog amplification and filtering	Enables analog signal conditioning critical for sensors, control systems, and biomedical data processing.
IC 7805		• Linear Voltage Regulator • Output: +5V fixed • Max current: 1A (with heatsink) • Over-heat/short circuit protection	Ensures regulated power supply delivery for stable operation of microcontroller-based intelligent systems.
IC 7408		• Quad 2-input AND Gate • TTL logic family • Operating Voltage: 5V • Used for decision-making circuits	Enables logical decision-making in automation workflows requiring AND operations for safety and process validation.

IC 7400		• Quad 2-input NAND Gate • Standard TTL IC • Logic level operation at 5V • Basic digital logic building block	Supports core logic design in decision-making circuits for intelligent embedded applications.
IC 7432		• Quad 2-input OR Gate • 5V TTL compatible • High-speed switching • Boolean logic operations	Enables advanced signal processing in digital logic for automated industrial control and data routing.
IC 7402		• Quad 2-input NOR Gate • Standard 5V TTL logic • Low-power consumption • Fundamental logic processing	Provides logic inversion and control functions critical to reliable embedded system operation.
Wire Stripper		• Manual insulation removal tool • Supports multiple wire gauges • Anti-slip grip handle • Prevents conductor damage	Supports professional circuit development by ensuring clean and accurate wiring for robust embedded electronics.
Insulation Tape		• PVC electrical insulation • Flame-resistant material • Width: 1.5–2 cm (typical) • Prevents short circuits and shock	Enables electrical insulation and safety protection in prototype and industrial systems to prevent unintended short circuits.
Screwdriver Set		• Multi-bit toolkit • Magnetic tip (in most sets) • Precision screw handling • For hardware installation/maintenance	Essential hardware implementation tool for assembly, maintenance, and scalable installation of smart devices and IoT systems.