Project Title: Solar Motion-Sensing Lamp (IoT + Embedded + Renewable Energy)

Overview:

Designed and implemented a cost-effective, motion-activated solar lamp using an Arduino Nano, LiFePO4 battery, and PIR motion sensors. The system offers optimized power management with intelligent LED brightness control, leveraging solar energy to charge and power outdoor lighting efficiently.

Key Features:

- Microcontroller: Arduino Nano

- Motion Detection: PIR Sensor (5-8m range, 110 degrees angle)

- Battery: 12.8V, 6Ah LiFePO4 (76.8Wh capacity)

- Solar Panel: 20W, 12V Polycrystalline

- LED Control: MOSFET switching with PWM-based brightness modulation

- Enclosure: IP55-rated Plastic Enclosure (water and dust resistant)

- Charge Controller: 5A PWM (cost-effective and reliable)

Firmware Functionality:

- Interrupt-driven motion detection via PIR sensor

- Full brightness for 5 seconds on motion trigger

- Dim brightness for next 10 seconds

- Auto-off after 15 seconds of inactivity

- Efficient power usage for longer battery life

Testing & Validation:

- Motion detection verified under varying light and distances

- Solar charging tested under real sunlight conditions

- Rain and dust exposure tests for IP55 compliance

- Battery ran for 2+ nights on full charge

- Daily logging for performance metrics

Performance Metrics:

- Energy Requirement: ~24Wh/day

- Battery Life: 2000+ cycles

- Charging Time: ~1 sunny day (5.5h sunlight @ 20W panel)

- Operational Temp: -10 degreesC to 50 degreesC

Competitive Advantage:

- Superior LiFePO4 battery lifespan and safety

- Modular design for easy repair and upgrades

- 30% cheaper than similar commercial options

- Localized design optimized for Indian weather

Future Enhancements:

- Upgrade to MPPT controller

- Add IoT features (Bluetooth, remote monitoring)

- Expandable battery modules

Outcome:

Successfully demonstrated a reliable and affordable motion-sensing solar lighting solution, validated by a structured test plan and comparison with market alternatives. Delivered significant cost savings and enhanced environmental resilience.