Practical Robotics Projects with Arduino

(CSE 4571)

Lab Assignment No – 01

LED Blinking

Submission Date: 18/09/25

Branch: CSE		Section: 51
Name	**Registration No.**	**Signature**
Allampalli Ritikh	2241018124	ritikh

Department of Computer Science and Engineering
Institute of Technical Education and Research (Faculty of Engineering)
Siksha 'O' Anusandhan (Deemed to be University)
Bhubaneswar, Odisha-751030.

Answers to Pre-Lab Questions

① PinMode (Pin, input/output) sets a pin direction.
digitalWrite (Pin, HIGH/LOW) drives an output pin HIGH or LOW.

② It creates a visible ON/OFF pause. Without it the loop runs so fast, the LED seems constantly on or flikers imperceptibility

③ $\frac{1}{2}$ delay, (Change delay 1000 to delay 500) [Both on and off delay]

④ Wire each LED to 2 different digital pins. In code set LED1 as high and LED 2 Low, delay and invert.

⑤ Excess current flows through the LED pin. There might be LED damage or aurdino pin burnout.

⑥ Microcontroller is the brain of aurdino board. On aurdino arduino uno ATmega328P chip. It is responsible for :-

i) Running our sketch stored in its cache memory
ii) Handling digital input/output.
iii) Used for delays, counting events, etc.
iv) ATDC (Analog to Digital Converter): It converts analog signals into numbers which arduino can process.
v) UART: Serial Communication - copying through the moniter via serial computer

⑦ Digital Pins (0-13): Read, Write HIGH/LOW.
Analog Pins (A0-A5): Read voltages and can be used as digital pins if needed.

⑧ Each digital Pin I/O of arduino UNO can safely provide 20mA of current and maximum 40mA of current.

⑨

(9)

Uploading VIA USB	Uploading VIA Power Supply
• The USB cable connects arduino to the computer.	• It provides both power (5v) and a communication link.
• Through USB, the arduino IDE can upload sketches to ATmega328p micro controller via built in USB to serial	• Arduino UNO can also run from Barallel Jack, of 5v pin
• So USB is required to program the arduino.	• External supply is used when the board needs to work independently without being tethered to the computer. It cannot upload sketches only provide power to the board.
• Provides 5V from computer	• Provides 7 to 12 V (Regulated to 5V).

(10) The arduino UNO has a small onboard LED labelled L connected internally to digital pin 13 (through built in register). It is mainly used as status indicator and testing code efficiently.

(11) Robot is a programmable machine capable of sensing its environment processing information and performing action either autonomously or semi autonomously.
A simple automated machine follows predefined actions and cannot adapt to changes, whereas a robot can sense the environment, process or decide and perform actions accordingly.

(12) Sensing: Sensors collect information about the robot's environment and its own state (eg: cameras, touch sensors, LIDAR.).

Control: The control system (robot's brain) processes sensor data, makes decisions and sends commands (using microcontrollers, AI or algorithms).

Actuation: Actuators (robot's muscles) execute actions by moving parts or interacting with environment (eg: motors, grippers, wheels).

(13) It means that the robot behaviour can be modified without changing the hardware.

It is unethical because a single robot can perform various task just by updating the problem (flexibility).

Adaptability - Robots can be adjusted to work in

Cost Effectiveness - Instead of building new machines, reprogram allows reprogramming of hardware.

Intelligence - With programmability, a robot would behave like a simple machine with fixed action.

Answers to Pre-Lab Questions

(14) · Autonomous delivery robots by foot or by delivery bots
· Use blinking LED as status indicators. Green = Working
Blue = Waiting and Red = Error.
· Industrial robots: Robotic arms in factories
· Have indicators light that blink to show operation in progress, safety alert etc.

(15) An LED indicator works like a debugging tool in robotics helping engineer to trace program and perform programs flow and detect error quickly.

—x—

control?

9. How does the Arduino distinguish between different LED patterns in the sketch (e.g., sequential vs. random)?

C. **Robotics & System Understanding**

10. Why are blinking LEDs often used as a first step in learning robotics and embedded systems?

11. In what ways can LED indicators assist in debugging larger robotic systems?

12. If you were to expand this experiment into a real robotic system, how might LED patterns be used for status indication or fault detection?

ANS

A)

1) Using a global variable makes the code cleaner and easier to update. Without it, values are hardcoded and harder to change.

2) 25% → LED is dimmer and blinks quickly.
50% → Balanced brightness and timing
75% → LED stays on longer and appears brighter.

3) Without loop: More lines, repetitive code
With loop: Shorter, cleaner and easier to modify
For loop is more efficient

4) Reading input needs correct baud rate
Input must be converted from string to number.
Timing issues if input isn't entered clearly / quickly.

5) Basic Chaser: LED blink one by one
Custom LED Chaser: Use logic like random, reverse, alternate and smooth transition.

B)

6) Resistor limit the current flowing through LEDs. Without them, too much current can damage or burn out the LEDs and even harm the Arduino.

7) Digital pins send ON/OFF signals to each LED. By assigning each LED to a seperate pin, we can control them individually or in patterns using code.

8) PWM rapidly turns the LED on/off. The longer it's ON the brighter it looks.

Yes PWM also works for motor. controlling speed instead of brightness.

9) Each pattern is written as a seperate function in the sketch. The Arduino runs them one by one based on conditions (like random number or user input).

Eg: random () creates unpredictable patterns while for creates sequential ones.

10) . They are simple and visual making it easy if your code and hardware work.

. Help beginers learn digital output, timing and basic circuit setup.

. Great for building confidence before moving to motors, sensors or complex systems.

11) . Show power status (ON/OFF)

. Indicate if a sensor or motor is active

. Blink to show error codes, data flow or program steps

. Help locate issues without needing a screen or serial monitor.

12) Green blink = system OK

Red blink = fault detected.

Flashing sequence = battery low, sensor error or mode change

Custom patterns = show robot states like idle, moving, charging or warning.

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Lab Assignment No – 02

Push Button Control

Submission Date: 10/10/25

Branch: CSE		Section:
Name	**Registration No.**	**Signature**
Allampalli Ritikh	2241018124	ritikh

Department of Computer Science and Engineering
Institute of Technical Education and Research (Faculty of Engineering)
Siksha 'O' Anusandhan (Deemed to be University)
Bhubaneswar, Odisha-751030.

Answers to Pre-Lab Questions

① A push button is a simple mechanical switch that makes or breaks an electrical circuit when pressed. It is typically used for controlling electronic devices

② . Momentary Push Button: These button only stay in a particular state when pressed Eg: Doorbell button.

. Toggle Push: These button latch into a position.

③ The purpose is to use the push button as an input device to control electronic component such as LEDs or motors, based on the button state, pressed or released.

④ Pull-up resistors: Pulls the voltage to the high state when no button is pressed and read logic 1 in absence of input.

Pull-down resistors: Pulls the voltage to a low stage where no button is pressed and reads logic 0 when button is not pressed

⑤ Pull ~~down~~ up: One end of the push button is connected to ground and the other end is connected to the arduino pin with the internal or external pull up resistor.

Pull down: One end of the push button is connected to a 5 V and other end is connected to the arduino pin with pull down resistor of 2 gnd

6) External pullup resistor ensures that the input pin is in high state when the button is not pressed, preventing floating states.

7) PWM is a technique used to simulate analog output by varying the D.C of digital signal. For LEDs, PWM controls brightness by controlling how the led stays on vs off within a given time frame.

Answers to Pre-Lab Questions

③ Yes Pwm can control the brightness of other lights if the light electronic ~~setup~~ strip allows it. However for lamps, Pwm controller may cause flickering unless it is high enough for frequency.

Answers to Post-Lab Questions

① LOW, with a pullup, the pin is pulled to VCC (HIGH). When the button is not pressed and when pressed, connects the pin to the GND. which reads low.

② LOW, changing the pullup resistance doesn't change the logical result.

③ LOW, internal pullup behaves the same as the external pullup.

④ LOW, when pressed (if button wired to GND). However when not pressed. the pin will be floating unless you have an external pullup or pulldown.

⑤ With a pull down, the pin is held at GND (LOW) when not pressed and pressing connects the pin to VCC which reads HIGH.

⑥ Max Current = 20mA

F.V = 2V

P.S = 5V

$$\text{Brightness} = \frac{\text{P.S} - \text{F.V}}{I} = \frac{5-2}{0.02} = 150$$

⑦ Duty Cycle = 25%

R = 220Ω

V_{cc} = 5V

$\Rightarrow V = IR$

$$\Rightarrow I_{ON} = \frac{V}{R} = \frac{5-2}{220} = 13.6\text{ mA}$$

$I_{avg} = 0.25 \times 13.6$

$= 3.4$ mA

Practical Robotics Projects with Arduino

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Lab Assignment No – 03

Light & Sound Show

Submission Date: 25.10.25

Branch: CSE		**Section:**
Name	**Registration No.**	**Signature**
Allampalli Ritikh	2241018124	ritikh

Department of Computer Science and Engineering
Institute of Technical Education and Research (Faculty of Engineering)
Siksha 'O' Anusandhan (Deemed to be University)
Bhubaneswar, Odisha-751030.

Pre-Lab Questionnaire:

1) What is the purpose of the "analogRead" command in Arduino?
2) How can you convert analog voltage to voltage reading in volts using Arduino?
3) Can you use the "analogRead" command to measure digital signals?
4) What is the maximum analog voltage that can be read by the Arduino?
5) What is the range of values that the "analogRead" command can output on the Arduino platform?
6) What is the function of the map() function in Arduino?
7) What is the relationship between light intensity and the resistance of a photoresistor?
8) How can a photoresistor be used to measure changes in light intensity?
9) What is the resistance range of a typical photoresistor in bright light conditions?

ANSWERS

① It reads the analog input voltage applied to an analog pin and converts it into a digital value between 0 and 1023 using 10 bit ADC.

② $V = (ADC\ value \times V_{ref})/1023$

③ No, digital signals are read using digitalRead() [HIGH/LOW]. analogRead() is only for analog voltages that vary continously.

④ Maximum readable voltage by arduino is 5V.

⑤ Integer values from 0 to 1023.

⑥ It rescales one range of values to another
Eg) Converts the potentiometers 0 to 1023, range to an LED brightness range of 0 to 255.

⑦ The resistance of a LDR decreases as light intensity increases.

$$Resistance \propto \frac{1}{Light\ intensity}.$$

⑧ It forms part of a voltage divider circuit. The voltage across the LDR changes with light level, higher voltage in darkness, lo in bright light allowing measurement of light intensity.

) Usually between 1 kΩ and 5 kΩ

6) If the ADC value of a potentiometer is 256 and the reference voltage is 5V, what is the voltage reading in volts?

7) If the reference voltage is changed to 3.3V, what is the voltage reading in volts for an ADC value of 750?

8) If the ADC value of a potentiometer is 1023, what is the voltage reading in volts for a reference voltage of 5V?

9) What is the formula to convert ADC value to voltage reading in volts?

10) What is the resolution of the analog-to-digital converter (ADC) in the Arduino board?

11) How does the Arduino handle noisy analog signals?

12) How can you adjust the range of LED brightness values using the map() function?

Answers to Post-Lab Questions

(1) $V = \frac{\text{ADC Value} \times V_{ref}}{1023}$

$= \frac{512 \times 5}{1023} \approx 2.50\ V$

(2) As the resistance of second resistor increases, the voltage across it increases, hence analog voltage reading increases.

(3) By using the map function or scaling formula to convert the raw ADC value 0 to 1023 into a desired range.

(4) $V = \frac{1023 \times 5}{1023} = 5\ V$

(5) Maximum value of ADC is 1023.

$$V = \frac{265 \times 5}{1023} \approx 1.25\ V$$

$$\frac{750 \times 3.3}{1023} = 2.42\ V$$

(8) $$V = \frac{1023 \times 5}{1023} = 5\ V$$

(9) $$V = \frac{ADC_{value} \times V_{ref}}{1023}$$

(10) 10 bit resolution ie $2^{10} = 1024$ levels (0 to 1023)

(11)
- It averages multiple analog read samples.
- We can use capacitors or smoothing algorithm to reduce noise.
- Internal sample and hold circuits provide stable readings.

(12) By mapping the 10 bit ADC range (0 to 1023) to an 8 bit PWM range (0 to 255).

Eg:
```
Brightness = map(sensorValue, 0, 1023, 0, 255);
analogWrite(ledPin, brightness)
```

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Lab Assignment No – 04

ULTRASONIC & IR SENSING

Submission Date: 04/11/25

Branch: CSE		Section:
Name	**Registration No.**	**Signature**
Allampalli Ritikh	2241018124	ritikh

Department of Computer Science and Engineering
Institute of Technical Education and Research (Faculty of Engineering)
Siksha 'O' Anusandhan (Deemed to be University)
Bhubaneswar, Odisha-751030.

Pre-Lab Questions

1. What is the working principle of the HC-SR04 ultrasonic sensor for distance measurement?
2. Mention the function of Trigger pin and Echo pin in the HC-SR04 sensor.
3. Write the formula to calculate distance from the ultrasonic sensor using the speed of sound.
4. What is the typical range of distance measured by an HC-SR04 ultrasonic sensor?
5. What is the working principle of an Infrared (IR) sensor used for obstacle detection?
6. Differentiate between active IR sensor and passive IR sensor with examples.
7. State any two applications of ultrasonic sensors in real life.
8. Why is it necessary to use pinMode() and digitalWrite() functions in Arduino while interfacing sensors?
9. How does an IR sensor distinguish between the presence and absence of an obstacle?
10. Mention one key advantage and one limitation of ultrasonic sensors compared to IR sensors?

1) HC-SR04 emits sound waves from its transmitter. These waves hit an obstacle and reflect back to the receiver. By measuring the time taken for echo to return, the distance is measured using speed of sound.

2) Trigger Pin: Sends a short 10 µs (microseconds) pulse to start a measurement

Echo Pin: Receives the reflected signal and outputs a pulse whose duration corresponds to the time taken for echo to return.

3) Distance (in cm) = $\frac{\text{Time (µs)} \times 0.034}{2}$

4) 2 cm to 400 cm

5) An IR sensor has an IR led (transmitter) and a photodiode (receiver). When an obstacle deflects an emitted IR light, the sensor outputs a signal indicating an object presence.

⑥

ACTIVE	PASSIVE
• Emits and detects its own IR light reflection.	• Detects natural IR radiation from object.
• Obstacle sensor	• PIR motion detector.

⑦ i) Parking assistance and collision avoiding system.
ii) Liquid level and distance measurement in industrial automation.

⑧ • pinMode defines whether a pin acts as INPUT / OUTPUT
• digitalWrite sets or clears output pins to send control signal.

⑨ When an object is nearby, reflected IR light reaches the receiver that is LOW output (0V).
When no object is present, no reflection ie HIGH output (5V).

⑩ Advantages : Works reliably in dark or smokey environments (not affected by lightning).

Limitation: Performances can be affected by temperature, humidity or soft surfaces that absorb sound.

7. Why is it necessary to divide the total sound travel time by 2 in ultrasonic distance measurement?
8. What logic output does the IR obstacle sensor provide when an object is detected?
9. Mention one limitation of using only IR sensors for obstacle detection in mobile robots.
10. Suggest a practical application where both ultrasonic and IR sensors are used together for better performance.?

① If the trigger pin is not proper 10 µs, the sensor won't emit an ultrasonic burst properly so no echo signal will be received and no distance will be measured.

② Distance = $\frac{\text{Echo Time} \times \text{Speed of Sound}}{2}$

= $\frac{0.002\text{s} \times 343}{2}$ = 34.3 cm.

③ Because Ultrasonic sensors use soundwaves which are not affected by sunlight or ambient light intensity while IR sensor depend on light reflection that can be disturbed by sunlight.

④ Bright sunlight contains infrared radiations that can saturate the receiver causing false detection or making the IR sensor insensitive to nearby obstacle.

⑤
```
if (distance < 15) {
    digitalWrite (ledPin, HIGH);
} else {
    digitalWrite (ledPin, LOW);
}
```

The LED lights up when the obstacle closes upto 15 cm.

(6) Total time = $\frac{(2 \times \text{distance})}{\text{speed of sound}} = \frac{2 \times 2}{343} = 11.66$ ms

∴ Echo Pulse duration is 11.66 ms.

(7) Because the sound wave travels to the object and back so dividing by 2 gives 1 way distance from sensor to obstacle.

(8) When an object is detected, the sensor gives a LOW, 0V logic output.
When no object is detected, it gives a HIGH (5V) output.

(9) IR sensor perform poorly with dark, or transparent surfaces because such materials reflect very little light leading to inaccurate detection.

(10) In autonomous robots or smart vehicles combining ultrasonic and IR provides reliable obstacle avoidance in all lighting or surface condition.

Practical Robotics Projects with Arduino

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Lab Assignment No – 05

Temperature Monitoring

Submission Date: 10/11/25

Branch: CSE		**Section:**
Name	**Registration No.**	**Signature**
Allampalli Ritikh	2241018124	ritikh

Department of Computer Science and Engineering
Institute of Technical Education and Research (Faculty of Engineering)
Siksha 'O' Anusandhan (Deemed to be University)
Bhubaneswar

Pre-Lab Questions

1 What is the function of the Analog-to-Digital Converter (ADC) in Arduino Uno?
2 What is the range of digital values that the analogRead() function can output in Arduino Uno?
3 What is the voltage range that can be read by the Arduino Uno's ADC?
4 How is the analog voltage from the LM35 sensor related to temperature in degrees Celsius?
5 Write the formula used to convert the ADC reading from the LM35 sensor into temperature.
6 What type of signal does the DHT11 sensor provide to the Arduino — analog or digital?
7 Which library is used in Arduino to read data from the DHT11 sensor?
8 What parameters can be measured using the DHT11 sensor?
9 Why might temperature readings from the LM35 and DHT11 sensors differ slightly?
10 How can temperature readings from both LM35 and DHT11 be displayed on the Serial Monitor or LCD?

① The ADC in arduino UNO converts the analog input voltage into a digital value that the micro-controller can process.

② The analog read function outputs value ranging from 0-1023 corresponding to a 10 bit ADC resolution.

③ The arduino uno can read analog voltages in the range of 0-5V.

④ The LM135 sensor provides an output of 10mV per centigrade
Eg: 250mV corresponds to 25°C.

⑤ $T(°C) = \frac{(\text{Analog Value} * 5.0 * 100)}{1024}$

⑥ The DHT11 sensor provides a digital data signal to the arduino.

⑦ The DHT library #include <DHT.h> is used to read data from the DHT11 sensor.

⑧ The DHT11 sensors measure temperature and humidity.

⑨ The readings may differ due to sensor calibration, response time accuracy variation variables and environmental factors affecting each sensor differently.

⑩ By reading the data from both sensors in the arduino code and by using serial.print() or display it on a 16x2 I2C LCD

Answers to Post-Lab Questions

1. What is the significance of resolution in an Analog-to-Digital Converter, and how does it affect measurement accuracy in Arduino?
2. How does the reference voltage (Vref) influence the output of the ADC in Arduino Uno?
3. Explain the concept of sampling in ADCs and why sampling rate is important in data acquisition systems.
4. What are the advantages and disadvantages of using analog sensors like LM35 compared to digital sensors like DHT11?
5. How does noise affect analog readings in microcontroller-based systems, and what techniques can be used to reduce it?

① The resolution of an ADC determines how finely it can divide the input voltage ranges into digital steps :-

i) In arduino uno, the ADC is a 10 bit. meaning it can represent the analog voltage as 1024 discrete values.

ii) Higher resolution gives more precise and accurate reading.

② The reference voltage voltage sets the maximum measurable analog voltage for the ADC.

(i) The ADC compares the input voltages with Vref

(ii) If $V_{ref} = 5V$, an analog input of 5V corresponds to the max readings (1023).

(iii) Using a lower Vref increases sensitivity for smaller voltages improving accuracy for low voltage sensors.

(3) Sampling is the process of taking discrete voltage measurement at regular time intervals.

The sampling rate determines how frequently the signal is measured.

A higher sampling rate ensures accurate tracking of rapidly changing signals while a low sampling rate can cause distortion.

In temperature sensing, moderate sampling rates are sufficient because temperature change gradually.

(5) Noise introduces small fluctuations in analog readings causing unstable measurement.

Techniques to reduce noise.

- Use short, shielded wires and proper grounding.
- Take multiple reading and arrange them in code.
- Use software filters.

(4)

LM35	DHT 11
Advantages • Higher accuracy • Wider range	Advantages • Direct digital output • Stable reading.
Disadvantages • Noise sensitivity • Requires ADC.	Disadvantages • Lower accuracy • Limited range.