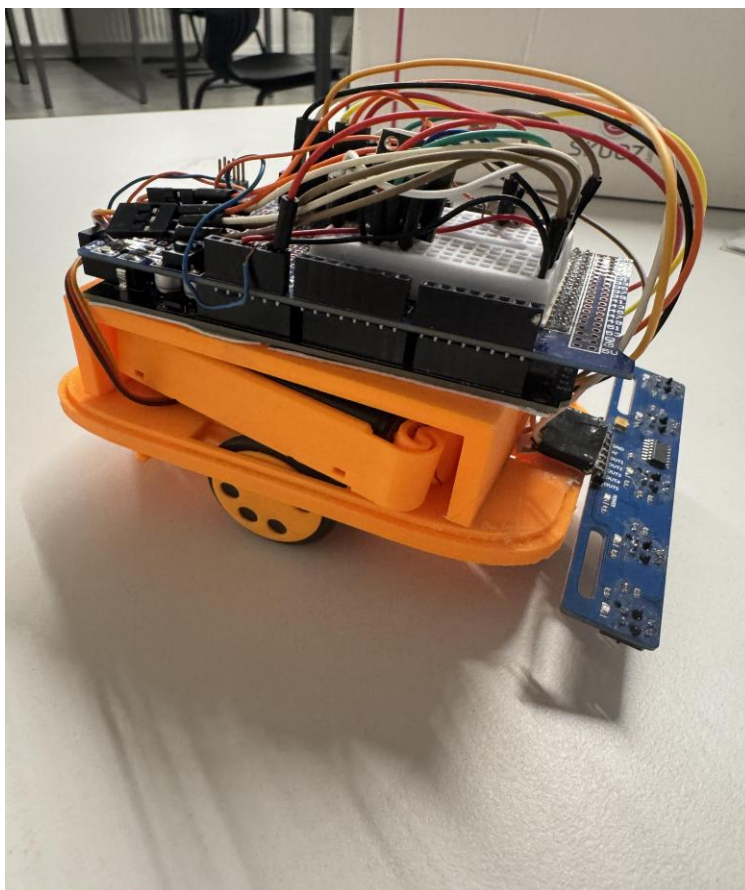




REMOTE WORKSHOP FOR PROGRAMMING

Arduino-Based Autonomous Robotics Systems Manual



Version_20251102

Student Name:

Delivery Date:



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1. CORE AREA

GENERAL/KNOWLEDGE:	Electronics, Mechatronics and Programming
PARTICULAR/ACTIVITIES:	Development of autonomous robotic systems using microcontrollers

2. LEVEL OF THE STUDENTS

European Qualifications Framework	(EQF 3-4)
National Qualifications Framework	(NQF 3-4)

3. . PREVIOUS KNOWLEDGE

In order to use the equipment available in this workshop, it is necessary to have some previous knowledge that will help to understand and carry out the proposed practices.

This previous knowledge includes:

1. Basic understanding of electronics (voltage, current, resistance)
2. Fundamentals of Arduino programming (C/C++ syntax)
3. Understanding of digital inputs and outputs
4. Basic knowledge of servo motor control using PWM signals
5. Understanding of sensor operation (IR sensors for line detection)
6. Ability to read and interpret wiring diagrams



It is proposed to carry out a questionnaire prior to accessing the workshop in order to have evidence that the user has sufficient knowledge to operate the autonomous robot.

4. DESCRIPTION OF THE WORKSHOP

4.1 System Overview

The autonomous line-following robot is an educational platform designed to demonstrate fundamental concepts in robotics, sensor integration, and programming. The robot autonomously navigates by following black lines on a light surface using infrared (IR) sensors.

4.2 Operating Principle

The robot operates using a simple yet effective algorithm:

1. The robot continuously monitors the IR line sensor array for black line detection
2. When no black line is detected, the robot rotates in place to search for a line
3. Once a black line is detected by the sensors, the robot moves forward following the line
4. When the line ends or is lost, the robot returns to the search mode (rotating)
5. This cycle repeats, allowing the robot to continuously track and follow any black line path

4.3 Hardware Components

Main Components:

1. Arduino MEGA 2560 - Main microcontroller board with prototype shield
2. 5-Channel IR Line Sensor Array - For detecting black lines on light surfaces
3. 2x Continuous Rotation Servo Motors (TS90D 9g) - For wheel propulsion
4. Piezo Buzzer/Speaker - For audio feedback and alerts
5. Battery Pack - Power supply located under the chassis wing
6. 3D Printed Chassis - Custom orange housing with two-layer design
7. Ball Caster Wheels - For stable three-point contact

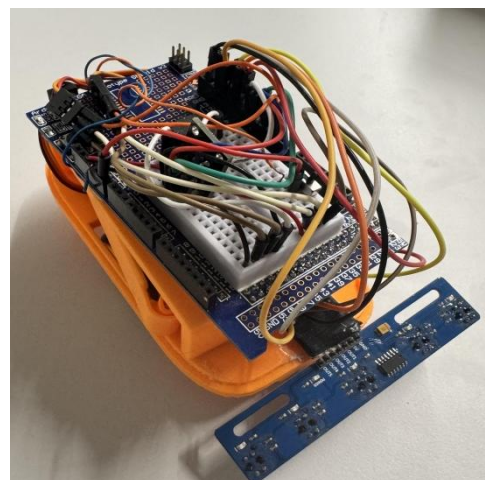


Figure 1: Electronics assembly with Arduino MEGA and breadboard

4.4 Physical Construction



Figure 2: Bottom view showing servo motors and line sensor array

The robot chassis is entirely 3D printed in orange PLA material, featuring a compact two-layer design. The lower layer houses the continuous rotation servo motors that drive the yellow wheels, while the upper layer contains the electronics including the Arduino MEGA, prototype shield with breadboard, and wiring connections.

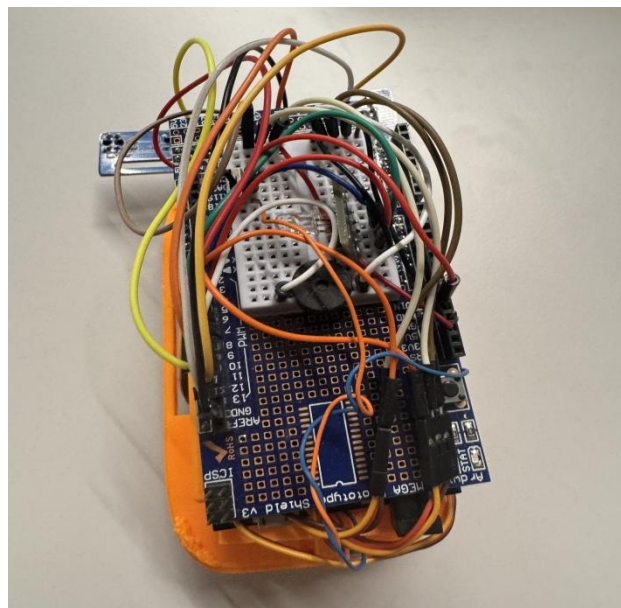
The 5-channel IR line sensor array is mounted at the front of the robot, positioned close to the ground for optimal line detection. Ball caster wheels at the front and rear provide stable three-point contact with the surface.

4.5 Electronics Assembly

Figure 3: Top view of electronics with Arduino MEGA and wiring

Key Electronic Features:

- Arduino MEGA provides ample I/O pins for all sensors and actuators
- Prototype shield allows for easy prototyping and modifications
- Mini breadboard enables component testing and buzzer integration
- Color-coded wiring for easy identification and troubleshooting



5. WIRING DIAGRAM AND CONNECTIONS

5.1 Pin Configuration

Component	Arduino Pin	Description
Left Servo	D9 (PWM)	Left wheel continuous rotation servo
Right Servo	D10 (PWM)	Right wheel continuous rotation servo
Buzzer	D8	Audio feedback speaker
Line Sensor OUT1	A0	Leftmost IR sensor
Line Sensor OUT2	A1	Left IR sensor
Line Sensor OUT3	A2	Center IR sensor
Line Sensor OUT4	A3	Right IR sensor
Line Sensor OUT5	A4	Rightmost IR sensor
Line Sensor VCC	5V	Sensor power supply
Line Sensor GND	GND	Ground connection

5.2 Power Connections

The robot is powered by a battery pack located under the wing section of the chassis. The servo motors require a separate power connection to handle the current requirements:

1. Battery positive (+) connects to Arduino VIN and servo power rail
2. Battery negative (-) connects to common ground (GND)
3. Servo signal wires connect to designated PWM pins
4. Line sensor powered from Arduino 5V regulated output

6. SAFE USE OF THE EQUIPMENT

The activities proposed in this workshop can be performed without direct physical supervision. However, the following safety guidelines must be observed:

- Ensure the battery is properly secured before operation
- Operate the robot on a flat, stable surface
- Keep fingers away from moving wheels during operation
- Disconnect power before making any wiring changes
- Use appropriate voltage levels (5V logic, compatible battery voltage)
- Do not expose electronics to water or excessive humidity

7. PROPOSED ACTIVITIES

The following activities are proposed for use with this workshop:

- a. Arduino IDE Setup and Communication: Install Arduino IDE, establish USB connection with Arduino MEGA, verify communication by uploading basic blink sketch.
- b. Servo Motor Control: Learn to control continuous rotation servo motors using the Servo library. Experiment with different speed values and directions.
- c. Line Sensor Calibration: Read and interpret values from the 5-channel IR line sensor array. Calibrate threshold values for line detection.
- d. Basic Line Following: Implement simple line following algorithm using center sensor only.
- e. Advanced Line Following: Implement multi-sensor line following with proportional control for smoother tracking.
- f. Sound Feedback Implementation: Program the buzzer to provide audio feedback for different robot states.
- g. Line Search Algorithm: Implement the rotating search behavior when line is lost.
- h. Complete System Integration: Combine all components into fully autonomous line-following robot.

8. SAMPLE CODE STRUCTURE

The following pseudocode outlines the basic algorithm implemented in the robot:

```
// Initialize components
setup():
    attach servo motors to pins 9 and 10
    configure sensor pins as inputs
    configure buzzer pin as output

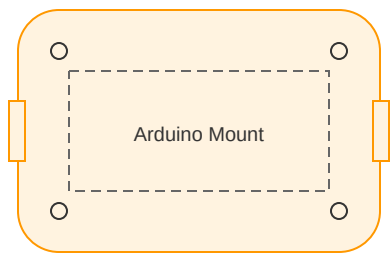
// Main loop
loop():
    read all sensor values

    if (black line detected):
        move forward following the line
        play short beep
    else:
        rotate in place to search for line
        play searching tone
```

9. TROUBLESHOOTING

Problem	Solution
Robot doesn't move	Check battery charge, verify servo connections, confirm code is uploaded
Robot spins continuously	Calibrate line sensor threshold values, ensure sensor is close to ground
Erratic movement	Check for loose wiring, verify servo center positions, clean sensor surface
Line not detected	Ensure sufficient contrast between line and surface, adjust sensor height
No sound from buzzer	Check buzzer polarity, verify pin connection, test with simple tone code

PART 1: TOP CHASSIS (Electronics Platform)



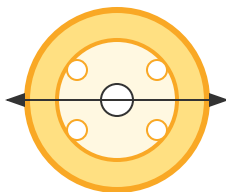
120 mm

Side View - Height: 15 mm

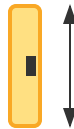
Specifications

Material: PLA
Color: Orange
Infill: 20%
Layer: 0.2mm
Walls: 3
Support: No

PART 3: DRIVE WHEELS (x2)



Ø 65 mm

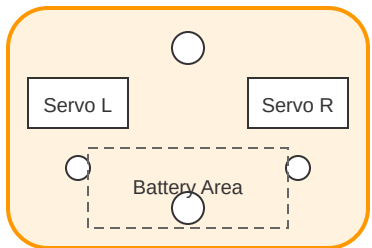


10 mm

Specifications

Material: PLA
Color: Yellow
Infill: 25%
Qty: 2

PART 2: BOTTOM CHASSIS (Motor Housing)



120 mm

Side View - Height: 35 mm

Specifications

Material: PLA
Color: Orange
Infill: 30%
Layer: 0.2mm
Walls: 4
Support: Yes

PART 4: LINE SENSOR MOUNT BRACKET



90 mm

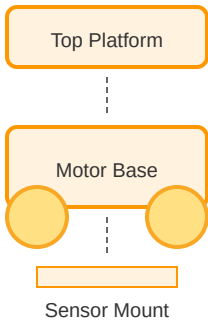


20 mm

Specifications

Material: PLA
Color: Orange
Infill: 20%
Support: No

ASSEMBLY VIEW - Exploded



1. Print all parts
2. Install servos in base
3. Attach wheels to servos
4. Mount Arduino on top
5. Connect platforms
6. Attach sensor bracket
7. Wire all components

BILL OF MATERIALS - 3D Printed Parts

Part	Qty	Material	Est. Time
Top Chassis	1	PLA Orange	2h 30min
Bottom Chassis	1	PLA Orange	4h 00min
Drive Wheel	2	PLA Yellow	1h 00min
Sensor Mount	1	PLA Orange	0h 45min

TOTAL PRINT TIME:

~8h 15min

RECOMMENDED PRINT SETTINGS

- Printer: Any FDM printer (Ender 3, Prusa, etc.)
- Nozzle: 0.4mm standard
- Layer Height: 0.2mm (quality) or 0.28mm (draft)
- Infill: 20-30% (gyroid or grid pattern)
- Walls: 3-4 perimeters for strength
- Supports: Only for bottom chassis (motor cutouts)
- Bed Adhesion: Brim recommended for chassis parts

STL FILE AVAILABILITY

The 3D printable STL files for all parts shown in this document are available upon request.

Files can be provided in the following formats: STL, OBJ, STEP, or native CAD formats.

Contact the workshop coordinator for access to the digital design files.

Note: Dimensions shown are approximate. Final dimensions may vary based on component specifications.

WIRING DIAGRAM - Line Following Robot

Arduino MEGA 2560 with Servo Motors, Line Sensor Array, and Buzzer

