Components used:

Arduino Uno
DC Motors (with sufficient torque)
Motor Driver (L293D)
Ultrasonic Sensor (for obstacle detection)
Hall-effect Sensor (for current sensing)
LEDs (to indicate status)
Breadboard and Wires

Circuit Design:

Arduino Uno: Place the Arduino Uno on the workspace.
DC Motors: Connect the motors to the motor driver.
Motor Driver (L293D): Connect the motor driver to the Arduino and the motors.
Ultrasonic Sensor: Connect the VCC and GND to the power rails, and the Trig and Echo pins to digital pins on the Arduino.
Hall-effect Sensor: Connect the sensor to the Arduino for current sensing.
LEDs: Connect LEDs to digital pins with appropriate resistors.
Power Supply: Ensure all components are properly powered.

SAMPLE CODE

```
// Sample Arduino Code
const int trigPin = 9;
const int echoPin = 10;
const int ledPin = 13;
const int voltagePin = A0;

void setup() {
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
  pinMode(ledPin, OUTPUT);
  Serial.begin(9600);
}
```

```
void loop() {
  // Ultrasonic Sensor
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  long duration = pulseIn(echoPin, HIGH);
  int distance = duration * 0.034 / 2;
  Serial.print("Distance: ");
  Serial.println(distance);

  // Voltage Sensor
  int voltageValue = analogRead(voltagePin);
  float voltage = voltageValue * (5.0 / 1023.0);
  Serial.print("Voltage: ");
  Serial.println(voltage);

  // LED Indicator
  if (distance < 20 || voltage < 3.0) {
    digitalWrite(ledPin, HIGH);
  } else {
    digitalWrite(ledPin, LOW);
  }

  delay(1000);
}
```

1. Power Requirements

Components:

Arduino Uno: 5V, 40mA per I/O pin
DC Motors: 12V, 1.5A each (assuming 2 motors)
Ultrasonic Sensor: 5V, 15mA
Hall-effect Sensor: 5V, 10mA

LEDs: 5V, 20mA each (assuming 2 LEDs)

Total Power Consumption:
Arduino Uno: 5V * 40mA = 0.2W
DC Motors: 12V * 1.5A * 2 = 36W
Ultrasonic Sensor: 5V * 15mA = 0.075W
Hall-effect Sensor: 5V * 10mA = 0.05W
LEDs: 5V * 20mA * 2 = 0.2W
Total Power Consumption = 0.2W + 36W + 0.075W + 0.05W + 0.2W = 36.525W

2. Battery Selection

Battery Type:
LiPo Battery: Commonly used for robotics due to high energy density and discharge rates.
Battery Capacity Calculation:
Total Power Consumption: 36.525W
Operating Voltage: 12V (to match the motors)
Current Draw = Total Power / Operating Voltage = 36.525W / 12V = 3.044A

Assuming the robot needs to run for 1 hour: Battery Capacity = Current Draw * Time = 3.044A * 1h = 3.044Ah

To account for inefficiencies and safety margin, choose a battery with at least 20% higher capacity: Required Battery Capacity = 3.044Ah * 1.2 ≈ 3.65Ah

3. Peak Current and Wire Gauge

Peak Current:
DC Motors: 1.5A each
Total Peak Current: 1.5A * 2 = 3A
Wire Gauge Calculation:

For a peak current of 3A, a wire gauge of 22 AWG is typically sufficient for short distances (less than 1 meter).

4. PCB Design Considerations

Track Thickness:
For high-current paths (3A), use thicker tracks.
Using a PCB trace width calculator, for a 3A current and 1oz copper thickness, the recommended trace width is approximately 1.5mm.

Summary of Calculations

Parameter –Value
Total Power Consumption –-36.525W
Operating Voltage –12V
Current Draw –3.044A
Required Battery Capacity –3.65Ah
Peak Current –3A
Recommended Wire Gauge –22 AWG
Recommended Track Width –1.5mm

Component Table

Component Name	Component Justification	Component Power/Specification
Arduino Uno	Main microcontroller	5V, 40mA per I/O pin
DC Motor	Provides movement	12V, 1.5A
L293D Motor Driver	Controls motors	5V logic, 12V motor supply
Ultrasonic Sensor	Obstacle detection	5V, 15mA
Hall-effect Sensor	Current sensing	5V, 10mA

DETAILED CODE FOR ARDUINO

```
// Define pins for ultrasonic sensor
const int trigPin = 9;
const int echoPin = 10;

// Define pins for motor driver
const int motorPin1 = 3;
const int motorPin2 = 4;

// Define pin for Hall-effect sensor
const int hallEffectPin = A0;

// Define pin for LED indicator
const int ledPin = 13;

void setup() {
  // Set up ultrasonic sensor pins
```

```
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);

  // Set up motor driver pins
  pinMode(motorPin1, OUTPUT);
  pinMode(motorPin2, OUTPUT);

  // Set up LED pin
  pinMode(ledPin, OUTPUT);

  // Initialize serial communication for debugging
  Serial.begin(9600);
}

void loop() {
  // Measure distance using ultrasonic sensor
  digitalWrite(trigPin, LOW); // Ensure trigger pin is low
  delayMicroseconds(2); // Wait for 2 microseconds
  digitalWrite(trigPin, HIGH); // Send a 10 microsecond pulse to trigger
pin
  delayMicroseconds(10); // Wait for 10 microseconds
  digitalWrite(trigPin, LOW); // Set trigger pin low again

  // Read the echo pin and calculate distance
  long duration = pulseIn(echoPin, HIGH); // Measure the time for echo
  int distance = duration * 0.034 / 2; // Convert time to distance
  Serial.print("Distance: ");
  Serial.println(distance); // Print distance to serial monitor

  // Measure current using Hall-effect sensor
  int currentValue = analogRead(hallEffectPin); // Read analog value from
sensor
  float current = currentValue * (5.0 / 1023.0); // Convert analog value to
voltage
  Serial.print("Current: ");
  Serial.println(current); // Print current to serial monitor

  // Control motors based on distance
```

```
  if (distance < 20) { // If an obstacle is detected within 20 cm
    digitalWrite(motorPin1, LOW); // Stop motor 1
    digitalWrite(motorPin2, LOW); // Stop motor 2
    digitalWrite(ledPin, HIGH); // Turn on LED indicator
  } else {
    digitalWrite(motorPin1, HIGH); // Move motor 1 forward
    digitalWrite(motorPin2, LOW); // Move motor 2 backward
    digitalWrite(ledPin, LOW); // Turn off LED indicator
  }

  delay(1000); // Wait for 1 second before repeating the loop
}
```