Front Loaders In Action

InvisaTrax™ Transport System

InvisaTrax™ Components List

Quantity	Component Name
2	90° Motor Turns w/60 RPM motors mounted[1]
2	Motor Turn Gears
4	14 Unit Track Pieces
2	8 Unit Track Pieces
2	4 Unit Track Pieces
98	Chain Links (8 - 3mm RND, 8 - 3mm Cube)
8	3mm x 3mm Round Magnets - Chain
8	3mm x 3mm Cube Magnets - Chain
6	3mm x 3mm Round Magnets - Front Loaders
8	2mm x 0.5mm Round Magnets - Front Loaders
4	Brass Sliders
1	DC Motor Controller (used for manual testing)
1	Power Supply (battery or 6V DC Adapter)

1 - This assumes that the wires have already been soldered to the motor. See the InvisaTrax™ Transport System Instructions for details.

Additional Materials Used

Material Name & Description

1 in. x 2 ft. x 2 ft. Rigid Foam Board Insulation

20 x 30 x 3/16 in. Foam Board

92 lb 19.5 x 25.5in Fine Grain Craft Paper - Light Brown

Polycarbonate Sheet (0.010" thick)

#18 x 5/8” Wire Nails

Double-Sided Tape

Spray Adhesive

Scrap Foam Board Insulation

Baking Soda

Liquid Superglue

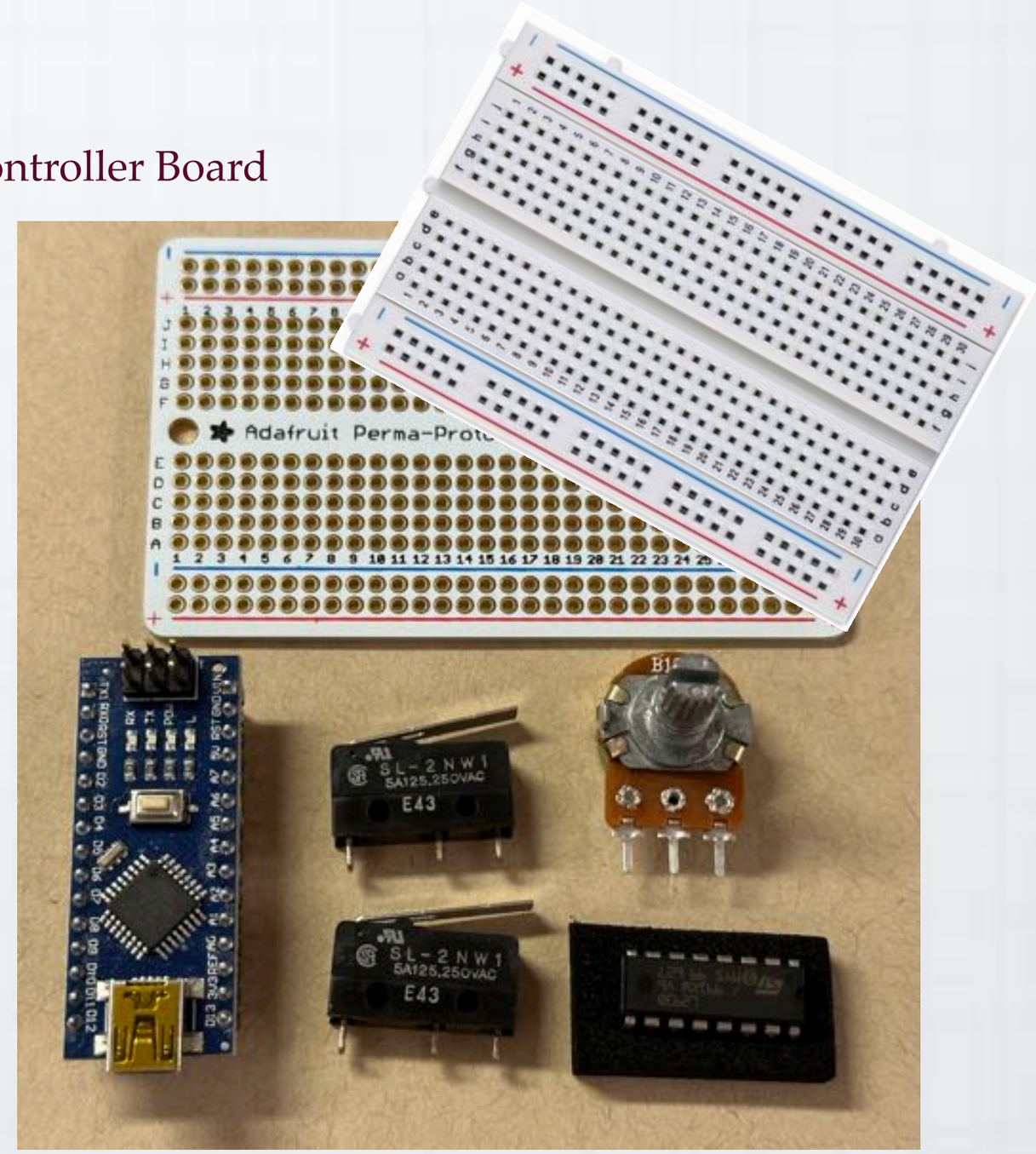
White Glue

Dirt (gathered from the yard)

Ertl® Front Loader (x2)

Electronic Components Used

Quantity	Name & Description
1	Arduino Nano ATmega328P Micro-Controller Board
1	L293D H-Bridge Motor Driver
1	10K Ohm Potentiometer
2	Momentary Switch - Lever Style
1	Solderless Breadboard or PCB Board
As Needed	Jumper Wires or 22 AWG Solid Core Hookup Wire



Tools Used

Tool Name & Description

Box Cutter (to cut foam board)

3/4" Forstner Bit (to drill hole for motor)

Double-ended Screw Driver: Flat & Philips Head

Tack Hammer

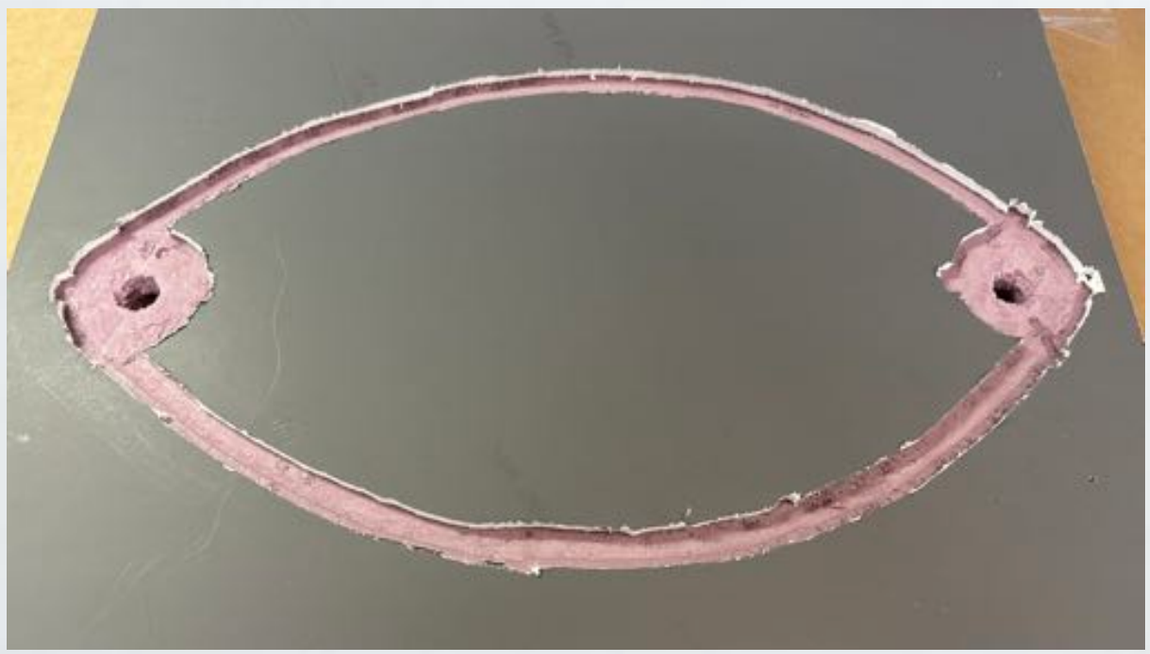
Dremel® Rotary Tool with Router Attachment

1/4" Dremel® Router Bit

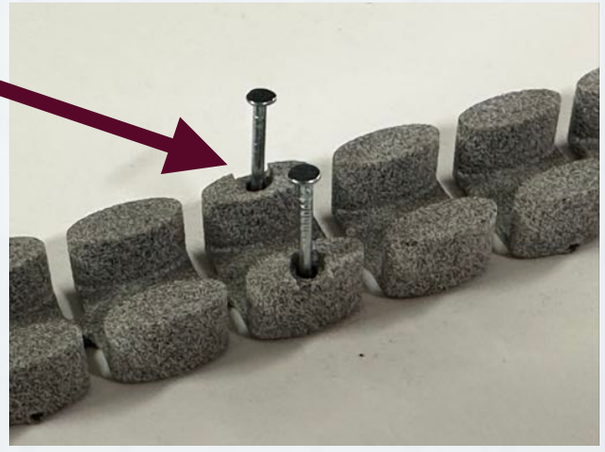
Foam Cutter/Electric Hot Knife

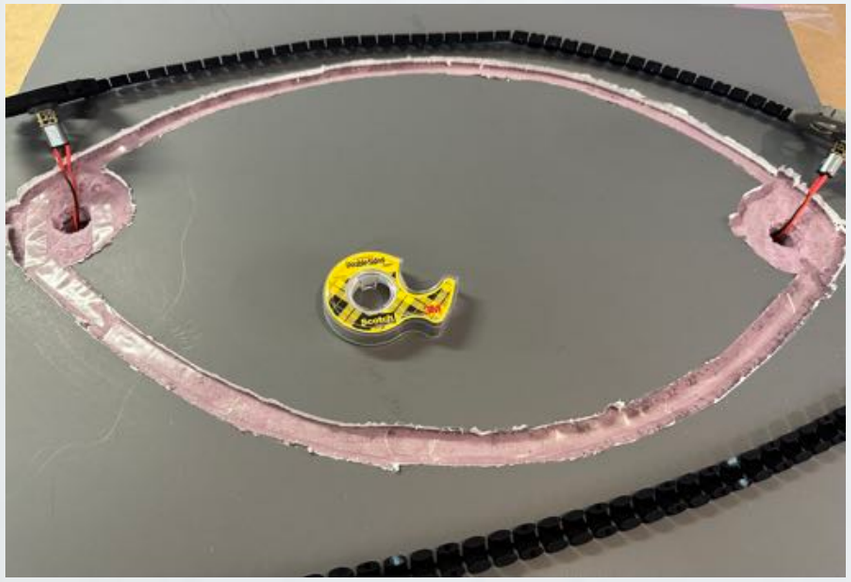
The Process

- Cut and glue the Foam Board to the Foam Board Insulation.
- Plan the layout and mark the locations of key items on the Foam Board.
- Lay the InvisaTrax™ track segments for the desired path. Trace around the outside of the track segments to use as a guide for routing a channel for the track.
- Mark where the motor turns will be placed and drill holes to house the motors.
- Use the Dremel® Rotary Tool to route the channel where the track will be placed. Set the router height to match the track height (7.5mm).
- Assemble and test fit the track and turns. Make any needed adjustments to the routed area.

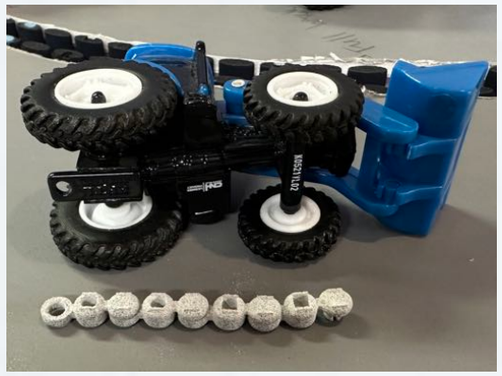


- Mount the track to the foam boards by placing the track pieces in the routed channel. Line the channel with double-sided tape for extra hold. Add a few wire nails to the track; place in the openings located in the sides of the track sections. Tap with a hammer or push with the flat blade of a screwdriver.





- Plan ahead for expansion and for running different vehicles. Measure out the number of chain links required to drive each type of vehicle.



Vehicle No. 1

Vehicle No. 2

- Create two sets of chain links with magnets inserted to accommodate both machines.

Four (4) 3mm x 3mm Round Magnets

Four (4) 3mm x 3mm Square Magnets

Note: the 3mm x 3mm square magnets are stronger than their round counter part. Use them at each end of the chain section to keep the larger, heavier vehicle on its path.

See the InvisaTrax™ Transport System Instructions for details on mounting the magnets.

- Superglue two (2) 2mm x 0.5mm round magnets to each brass slider.

- Bend the ends of the brass slider up and place them under the front loader. Adjust the height of the brass ends so they touch the underside of the front loader where they will be attached.

It is very important to get the height just right. Place a piece of heavy paper or card stock under the magnets. Use this as a spacer for attaching the magnets to the vehicle. This sets the magnets close to the ground but not touching it. Thus allowing for the wheels of the front loader to roll over the surface of the diorama. If the magnets are too close and touching the ground, they will slide over the ground but the wheels on the front loader will not rotate.

The brass ends can be cut, but bending the tips allows for easier adjustment and recovery if the measurements are wrong. Having the bent ends also provides a larger surface area for gluing to the chassis.

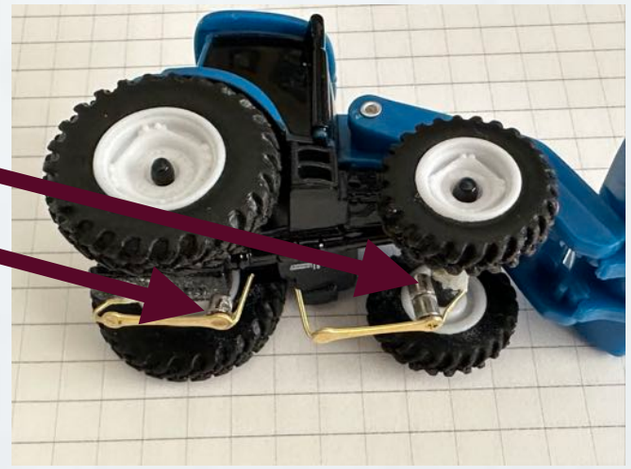
- Place the previously constructed chain links under the front loader; align the brass sliders mating them with the installed chain magnets. Mark where the brass sliders need to be attached to the chassis.

See the InvisaTrax™ Transport System Instructions for details on mounting the magnets.

- Use the liquid superglue and baking soda to attach the brass sliders to the underside of the front loader.

  Glue just the outside ends of each brass slider to the chassis, leaving the middle ends loose to allow for adjustment, if needed, to properly mate with the chain magnets.

- Place two (2) 3mm x 3mm round magnets on the front brass slider on the front 2mm magnet. Place one (1) 3mm x 3mm round magnet on the rear brass slider on the front 2mm magnet.



Note: This is just one method of mounting the magnets to a vehicle. The magnets can be mounted directly to the underside if the clearance allows. Holes can be drilled in the underside of the vehicle and the ends of the brass sliders inserted and superglued. The brass slider ends can also be bent around areas on the undercarriage. The most important aspect of mounting the magnets is getting the distance from the ground correct.

This combination of magnet sizes and location is just one possible solution for proper operation. Other combinations and placements of varying magnet sizes may also work. It is recommended to try various possible solutions to arrive at the one that works best with the vehicles being used.

See the InvisaTrax™ Transport System Instructions for details on mounting the magnets.

- Determine the path and the distance each vehicle will need to move to achieve the forward and reverse action. Mark those areas and lay the chain links with the magnets in place.

- Assemble the remaining chain links keeping the ones with the magnets in the designated area.
- Attach the motors and power to the DC motor controller and manually test the setup. Run the system at all speeds and both directions. The layout can be tested with vehicles at this stage.
- Cover the layout with the Polycarbonate sheet and attach using double-sided tape or spray adhesive. Be careful not to get adhesive on the track, chains, or turns.
- Test the system again with and without the vehicles. Be sure the chain is moving freely and the front loaders moving smoothly.

See the InvisaTrax™ Transport System Instructions for details on connecting motors to the controller.

- Cover the polycarbonate film with the light brown paper. Use spray adhesive to attach.

- Use the Magnetic Field Viewer to locate the chain links with magnets. Either move the viewer over the area where the track is located or place the viewer over the track and run the system until the magnetic fields appear.

- Place the front loaders on the track and manually test the system again. Make any needed adjustments to the magnets on the vehicles. Whether that be height or position over the chain link magnets.

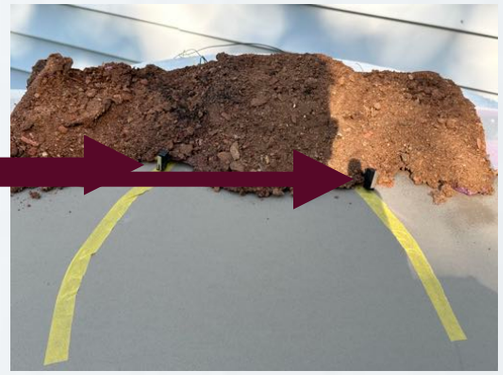
- Reposition the chain segments so they are located in the position previously marked as the travel path of the front loaders.

- Mark the travel path of the front loaders on the brown paper. One method is to attach a piece of pencil lead to the front loader and turn on the system. The lead will leave a light line where the front loader traveled.

- Create a pile of dirt, glue scrap pieces of foam insulation board together and cut (with hot foam knife) and/or melt with acetone. This will create a more realistic base to glue the dirt.
- Place the sculpted dirt pile on the base making sure it fits on the base and works well with the travel path of the front loaders.

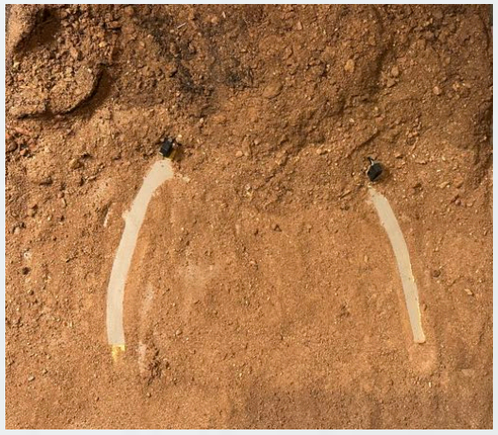
- Spray or brush diluted white glue over the dirt pile foundation and cover with dirt; either real dirt or artificial ground turf.
- Use thin tape to cover the area where the brass slider will travel using the guide lines previously drawn.
- Place the dirt pile on the base making sure it looks and feels good.

- Mount the switches to the base at the edge of the dirt pile making sure the front loaders can actuate them. Run the wires under the pile of dirt.
- Glue the pile of dirt to the base. The dirt pile can also be nailed to the base.



- Manually test the system to confirm the travel distance of the front loaders and that the front loaders can press the switches. Note: the switches are not active yet; this is just to test the front loaders switch pressing capability.

- Glue dirt to the rest of the base using diluted white glue. Try not to get dirt on the tape markers and make sure the dirt is thin where the front loader tires will roll.
- Remove the marking tape leaving a clean area where the brass sliders will travel. A very, very thin layer of dirt can be located here as long as the brass slider can move over it smoothly.



- Manually test the system again. Make sure the front loader tires roll easily over the dirt and that the brass sliders do not get caught on any dirt or debris in their path.
- Make any adjustments necessary for a smooth operation.

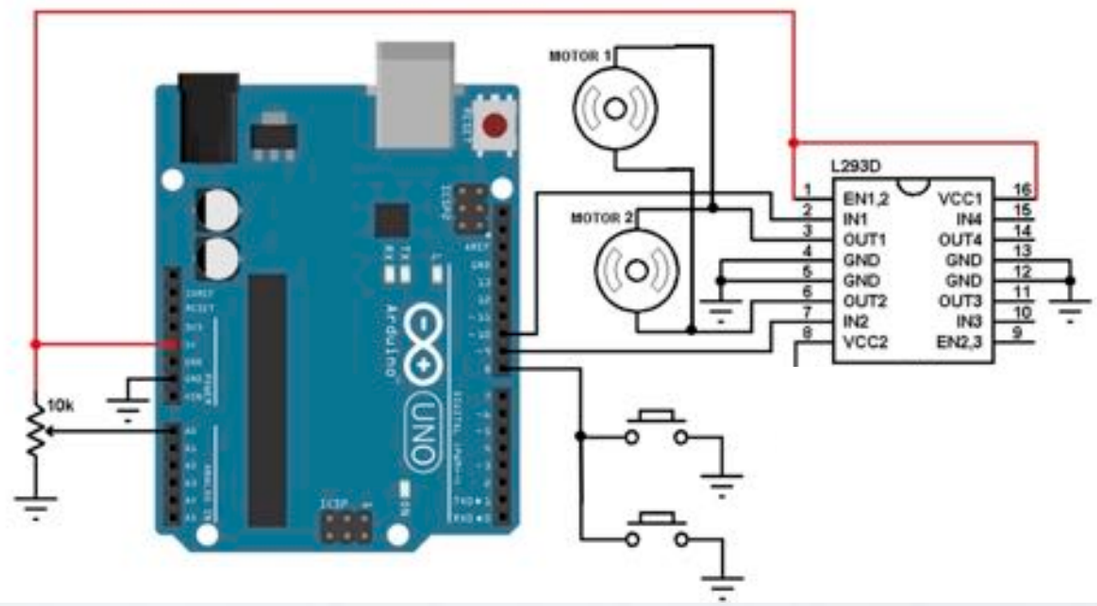
The following is just one possible Arduino motor control circuit and sketch.

The function of this circuit and sketch is to move the front loaders and when one of the switches is triggered, reverse the direction of the motors. Thus providing forward and reverse motion for both vehicles.

- Breadboard and test the Arduino Nano control circuit and program sketch.
- Once finalized and working, create a more permanent circuit by mounting and soldering all components to a PCB board.
- Test to make sure all solder joints are good, connections are correct, and wires are not crossed.
- Test the control system and vehicle placement making sure all functions operate as desired and the travel distances for the front loaders is correct.

Arduino DC motor control circuit:

Project circuit schematic diagram is the one below.



The speed of the DC motor (both directions) is controlled with the 10k potentiometer which is connected to analog channel 0 (A0) and the direction of rotation is controlled with the push button which is connected to pin 8 of the Arduino UNO board. If the button is pressed the motor will change its direction directly.

The L293D driver has 2 VCCs: VCC1 is +5V and VCC2 is +12V (same as motor nominal voltage). Pins IN1 and IN2 are the control pins where:

IN1	IN2	Function
L	H	Direction 1
H	L	Direction 2
L	L	Fast motor stop
H	H	Fast motor stop

As shown in the circuit diagram we need only 3 Arduino terminal pins, pin 8 is for the push button which toggles the motor direction of rotation. Pins 9 and 10 are PWM signal outputs, at any time there is only 1 active PWM, this allows us to control the direction as well as the speed by varying the duty cycle of the PWM signal. The active PWM pin decides the motor direction of rotation (one at a time, the other output is logic 0).

```ino
// Arduino DC motor speed and direction control

#define button   8
#define pot      0
#define pwm1     9
#define pwm2    10

boolean motor_dir = 0;
int motor_speed;

void setup() {
  pinMode(button, INPUT_PULLUP);
  pinMode(pwm1,   OUTPUT);
  pinMode(pwm2,   OUTPUT);
}

void loop() {
  motor_speed = analogRead(pot) / 4;
  if(motor_dir)
    analogWrite(pwm1, motor_speed);
  else
    analogWrite(pwm2, motor_speed);
  if(!digitalRead(button)){                  // If direction button is pressed
    while(!digitalRead(button));             // Wait until direction button released
    motor_dir = !motor_dir;                  // Toggle direction variable
    if(motor_dir)
      digitalWrite(pwm2, 0);
    else
      digitalWrite(pwm1, 0);
  }
}
```

Proudly Display the Results

https://youtu.be/d7pGK5mzwMc?si=ACYwOaiEM-lH2eMB