CEC Continuing Education Center

DesignNews

Modeling Robot Kinematics using Python and AI

DAY 3: Using an AI LLM to Provide Testing Code for a Robot Servo Motor

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Webinar Logistics

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- Participate in ‘Attendee Chat’ by maximizing the chat widget in your dock.

Dr. Don Wilcher

Visit ‘Lecturer Profile’ in your console for more details.

Course Kit and Materials

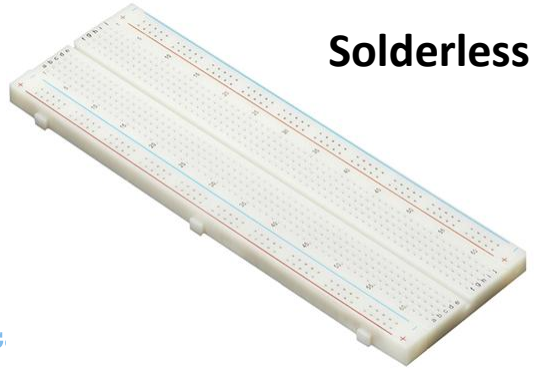
Adeept 5-DOF Robot Arm Kit

ESP32-DEVKITC-VIE

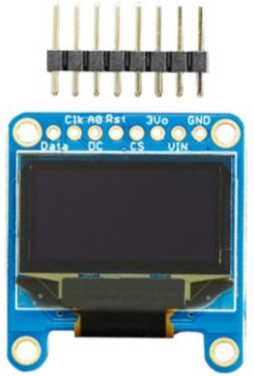
9G SERVO MOTOR KIT 180DEG

Adafruit Parts Pal Kit

Solderless Breadboard x2



OLED Display

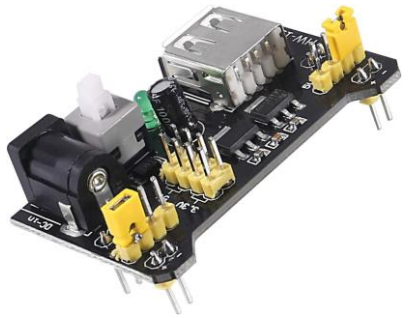


Course Kit and Materials

Jumper Wires: Male to Male

Jumper Wires: Male to Female

Solderless Breadboard Power Supply



18650 Rechargeable Battery

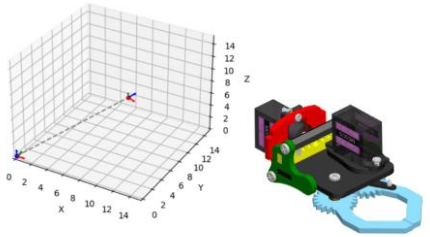
Research Perspective

- “Robotics is the art, knowledge base, and know-how of designing, and applying, and using robots in human endeavors (Niku, 2020).”
- “Using matrices, we first establish a method of describing objects, locations, orientations, and movements (Niku, 2020).”

Agenda:

- AI LLMs: Definitions and Research Perspectives
- Gemini Robotics: AI and Kinematics Use Cases
- Lab: Build a ESP32 DC Servo Motor Controller

AI LLMs: Definitions and Research Perspectives



"In the evolving landscape, the integration of Artificial Intelligence (AI) represents a transformative shift, stipulating a new era in learning" (Walter, 2024).

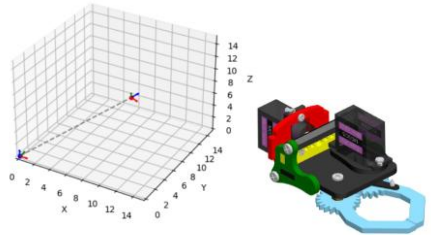
AI chatbots (Walter, 2024)

a) Chatbots known as AI are software applications designed to interact with humans through spoken or written language.

b) The rapid evolution of chatbot technology has been fueled by:
   i. Significant advancements in Natural Language Processing (NLP).
   ii. Machine Learning (ML).

c) As a branch of AI, NLP empowers machines to effectively analyze and comprehend human language.

AI LLMs: Definitions and Research Perspectives. . .



The emergence of Large Language Models (LLMs) contributed to the growing popularity of NLPs based on

a) exhibiting the capability to analyze data.
b) processing extensive text data.

Promoting uses of AI in engineering courses (Bravo et al., 2024)

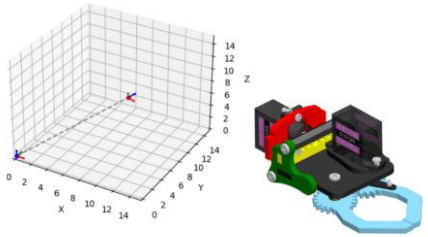
a) Assist learners with prior experience in programming and syntax in the C-Language.
b) Quickly generate example codes for programming the Arduino Uno.
c) Guide understanding the rules of Boolean Algebra.
d) Generate example code for microcontroller programming.

Question 1

Which statement is false?

a) Chatbots are known as AI software applications.
b) Natural Logic Process powers chatbot technology.
c) AI and NLP empower machines to analyze and comprehend human language.
d) none of the above

Gemini Robotics: An AI and Kinematics Use Case

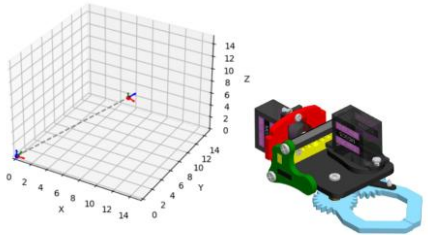


Google DeepMind – Gemini Robotics Purpose:

" Gemini Robotics brings Gemini AI capacity for multimodal reasoning and world understanding into the physical world – allowing robots of any shape and size to perform a wide range of real-tasks".

- Gemini Robotics is a universal AI platform that allows embodied intelligence using physical robots.
- The Gemini Robotics platform focuses on enhancing a robot's spatial understanding.
- Spatial understanding requires precise manipulation which aligns with kinematics.

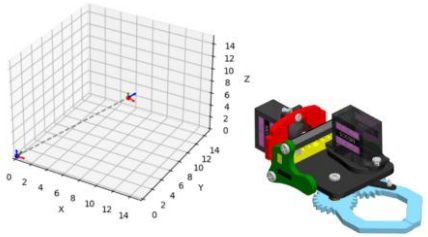
Gemini Robotics: An AI and Kinematics Use Case. . .



Kinematic Basics:

- Kinematics is the branch of mechanics that deals with the motion of objects without considering the forces that cause that motion.
- In robotics, kinematics focuses on the position, velocity, and acceleration of a robot's joints and end-effector (the "hand" of the robot).
- Precise manipulation requires very accurate control of a robot's movements. This control is achieved through kinematic calculations.
- **Forward kinematics:** Determines the position and orientation of the end-effector based on the joint angles.
- **Inverse kinematics**: Determines the required joint angles to achieve a desired end-effector position and orientation. This is crucial for precise manipulation.

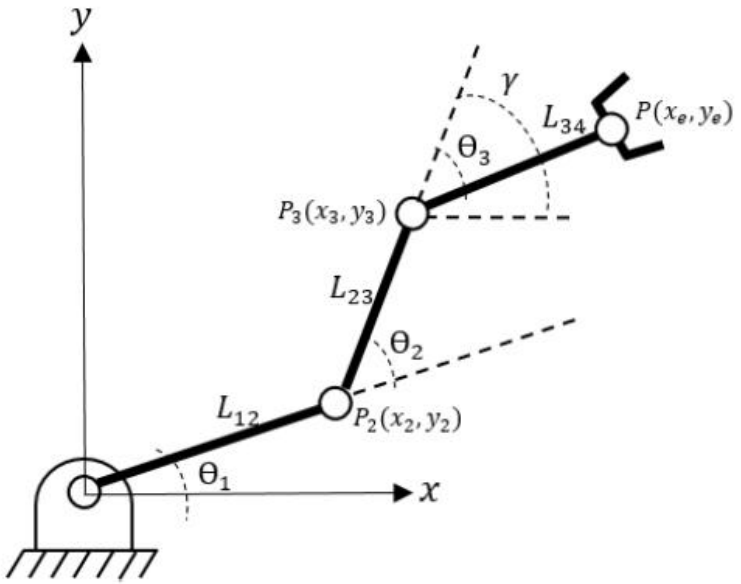
Gemini Robotics: An AI and Kinematics Use Case. . .



Kinematic Basics:

- To perform tasks like grasping a small object or inserting a part into a tight space, a robot needs to know exactly how to move its joints. This is where kinematic models and calculations are essential.

The focus of this webinar course!



Question 2

Which statement is false?

a) The Gemini Robotics platform allows embodied intelligence using physical robots.

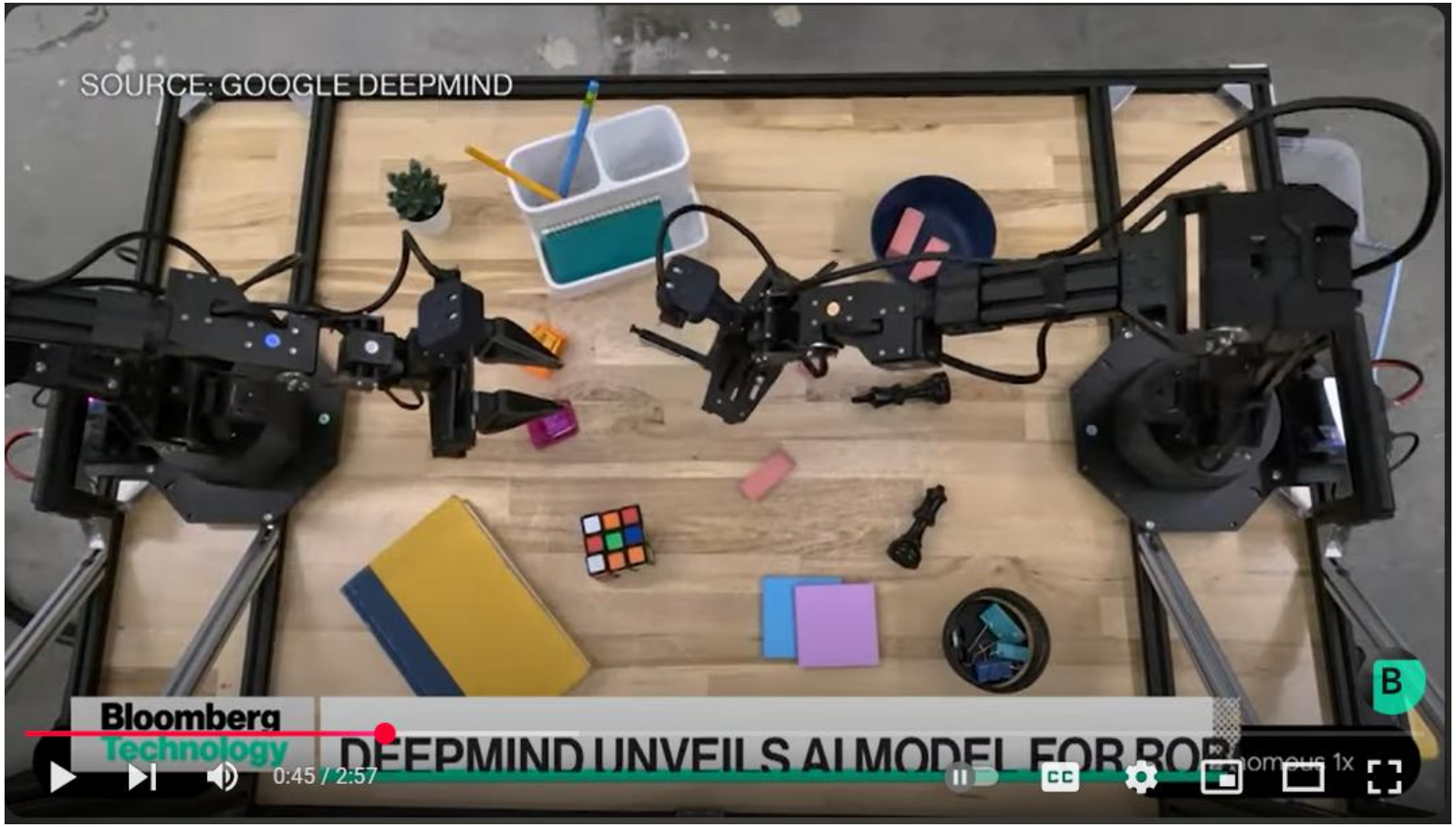
b) The Gemini Robotics platform focuses on enhancing a robot's NLP understanding.

c) Gemini Robotics brings Gemini AI capacity for multimodal reasoning and world understanding.

d) none of the above

Google Gives Robots Physical World Understanding

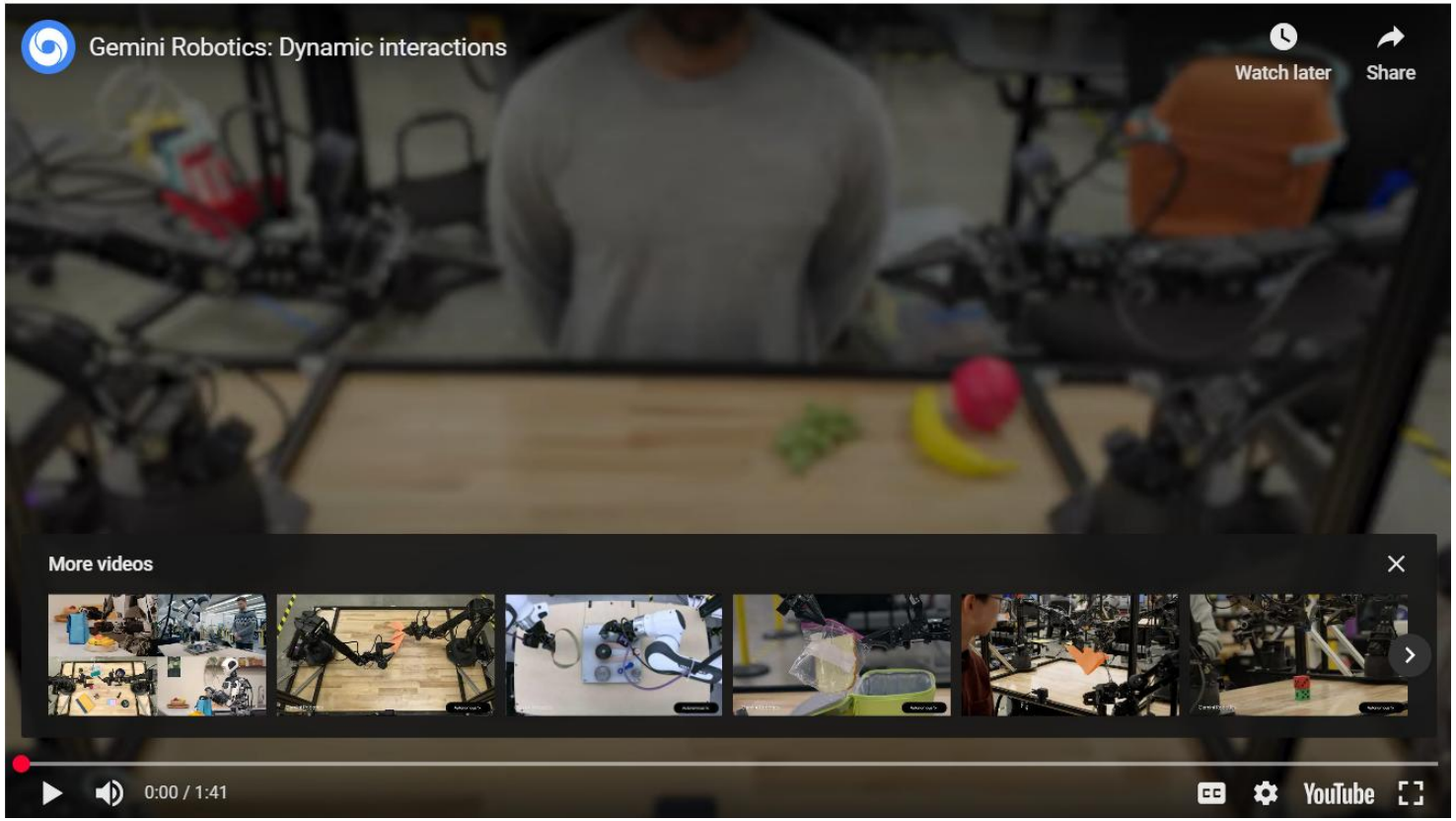
Research and Market Perspectives in the Consumer Robotics Field



https://www.youtube.com/watch?v=RY9k8xb9jgk

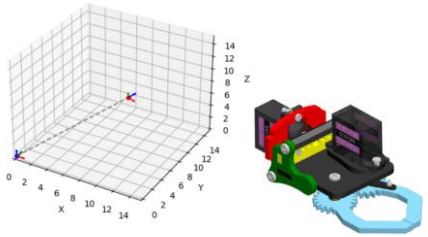
Gemini Robotics: Dynamic Interactions

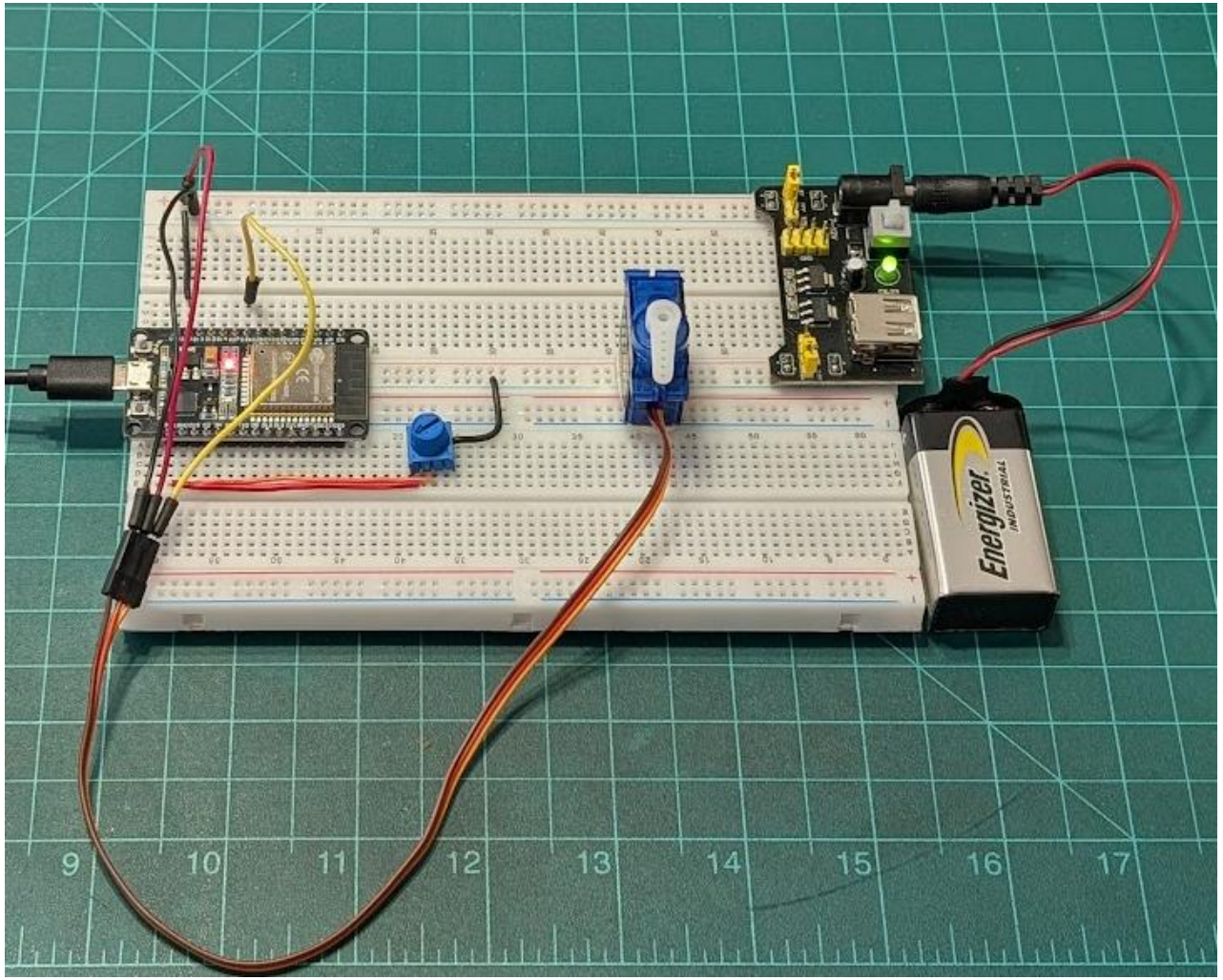
Good Examples of Robot Kinematics in Action: Scroll down the page to view the videos



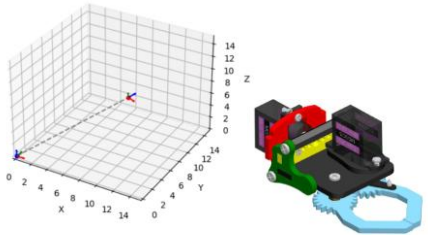
https://deepmind.google/discover/blog/gemini-robotics-brings-ai-into-the-physical-world/

Lab: Build An ESP32 DC Servo Motor Controller





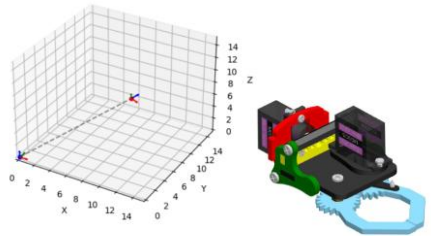
Lab: Build An ESP32 DC Servo Motor Controller. . .



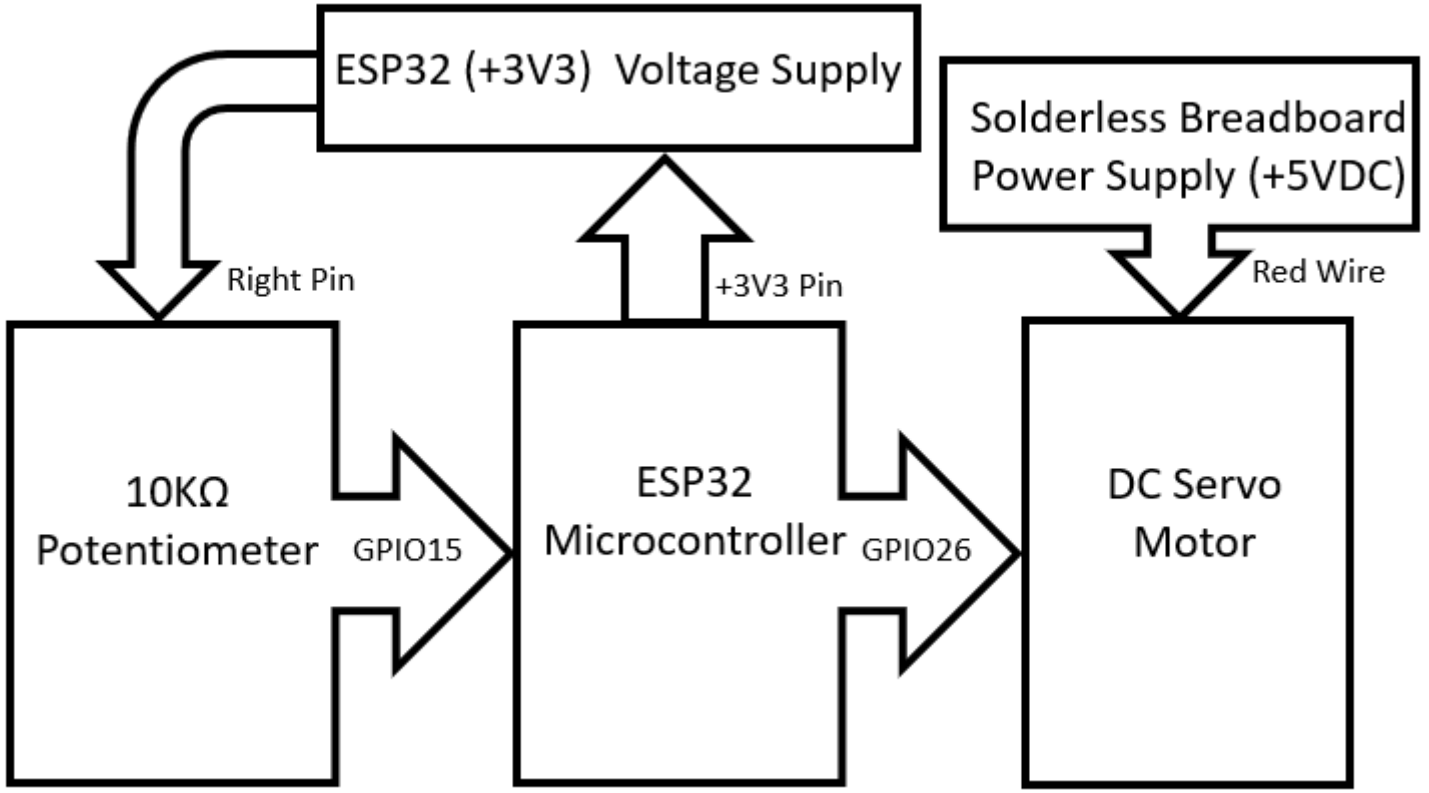
Participant Learning Objectives:

- Participants will learn to build a DC Servo Motor controller using an ESP32 microcontroller and a potentiometer.
- Participants will learn to program the ESP32 microcontroller using Mu software with MicroPython.
- Participants will learn to test the ESP32 DC Servo Motor Controller.
- Participants will learn to control the Adeept 5 DoF Robotic Arm's base using the ESP32 DC Servo Motor controller.

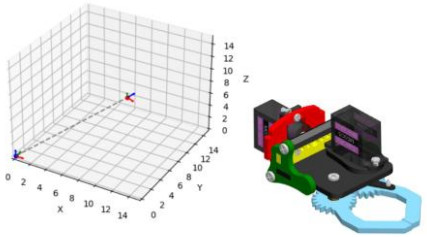
Lab: Build An ESP32 DC Servo Motor Controller. . .



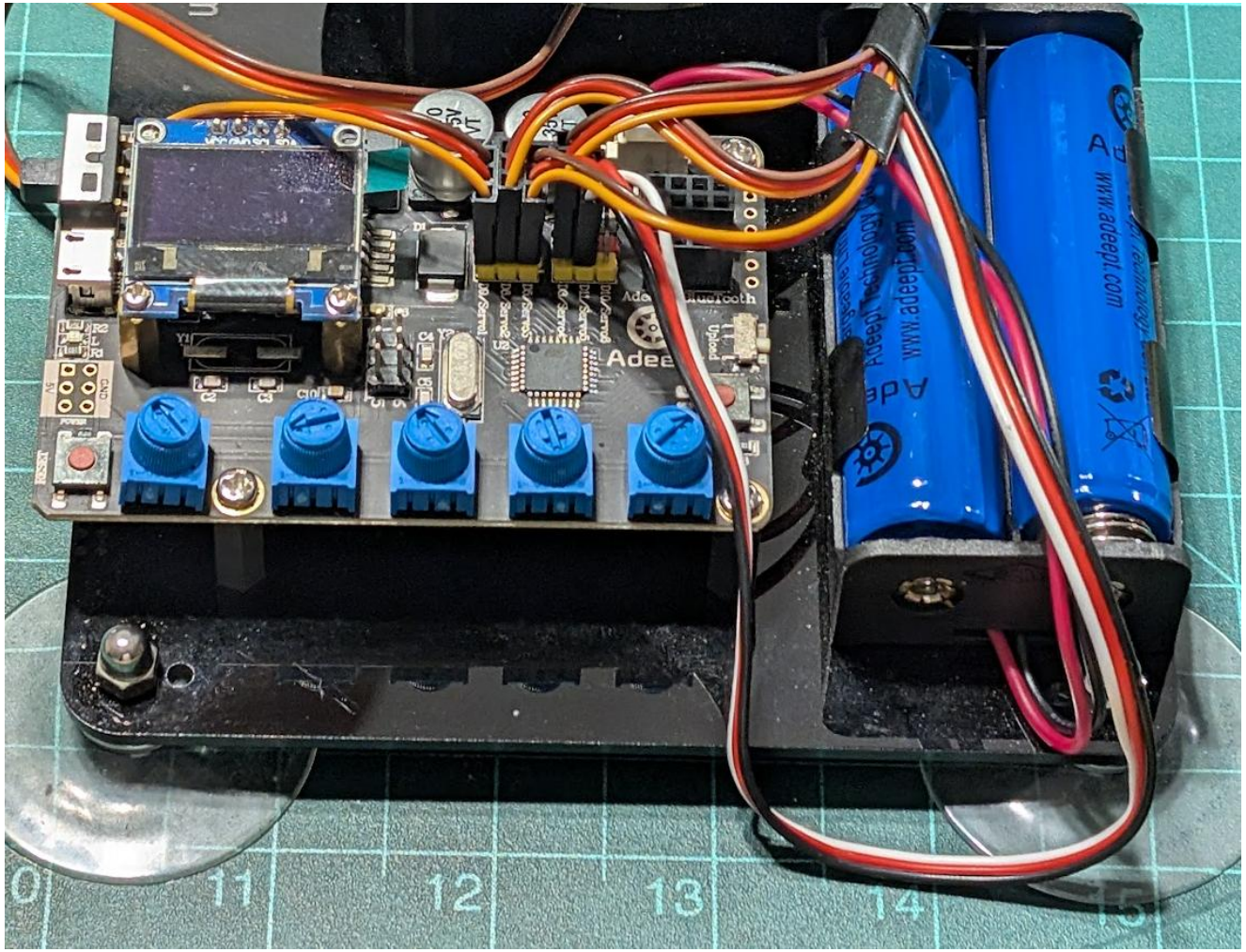
ESP32 DC Servo Motor Controller Prototype Concept Block Diagram



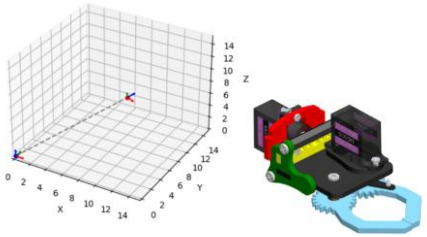
Lab: Build An ESP32 DC Servo Motor Controller. . .



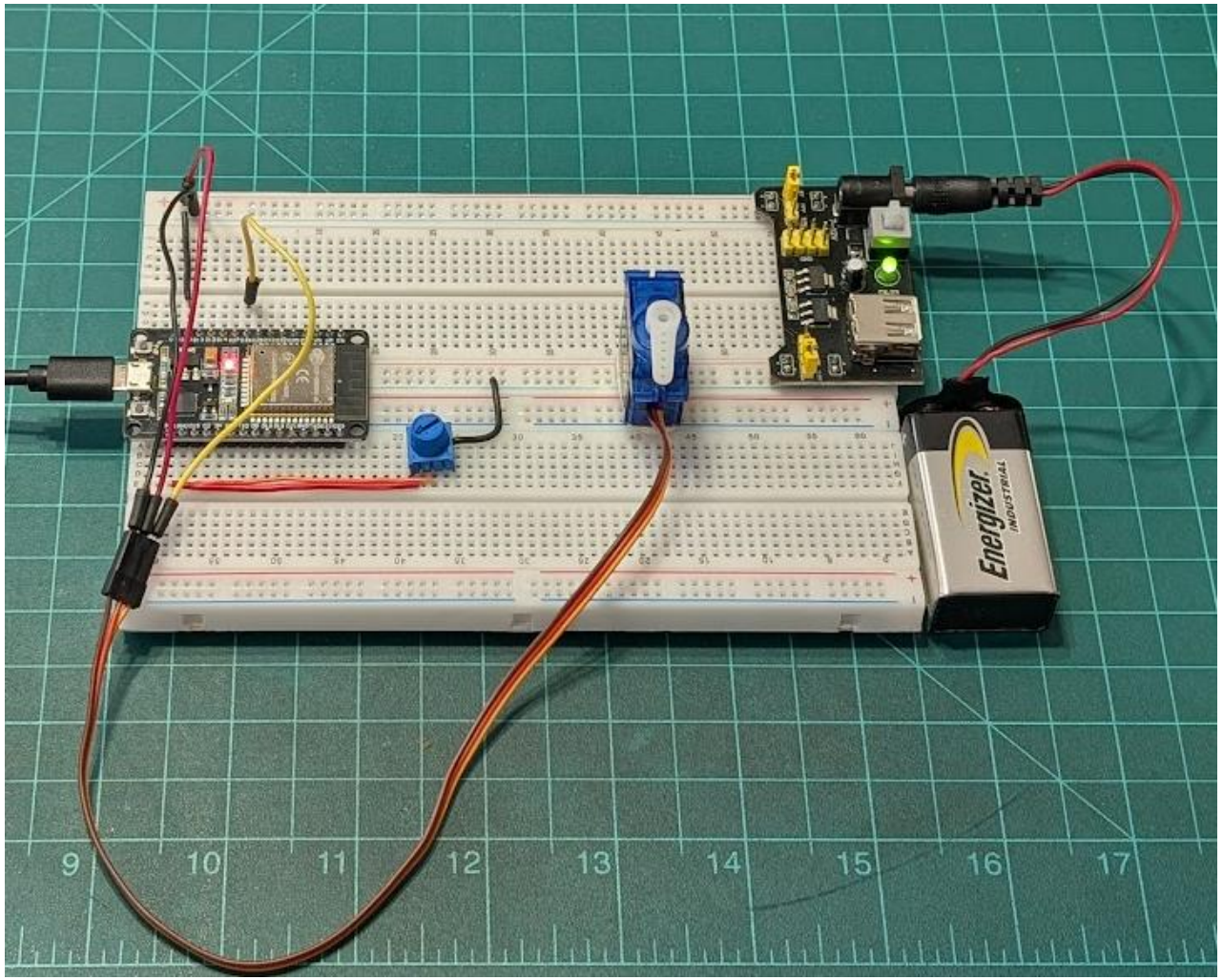
Actual Adeept 5 DoF Robotic Arm DC Servo Motor Controls



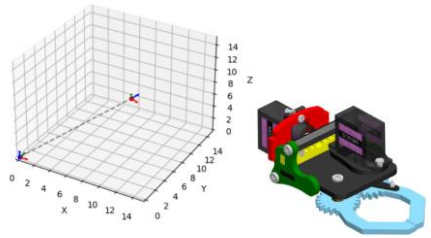
Lab: Build An ESP32 DC Servo Motor Controller. . .



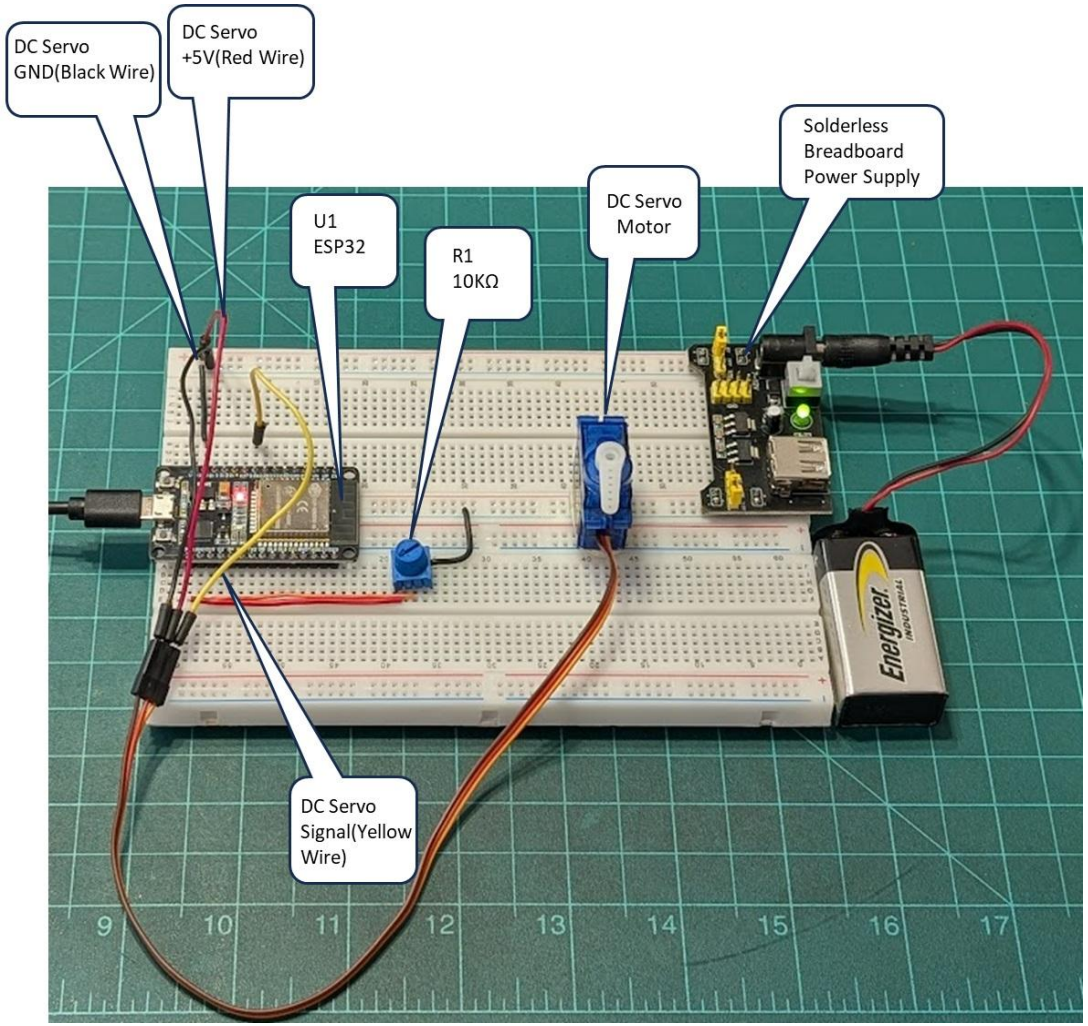
Equivalent ESP32 DC Servo Motor Controller Prototype



Lab: Build An ESP32 DC Servo Motor Controller. . .

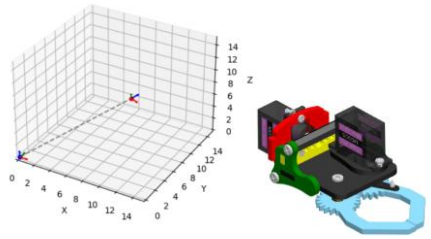


ESP32 DC Servo Motor Controller Prototype Parts Layout Diagram

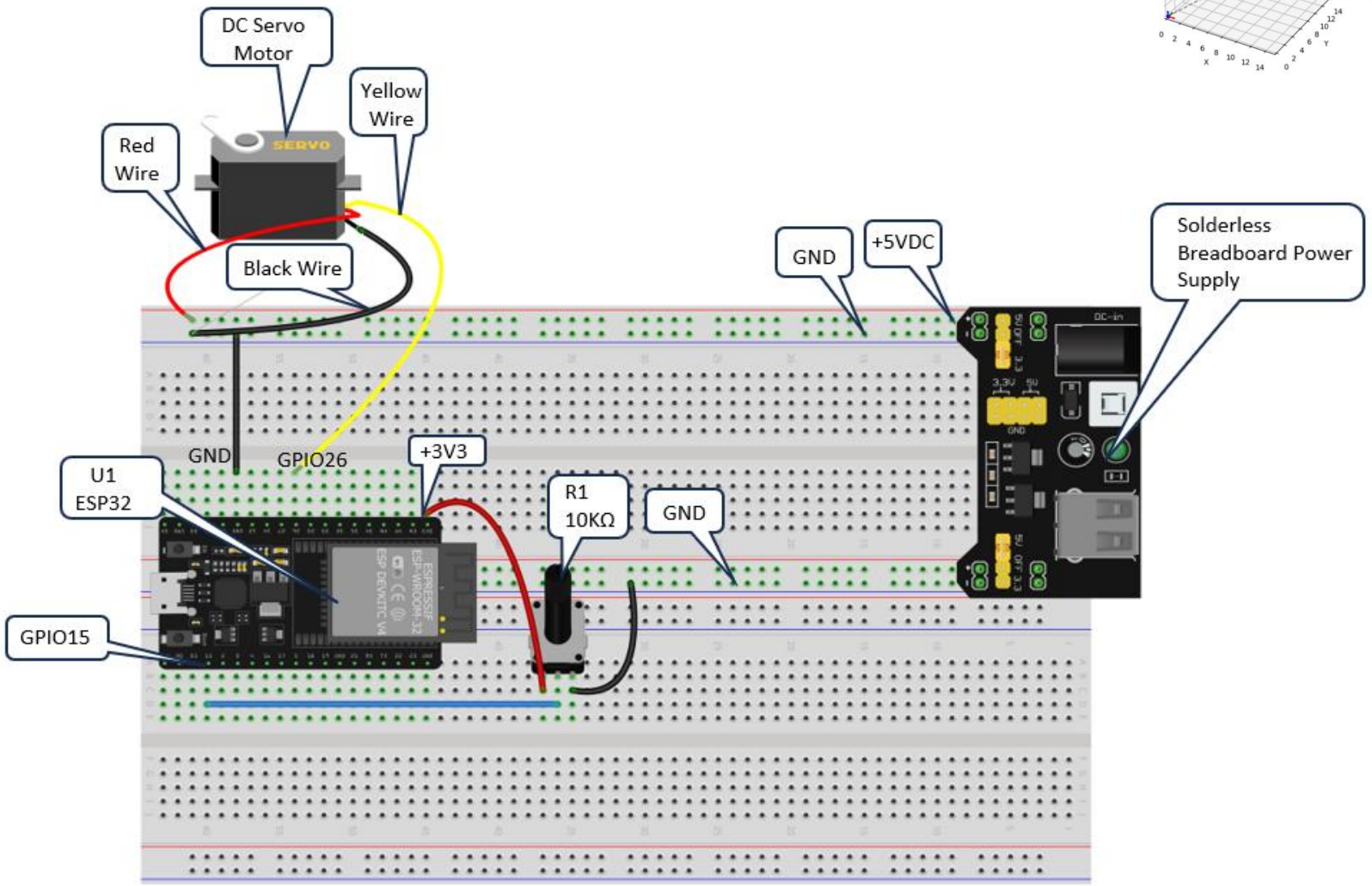


Note: DC Servo Signal(Yellow Wire) attached to GPIO26 of the ESP32.

Lab: Build An ESP32 DC Servo Motor Controller. . .



ESP32 DC Servo Motor Controller Pictorial Electrical Wiring Diagram



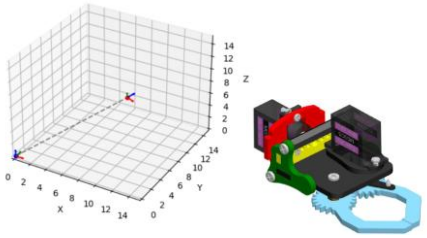
Note: The pin locations differ from those in the Parts Layout Diagram. Refer to the GPIO pins to ensure correct wiring to the ESP32 microcontroller.

Question 3

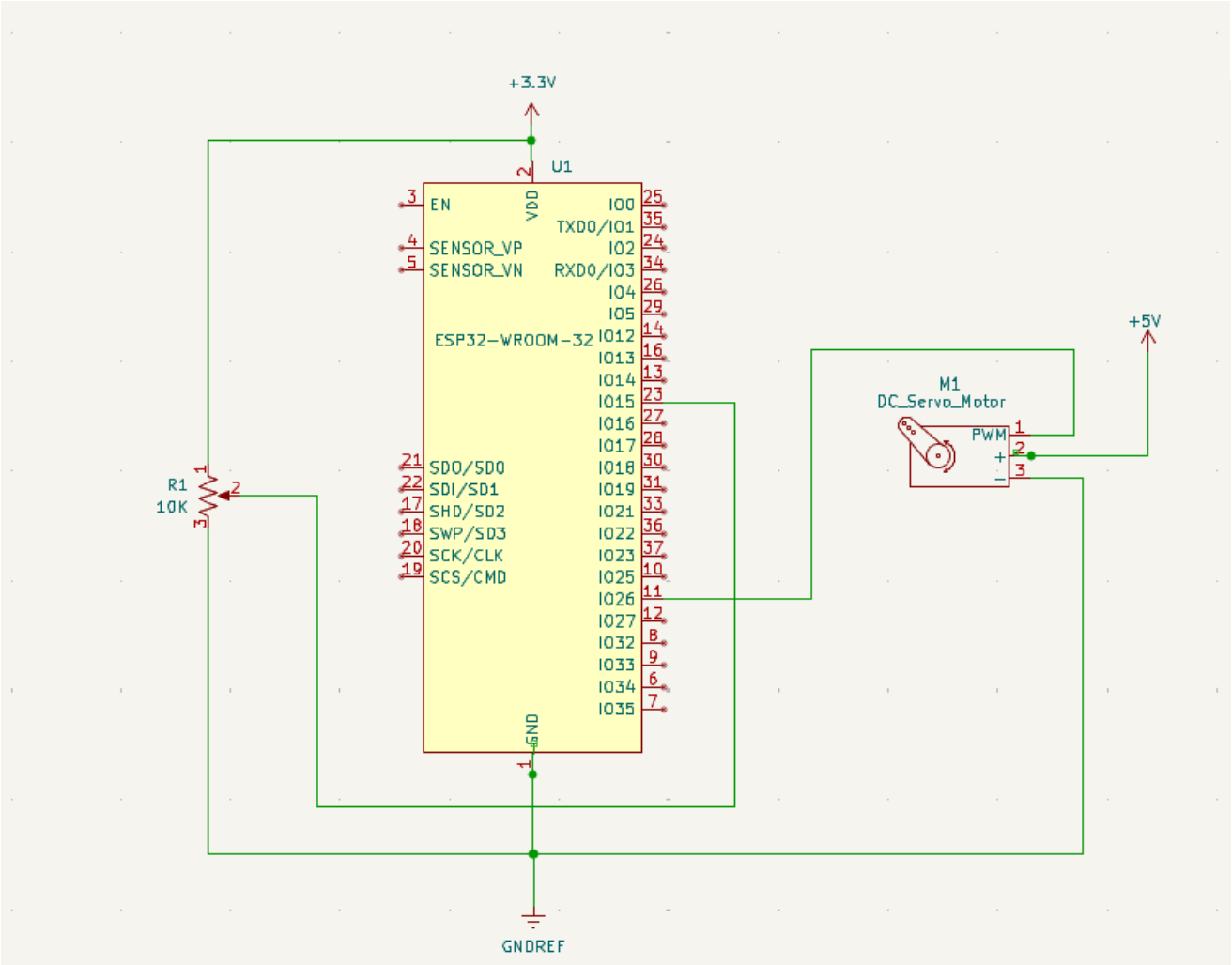
In reviewing slide 23, what color wire is connected to the GPIO26 pin of the ESP32 microcontroller?

a) Red
b) Black
c) Yellow
d) none of the above

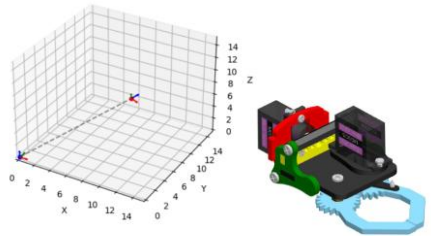
Lab: Build An ESP32 DC Servo Motor Controller. . .



ESP32 DC Servo Motor Controller Electronic Circuit Diagram

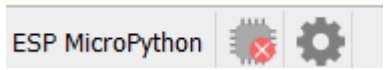


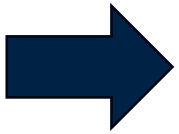
Lab: Build An ESP32 DC Servo Motor Controller…

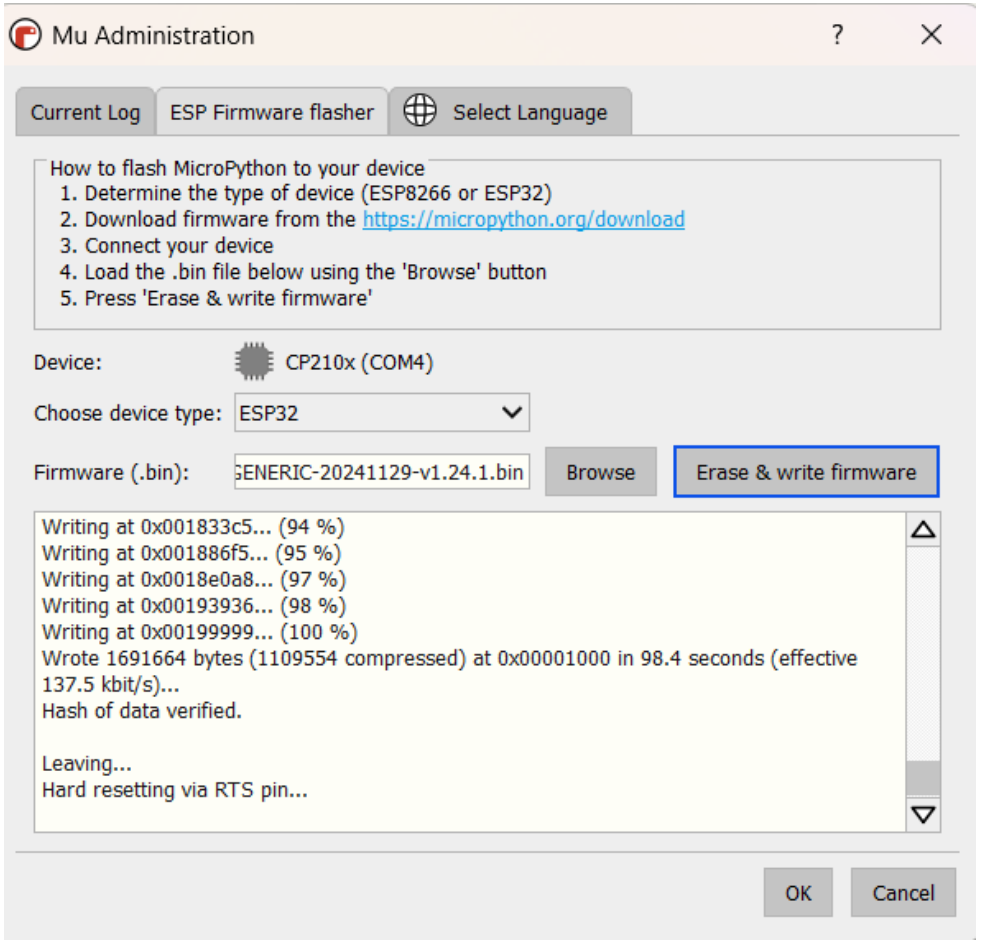


Burning ESP32 Firmware-Bin (Binary) File

Click the Gear Icon Button!







Click the Erase & write firmware Button!

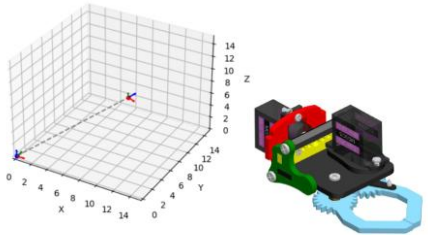
Click the OK Button!

Question 4

Which file format is used to write the MicroPython firmware into the ESP32 microcontroller?

a) hex
b) ino
c) bin
d) none of the above

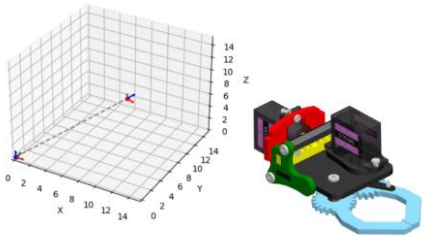
Lab: Build An ESP32 DC Servo Motor Controller. . .



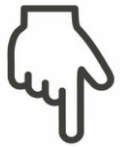
After MicroPython Firmware is burned into the ESP32, the following message will be displayed in the Console Window.

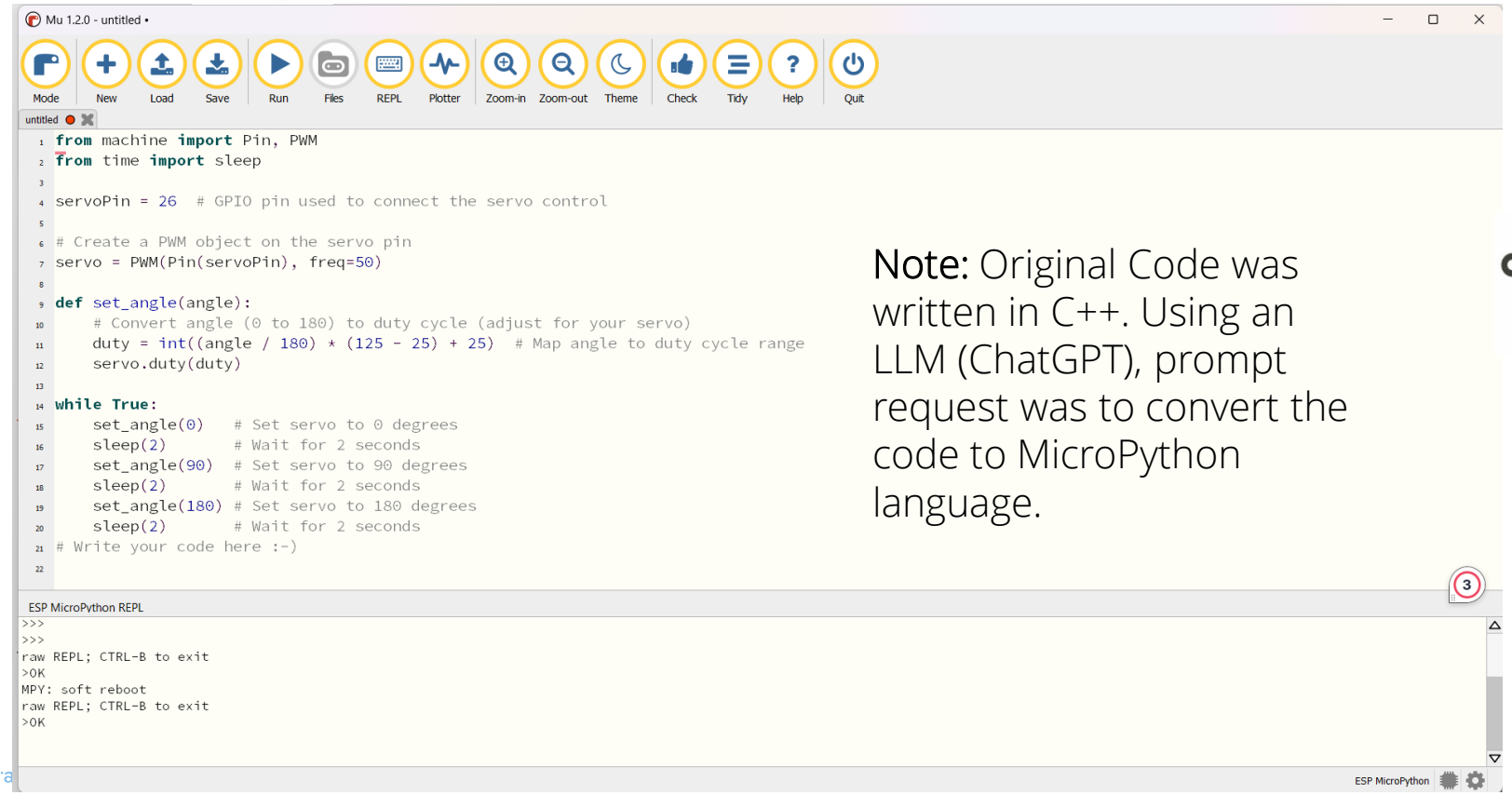
```
ESP MicroPython REPL
Type "help()" for more information.
>>>
MicroPython v1.24.1 on 2024-11-29; Generic ESP32 module with ESP32
Type "help()" for more information.
>>>
>>>
MicroPython v1.24.1 on 2024-11-29; Generic ESP32 module with ESP32
Type "help()" for more information.
>>>
ESP MicroPython
```

Lab: Build An ESP32 DC Servo Motor Controller. . .



Click the Run Button!



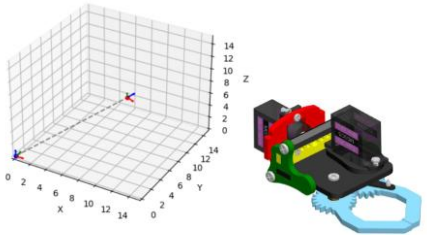


Note: Original Code was written in C++. Using an LLM (ChatGPT), prompt request was to convert the code to MicroPython language.

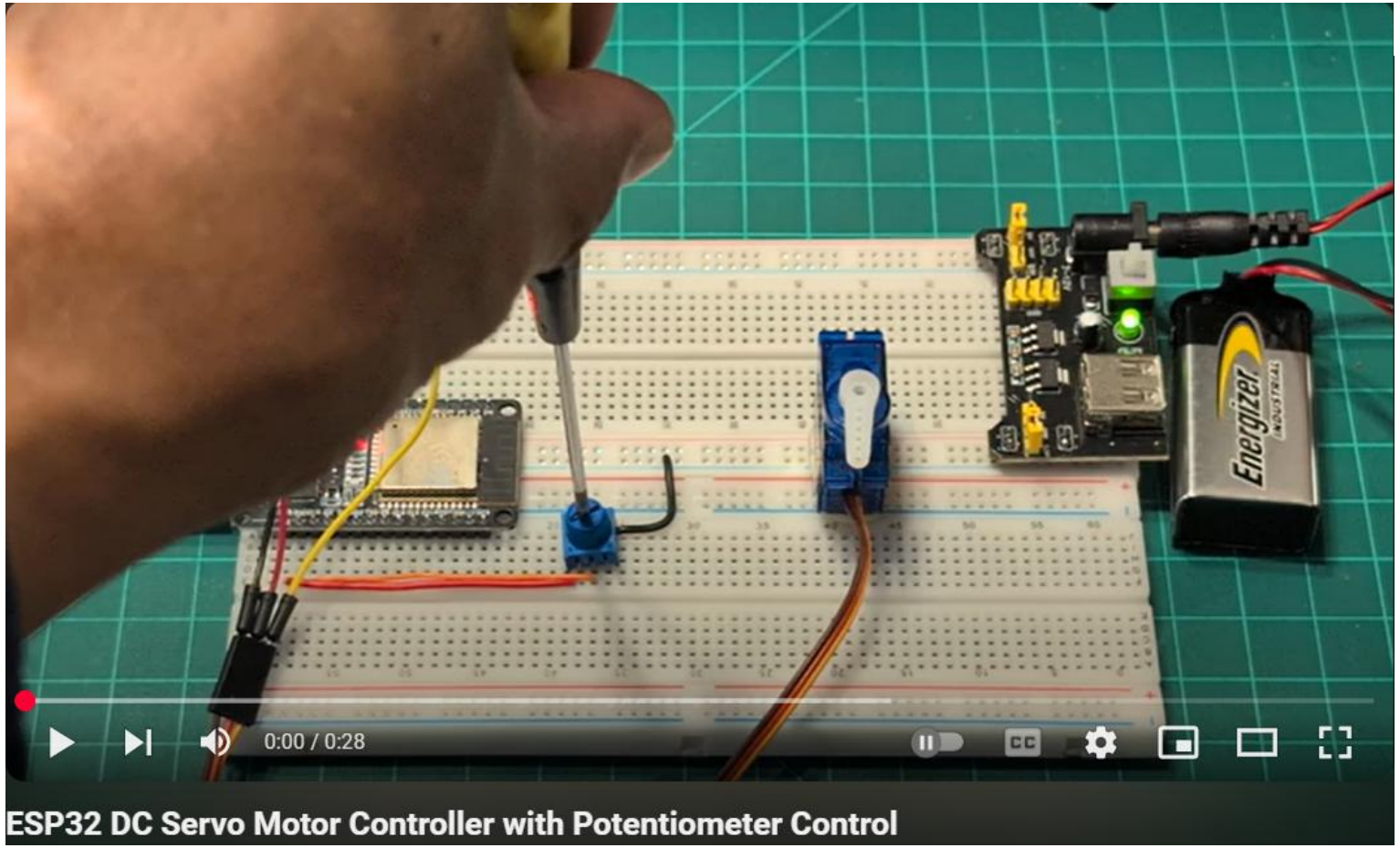
AI-Generated ESP32 DC Servo Motor Controller Python Code

REPL Message will be displayed here!

Lab: Build An ESP32 DC Servo Motor Controller. . .

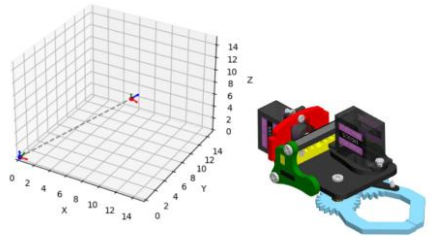


The ESP32 DC Servo Motor Controller In Action

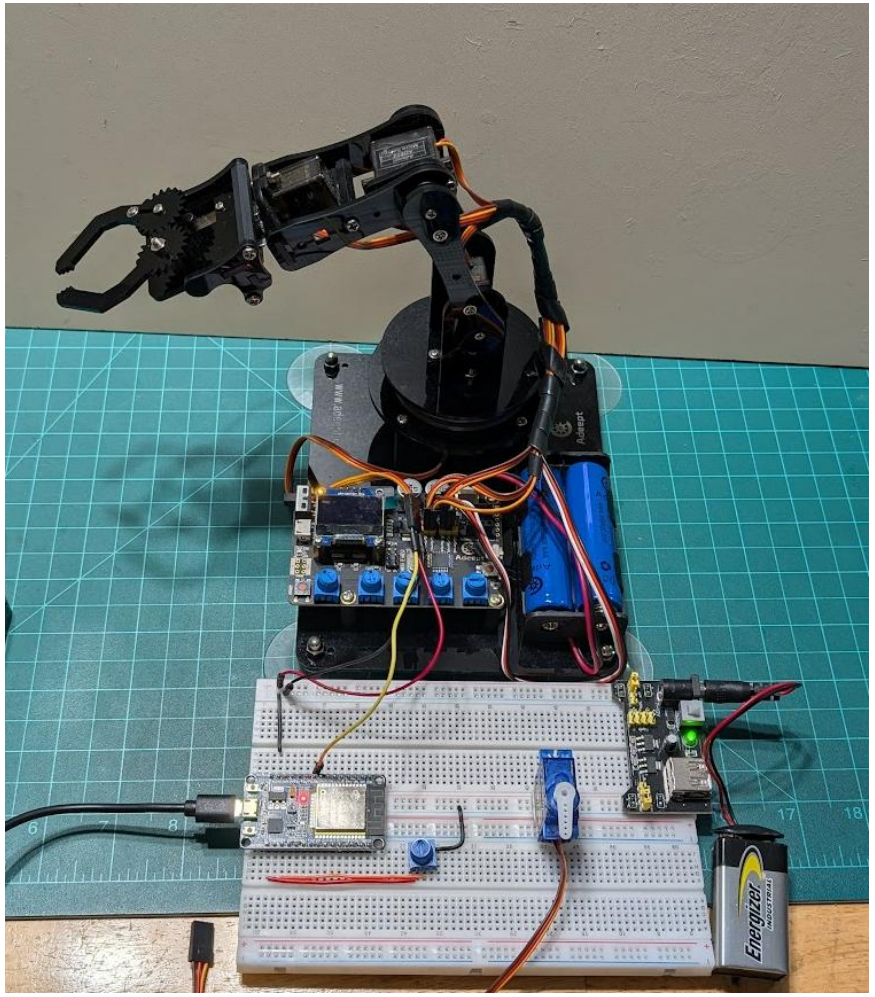


https://www.youtube.com/watch?v=GkA6UC9bPBg

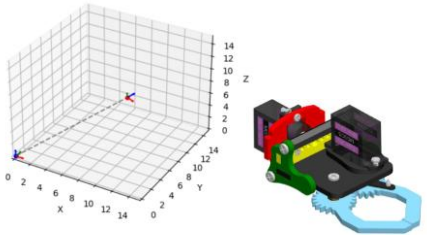
Lab: Build An ESP32 DC Servo Motor Controller. . .



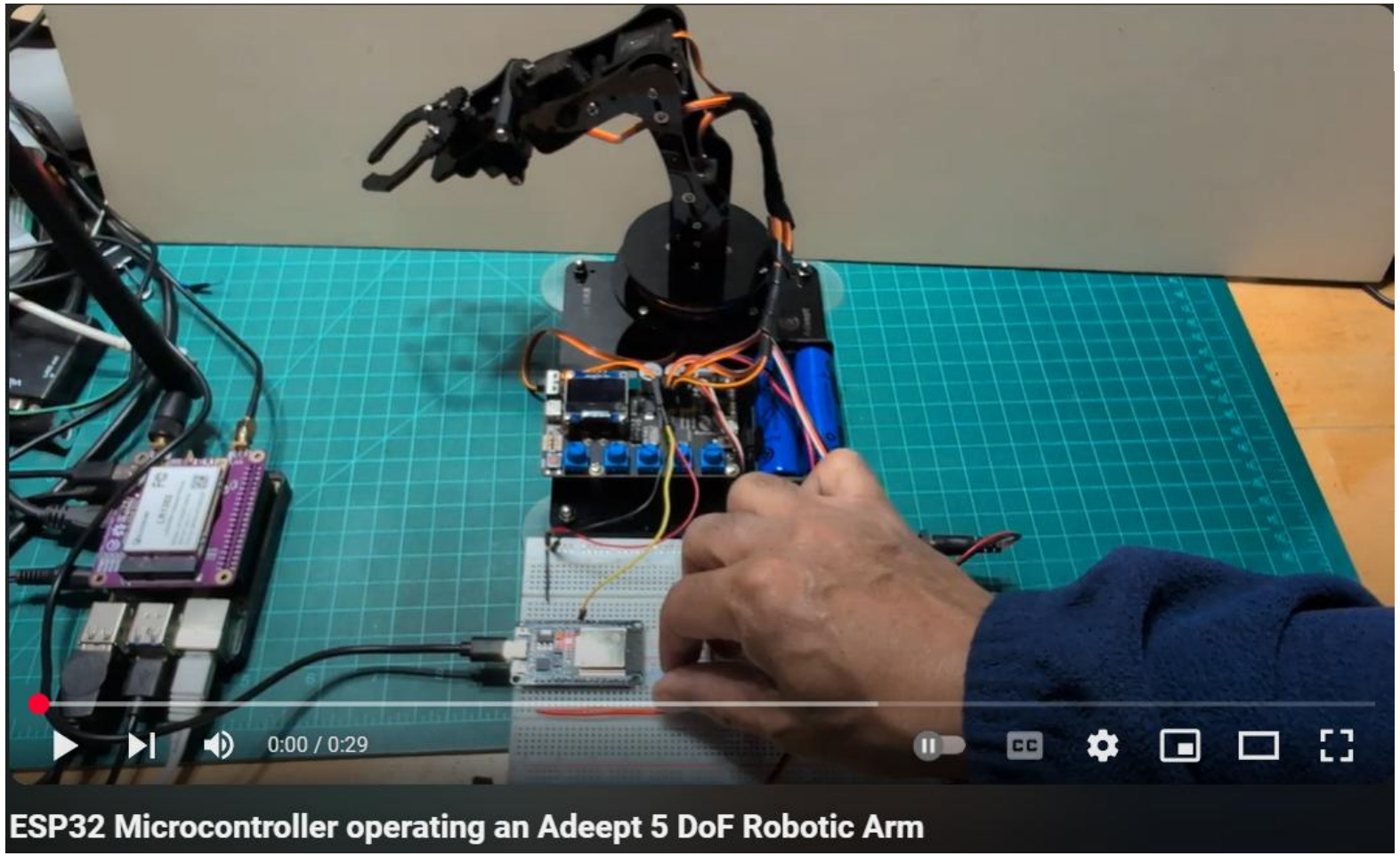
The ESP32 DC Servo Motor Controller can operate any Adeept 5 DoF Robotic 5 motors individually. Remove the DC Servo Motor of choice from the Adeept Controller. Use the same wiring convention as the ESP32 DC Servo Motor Controller. Refer to slides 20 and 21 for DC Servo Motor color code wiring scheme.



Lab: Build An ESP32 DC Servo Motor Controller. . .



The ESP32 Microcontroller Operating the Adeept Robotic Arm In Action



https://youtu.be/mCi4bT6HOHQ

Question 5

In reviewing slide 25, which pin is the 10KΩ potentiometer wired to?

a) 28
b) 11
c) 23
d) none of the above

Thank you for attending

Please consider the resources below:

Bravo, F. A., & Cruz-Bohorquez, J. M. (2024). Engineering education in the age of ai: Analysis of the impact of chatbots on learning in engineering. *Education Sciences 14*(484), 1-20, https://doi.org/10.3390/educsci14050484

Niku, S.B. (2020). Introduction to robotics: Analysis, control, applications (3rd ed). Wiley

Walter, Y. (2024). Embracing the future of ai in the classroom: The relevance of ai literacy, prompt engineering, and critical thinking in modern education. *International Journal of Educational Technology in Higher Education 21*(15), *1*-29. https://doi.org/10.1186/s41239-024-00448-3

Wilcher, D. (2025). *Modeling robot kinematics using python and ai*. GitHub. https://github.com/DWilcher/DesignNews-WebinarCode/blob/main/March_25_Webinar_Code.zip

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