



DesignNews

Hands-On with Industry 4.0 using the Raspberry Pi and the Arduino Platforms

DAY 1 : Introduction to Industry 4.0

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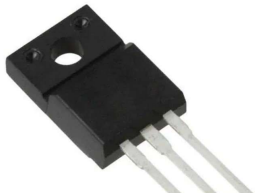
- Turn on your system sound to hear the streaming presentation.
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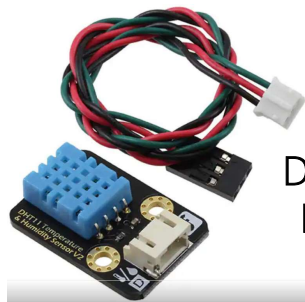
Dr. Don Wilcher

Visit 'Lecturer Profile' in your console for more details.

IRFS630A N-Channel PMOSFET



Axial DC Fan, 5VDC



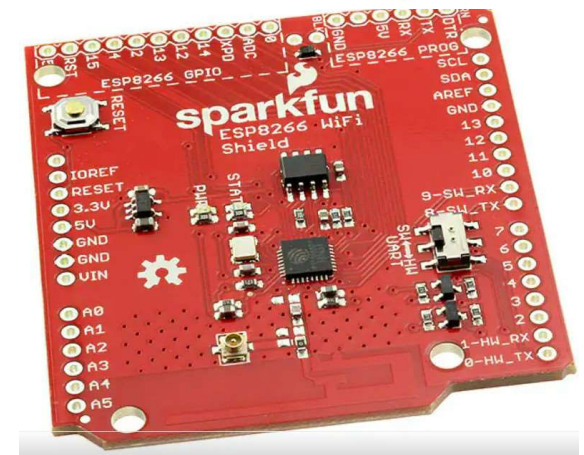
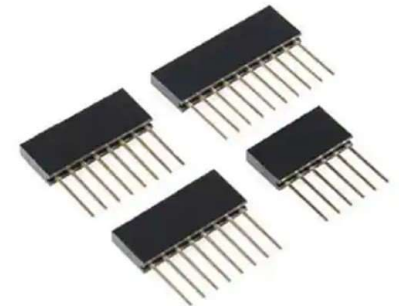
DHT Temperature-
Humidity Sensor

Course Kit and Materials



Osoyoo WiFi Internet of Things
Learning Kit

Arduino Stackable Header Kit



ESP8266 WiFi Shield



Agenda:

- Industry 4.0 Overview
 - a) History of the Industrial Revolutions
 - b) Four Design Principles
- Cyber-physical systems
 - a) CPS Concept Map
 - b) CPS System Model
- Lab: The Arduino – ESP8266 WiFi Shield Demo

Industry 4.0:



“ Over the last two decades, there has been massive progress in the fields of information technology, automation, robotics, Big Data, sensor technology (Internet of Things) and Artificial Intelligence (Russmann et al. 2015). These technological advances may be interpreted as prerequisites for the increasingly popular concept of Industry 4.0, which refers to the current trend of digitalization, automation, and data exchange in manufacturing (Kagermann et al., 2013; Schwab, 2016).”

Industry 4.0 Overview



- Industry 4.0 originated in 2011
 - a) formed from a high-tech strategy from the German government
 - b) the project's focus was the promotion of computerization of manufacturing.
- Industry 4.0 known as the Industrial Internet of Things (IIoT), is the integration of
 - a) Information
 - b) Communication technology in industrial production.
- Key architects of the Industry 4.0 strategy were:
 - a) Siegfried Dias (Bosch Executive)
 - b) Henning Kagermann (Former Chairman and CEO of SAP)
- Known as the Fourth Industrial Revolution

Question 1

Who were the Key Architects of the Industry 4.0 strategy?

- a) Kagermann and Dias**
- b) Kagermann and Schwab**
- c) Resnick and Gernshenfeld**
- d) None of the above**



Industry 4.0 Overview. . .



Image source: Marr, 2018

Industry 4.0 Overview: History of Industrial Revolutions. . .



Industry 4.0 is made up of four revolutions.

- 1st Revolution was Mechanization – Introduced by the steam engine
- 2nd Revolution was Electricity – Assembly lines powered by electrical energy
- 3rd Revolution was Automation – Using electronics and computers to replace manual work.
- 4th Revolution – Cyber-Physical Systems – The convergence of physical, digital, and virtual environments.

Industry 4.0 Overview: History of Industrial Revolutions

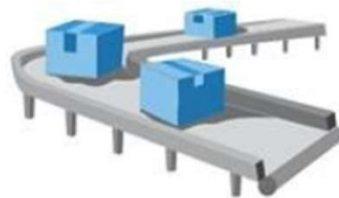


END OF THE 18TH CENTURY

START OF THE 20TH CENTURY

START OF THE 1970S

PRESENT



INDUSTRY 1.0 Mechanization

Introduced mechanization of production by using water and steam to increase production capacity and productivity, versus manual craft work.

1784 First mechanical loom

INDUSTRY 2.0 Electrification

Introduced labor-based mass production (assembly lines) powered by electrical energy

1870 First production line, Cincinnati slaughterhouses

INDUSTRY 3.0 Automatization

Introduced electronics and computers to replace manual work by stand-alone robotic systems

1969 First programmable logic controller (PLC), Modicon 084

INDUSTRY 4.0 Cyber-Physical Systems

The convergence of physical, digital, and virtual environments through **Cyber-Physical Systems (CPS)** and the **Internet of Things (IoT)**

Industry 4.0 Overview: Industry 4.0 Four Design Principles



- Interconnection
 - a) connecting machines, devices, sensors, and people together
 - b) interconnection accomplished using the Internet of Things (IoT) or Internet of People (IoP)
- Information Transparency
 - a) driven by IoT and IoP technologies
 - b) provides operators with comprehensive information to make decisions
- Technical Assistance
 - a) systems to assist humans in decision-making and problem-solving tasks
 - b) The tasks are related to safety or machine diagnostics and troubleshooting
- Decentralized decisions
 - a) Cyber-Physical Systems (CPS) making decisions on their own
 - b) CPS to perform tasks as autonomously as possible

Cyber-Physical Systems (CPS)



- The core concept of Industry 4.0 for building smart factories is CPS (Jiang, 2018).
- The term CPS was first introduced in a National Science Foundation workshop in 2006.
- The CPS approaches used to create smart factories have carried over to:
 - a) healthcare
 - b) smart grid
 - c) smart transportation
 - d) smart homes and buildings
 - e) smart cities

Question 2

What revolution introduced electronics and computers to replace manual work?

- a) 1st
- b) 2nd
- c) 3rd
- d) 4th



Cyber-Physical Systems (CPS): An AI Perspective



Prompt Engineering Inquiry of Cyber- Physical Systems using ChatGPT



Do cyber-physical systems use physical computing concepts?



Yes, cyber-physical systems (CPS) do use physical computing concepts. Physical computing involves the use of hardware and software to create interactive systems that can sense and respond to the physical world. Cyber-physical systems are a type of interactive system that integrates physical components (such as sensors, actuators, and control systems) with computing systems (such as software and networks).

In CPS, physical computing concepts are used to design and implement the physical components of the system, which interact with the computing systems to achieve the desired functionality. For example, in a smart building CPS, physical computing concepts would be used to design and implement the sensors that detect temperature, humidity, and other environmental variables, as well as the actuators that control heating, cooling, and lighting systems in response to those variables.

Overall, physical computing concepts play a crucial role in the design and implementation of cyber-physical systems, as they enable the systems to interact with and respond to the physical world in real-time.

Question 3

According to ChatGPT, CPS uses physical computing concepts.

- a) True**
- b) False**



CPS Concept Map

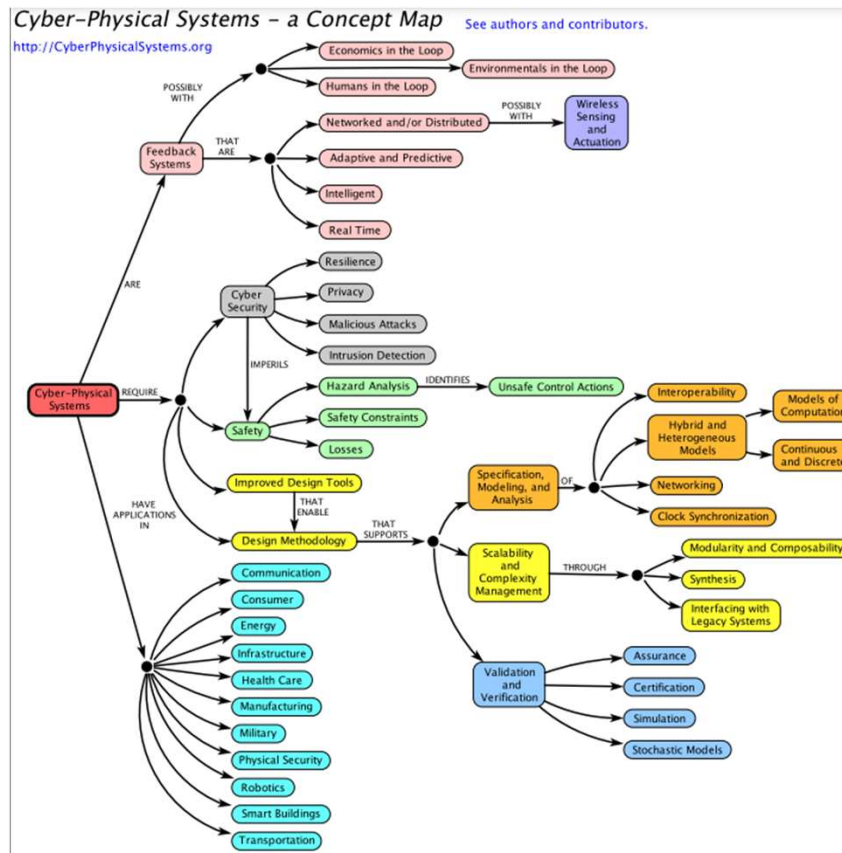


Image courtesy of:
<https://ptolemy.berkeley.edu/projects/cps/>

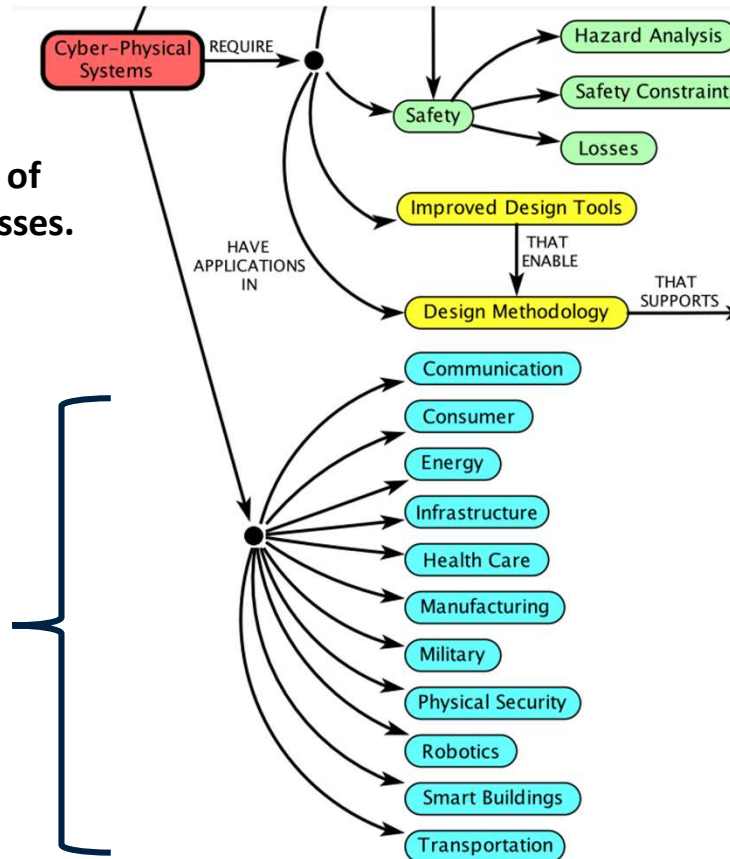
CPS Concept Map . . .



<https://ptolemy.berkeley.edu/projects/cps/>

Cyber-Physical Systems (CPS) are integrations of computation, networking, and physical processes.

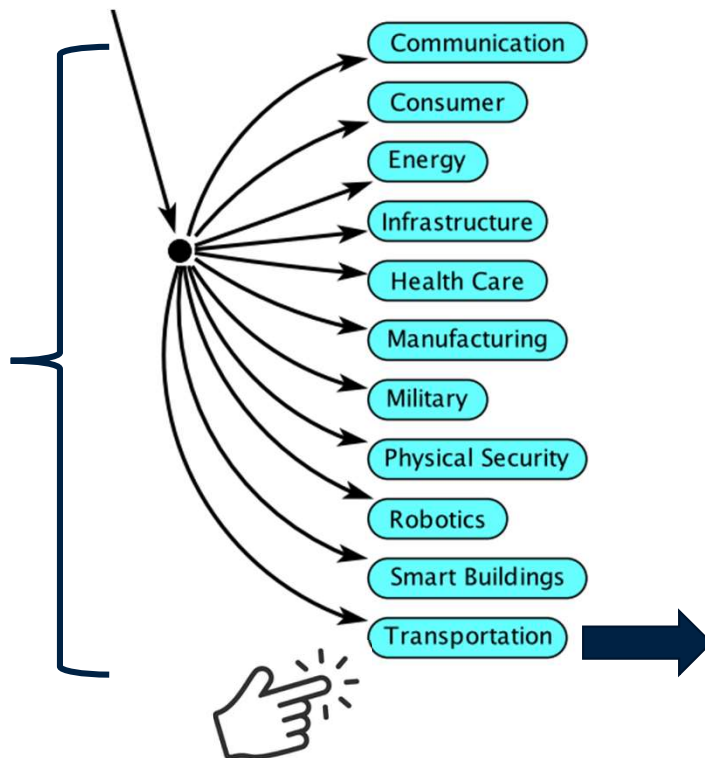

**CPS Applications:
 Opportunities!**



CPS Concept Map . . .



Nodes are
Interactive!



Application Description

Transportation

Transportation applications of CPS include:

- automotive systems;
- avionics and aerospace;
- elevators, escalators, and moving sidewalks;
- railroads; and
- traffic management.

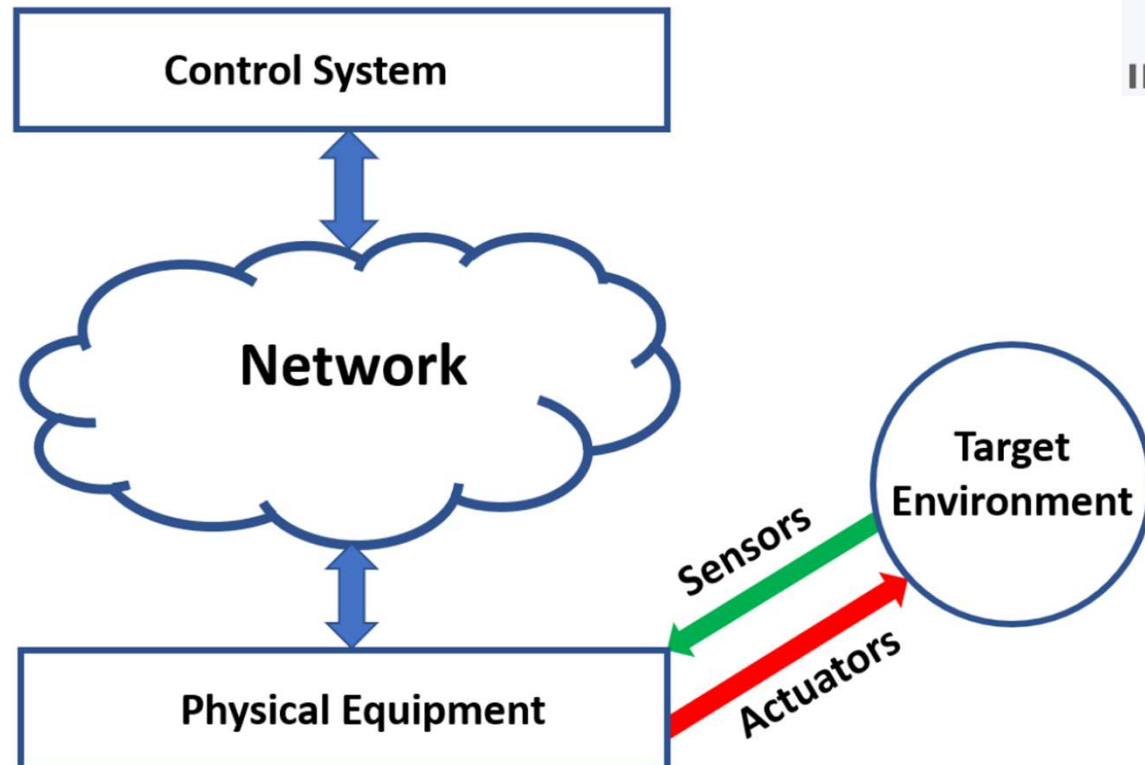
Major issues transportation system design include safety, efficiency, and response to emergencies and disasters.

CPS System Model

“CPS is an engineering system designed to control and operate physical processes through computers” (Mughees, 2020).



The Model provides a hands-on framework for exploring CPS System Concepts using Physical Computing Techniques. Design Opportunities!!

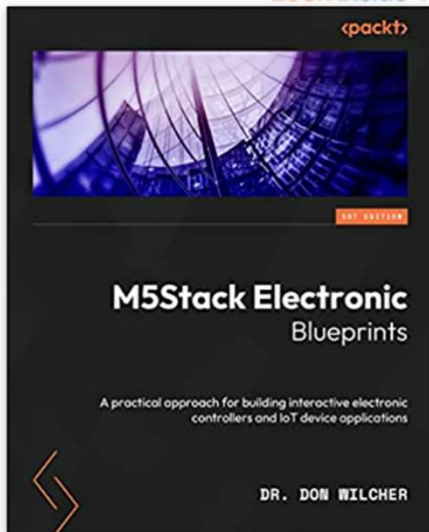
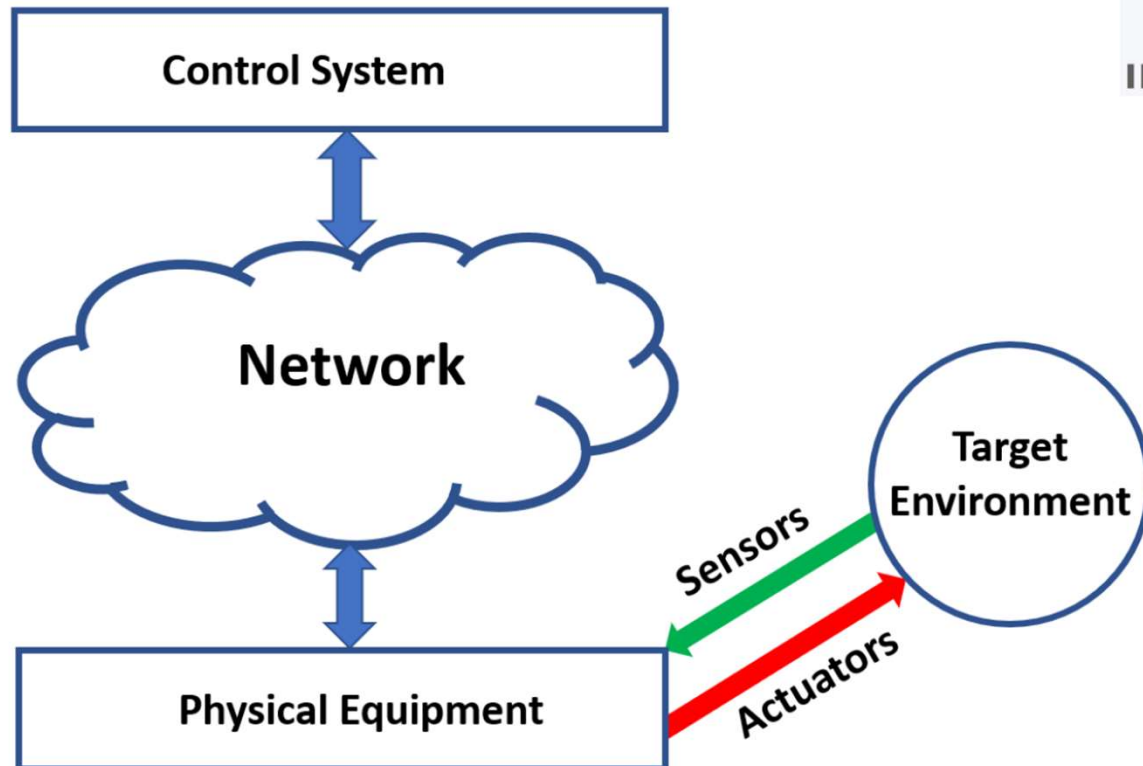




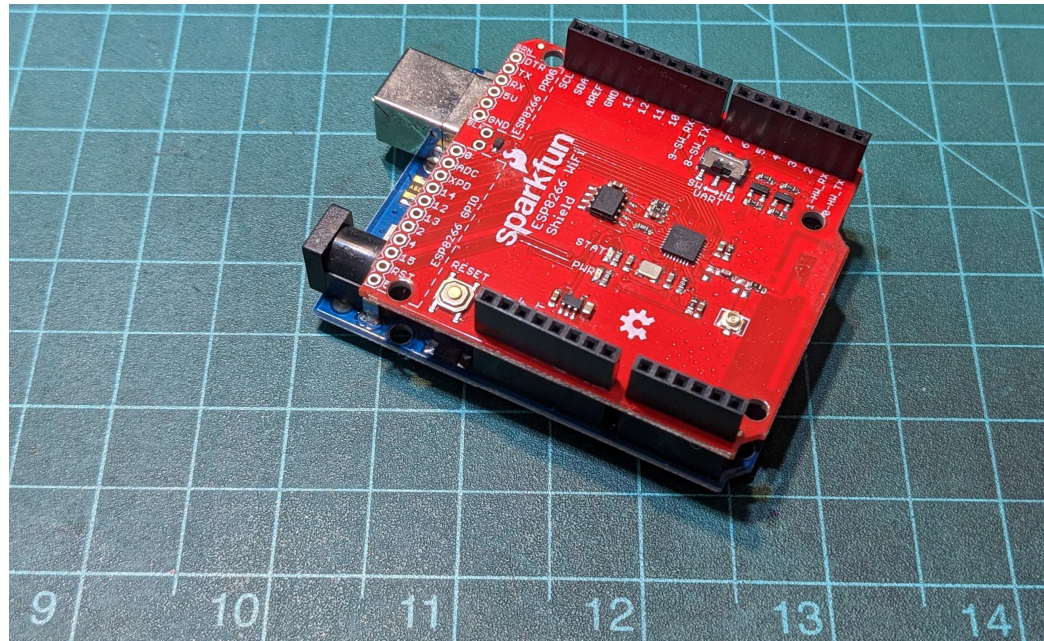
CPS System Model



The M5Stack Electronic Blueprints book supports the CPS System Model through engaging Physical Computing projects using the M5Stack Core and Core 2 IoT modules!



Lab: The Arduino - ESP8266 WiFi Shield Demo



Lab: The Arduino - ESP8266 WiFi Shield Demo



Lab Objectives:

- Participants will learn to assemble the header connectors to the ESP8266 WiFi Shield.
- Participants will learn to install the ESP8266 WiFi Shield AT library.
- Participants will learn to program the ESP8266 WiFi Shield AT library
- Participants will learn how to run the Demo Example

Note:

The SparkFun ESP8266 WiFi Hookup Guide will be referenced.

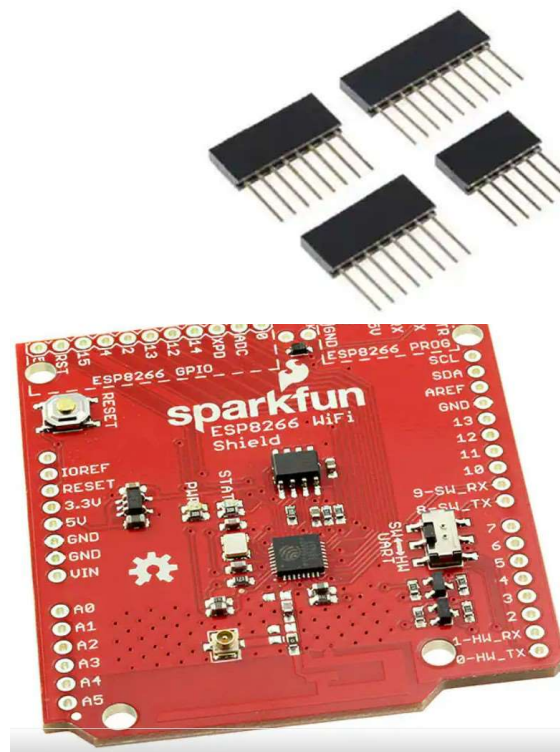
https://learn.sparkfun.com/tutorials/esp8266-wifi-shield-hookup-guide?_ga=2.217814751.831732555.1677901262-690993910.1674866084

Lab: The Arduino - ESP8266 WiFi Shield Demo

Arduino Stackable Header Kit



Assembly of
ESP8266 WiFi
Shield



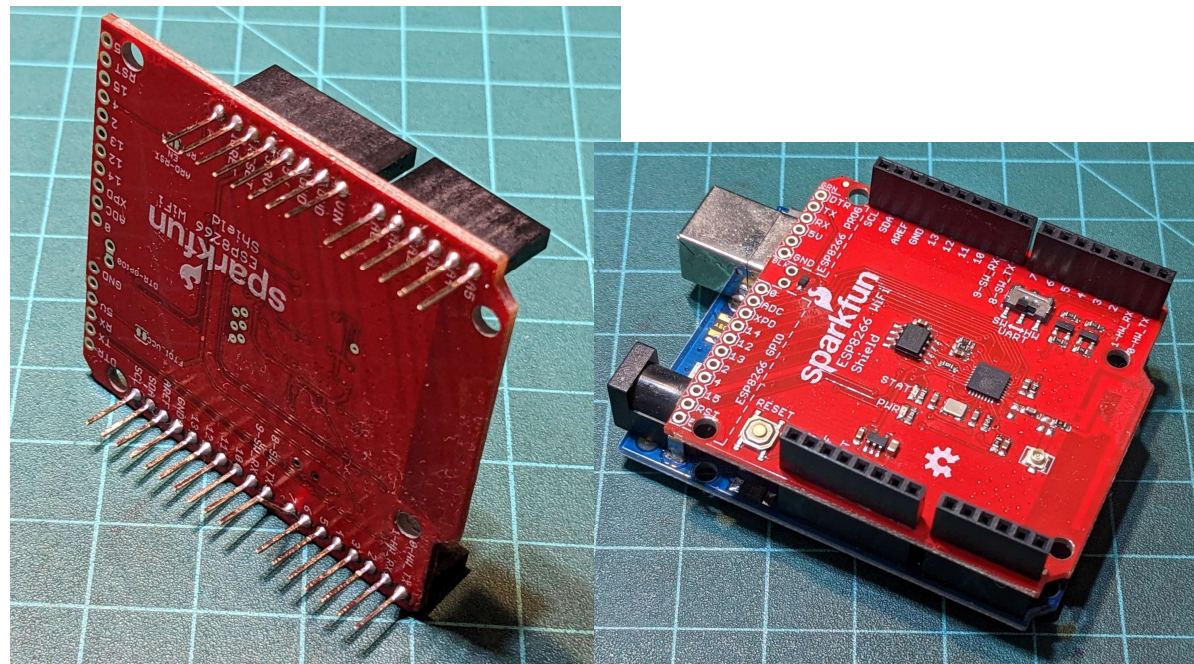
Solder Arduino Stackable
Header connectors to WiFi
Shield

ESP8266 WiFi Shield

Lab: The Arduino - ESP8266 WiFi Shield Demo



Assembled ESP8266
WiFi Shield



Lab: The Arduino - ESP8266 WiFi Shield Demo

Sparkfun ESP8266 WiFi Shield Hookup Guide:

https://learn.sparkfun.com/tutorials/esp8266-wifi-shield-hookup-guide?_ga=2.217814751.831732555.1677901262-690993910.1674866084



Scroll down here on
Sparkfun webpage,
Click here to obtain
zipped folder.



Click here



DOWNLOAD THE SPARKFUN ESP8266 AT LIBRARY

Installing the ESP8266 AT Library
Let's get to programming! To make interfacing with the shield's AT command set as painless as possible, we've written a simple Arduino library. You can get the library from our [GitHub repository](#), or download it by clicking the button below.

We recommend using the latest version of Arduino with this library (currently 1.6.5). For help installing the library check out our [Installing an Arduino Library tutorial](#).



Click here to go to the Arduino
Library tutorial webpage to
install resource

Lab: The Arduino - ESP8266 WiFi Shield Demo

Sparkfun ESP8266 WiFi Shield Hookup pdf Guide:



<https://www.digikey.com/htmldatasheets/production/1828319/0/0/1/esp8266-wifi-shield-hookup-guide.html>



ESP8266 WiFi Shield Hookup Guide

Introduction

The ESP8266 is a popular, inexpensive, WiFi-capable microcontroller (MCU) although it can be programmed like any microcontroller, the ESP8266's popularity was gained as a simple, serially-controlled WiFi gateway. Using an IoT command set, any microcontroller with a UART can use the ESP8266 to connect to WiFi networks, and interact with the rest of the Internet using a TCP or UDP. It's an easy (and cheap!) way to get your Arduino on the Internet.



There are a variety of designs based around the ESP8266, including this module board and more accessible development boards like the SparkFun ESP8266 Thing. The ESP8266 WiFi Shield fits a middle ground between the module and the Thing - it comes pre-flashed with an IoT command firmware, so it can be controlled by any UART, but it also breaks out and provides command access to all of the ESP8266's I/O. It comes in the familiar Arduino Shield shape, and should work with any standardized Arduino-compatible development board out there.

Whether you want an introduction to the ESP8266 - without leaving the comfortable hardware confines of your Arduino - or you just have a basic stock of components that need an inexpensive gateway to the Internet, the ESP8266 WiFi Shield may meet your needs.

Covered in this Tutorial

This tutorial details the hardware and firmware design behind the ESP8266 WiFi Shield. It also explains how to use the Shield with an Arduino-compatible development board and the Arduino IDE. The guide is broken down into a few sections, which you can navigate around using the table on the right. Those sections include:

Lab: The Arduino - ESP8266 WiFi Shield Demo

Attach Arduino Uno to Desktop PC or laptop computer using a USB cable



Observe on ESP8266 WiFi Shield:
a) Red LED is ON
b) Blue LED is Blinking



Question 4

The Blinking LED indicates that the ESP8226 has been connected to an Access Point (AP).

- a) True**
- b) False**



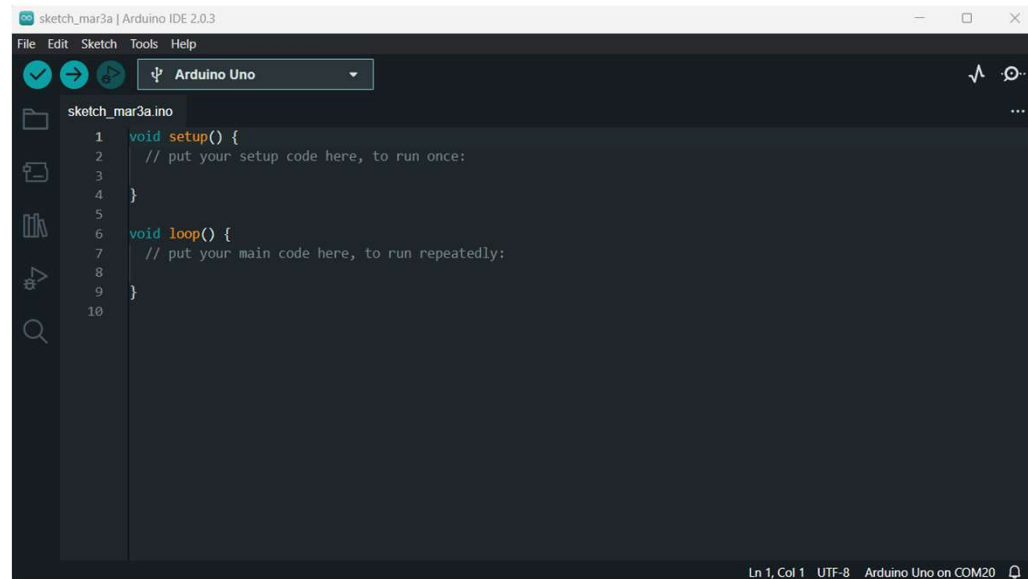
Lab: The Arduino - ESP8266 WiFi Shield Demo



Open the Arduino IDE

To run the ESP8266 WiFi Shield Demo:

File>Examples>SparkFun ESP8266 AT>
ESP8266_Shield_Demo



```
sketch_mar3a.ino
1 void setup() {
2   // put your setup code here, to run once:
3
4 }
5
6 void loop() {
7   // put your main code here, to run repeatedly:
8
9 }
10
```

Ln 1, Col 1 UTF-8 Arduino Uno on COM20

Lab: The Arduino - ESP8266 WiFi Shield Demo

Open the Arduino IDE



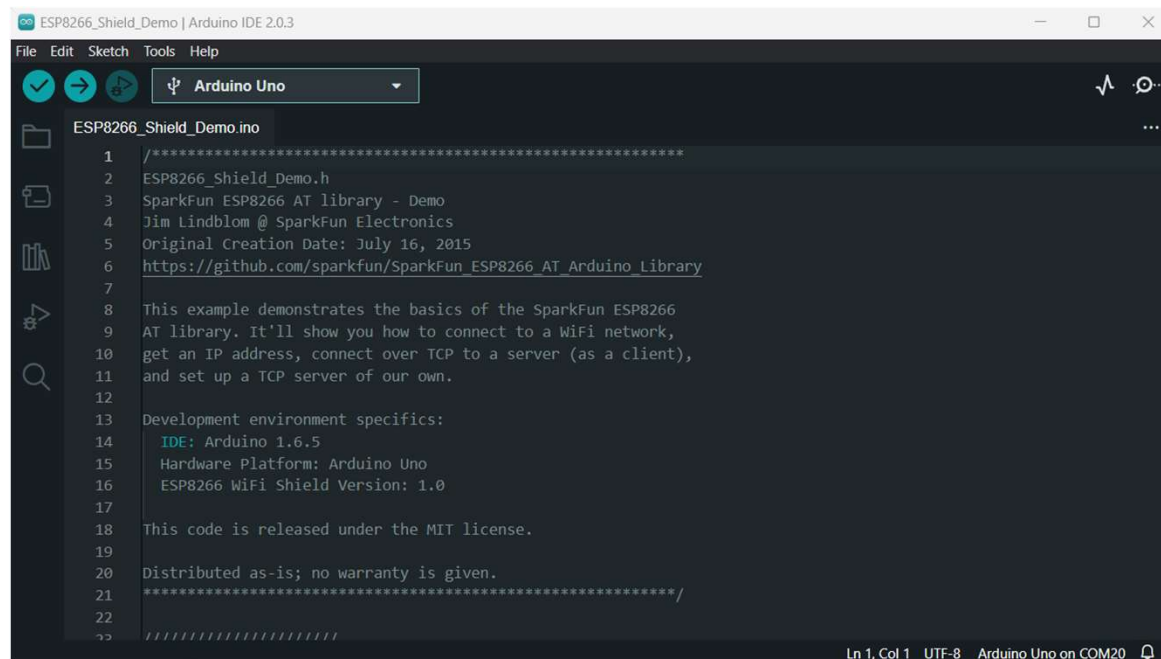
ESP8266_Shield_Demo:

Run Demo to :

- a) Compile code
- b) Download the compiled code to the ATmega328 microcontroller

NOTE:

Home Network SSID and PSWD will need to be entered at lines 36 and 37 of the Arduino Code



```
ESP8266_Shield_Demo | Arduino IDE 2.0.3
File Edit Sketch Tools Help
Arduino Uno
ESP8266_Shield_Demo.ino
1  /*****
2  ESP8266_Shield_Demo.h
3  SparkFun ESP8266 AT library - Demo
4  Jim Lindblom @ SparkFun Electronics
5  Original Creation Date: July 16, 2015
6  https://github.com/sparkfun/SparkFun_ESP8266_AT_Arduino_Library
7
8  This example demonstrates the basics of the SparkFun ESP8266
9  AT library. It'll show you how to connect to a WiFi network,
10 get an IP address, connect over TCP to a server (as a client),
11 and set up a TCP server of our own.
12
13 Development environment specifics:
14 IDE: Arduino 1.6.5
15 Hardware Platform: Arduino Uno
16 ESP8266 WiFi Shield Version: 1.0
17
18 This code is released under the MIT license.
19
20 Distributed as-is; no warranty is given.
21 *****/
22
23 ///////////////////////////////////////////////////////////////////
```


Lab: The Arduino - ESP8266 WiFi Shield Demo



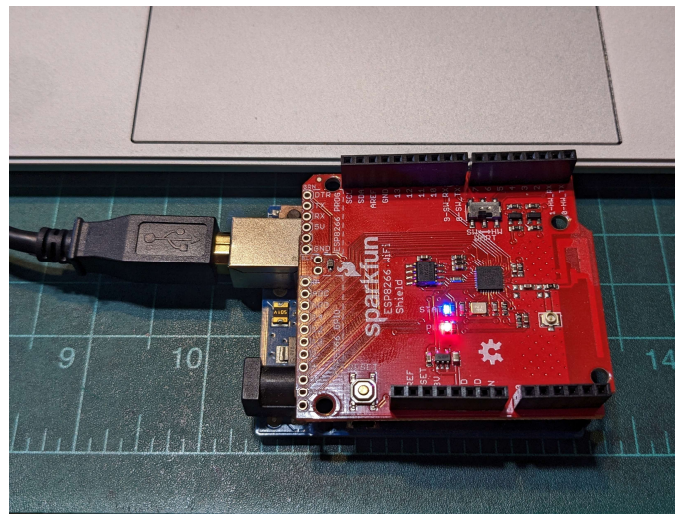
Demo Process and Output Results

INPUT

```
Press any key to begin.  
  
ESP8266 Shield Present  
Mode set to station  
Connected to: ATT6equ2SI  
Press any key to connect client.  
  
Press any key to test server.  
Press any key to test server.  
  
Server started! Go to [REDACTED]  
  
Client Connected!
```



PROCESS



Blue LED Stays ON: WiFi Shield
Connected to the Internet



OUTPUT

```
A0: 470  
A1: 392  
A2: 348  
A3: 315  
A4: 327  
A5: 305
```

Question 5

The demo output shown on slide 33 represents_____.

- a) virtual data
- b) analog data
- c) digital data
- d) None of the above



Thank you for attending



Please consider the resources below:

Kagermann, H., Wahlster, W., & Helbig, J. (2013). *Recommendations for implementing the strategic initiative Industrie 4.0: Securing the future of German manufacturing industry.*

<https://www.din.de/blob/76902/e8cac883f42bf28536e7e8165993f1fd/recommendations-for-implementing-industry-4-0-data.pdf>

Mughees, A. (Sept 05, 2020). *Discrete and process automation: From cyber-physical systems to pervasive intelligence.*

<https://electronics360.globalspec.com/article/15647/from-cyber-physical-systems-to-pervasive-intelligence>

Russamann, M., Lorenz, M., Gerbert, P., Waldner, M., Justus, J., Engle, P., & Hanrisch, M. (2015). *Industry 4.0 – The future of productivity and growth in manufacturing industries.* The Boston Consulting Group.

Schwab, K.(2016). *The fourth industrial revolution.* Penguin Random House.



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Thank You

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