NETWORK COMMUNICATIONS – INTERNET OF THINGS (IOT)

What is the Internet of Things (IoT) and how is it related to network communications?

The Internet of things (IoT) consists of physical devices connected to the Internet. IoT devices are a combination of sensors, software, and electronics that connect to a central location usually in the cloud. They are often connected through a wireless network through which they communicate with one another and feed information to a user's mobile device or computer. Through the device, the user can monitor a condition or control a process through a control panel or dashboard, known as the Human-Machine Interface. Internet-connected doorbells, thermostats, speaker systems and wearable fitness trackers are everyday examples of IoT devices. In industry, a variety of sensors monitoring quality and machine operational parameters for preventative maintenance.

Vocabulary

- Smart sensors – devices that receive and process data before sending to a centralized source; flow sensors used to measure water and natural gas usage – smart meters – are an example
- Cloud computing – delivery and storage of data over the Internet rather than on-site; Google's gmail is an example.
- Information security – processes used to protect information from unauthorized access, modification, or destruction. Requiring password entry to access devices and content is an example.

How will technicians use network communications and IoT technologies?

Network Communication Technicians familiar with IoT technologies will install, monitor, and maintain the IoT devices and the network communication software that connects them to ensure proper operation. This includes tasks such as installing software updates, developing procedures to detect and prevent system hacking, testing the network for malware, and troubleshooting system malfunctions. Their job often requires creative problem-solving, as in this example:

A company that manages large parking garages wanted to reduce the time its customers spent searching for open parking spots. Some drivers spend several minutes traveling up and down multiple floors to find an open parking spot. The distracted drivers looking for open parking spots are also a hazard to other cars and pedestrians. A network technician is assigned to investigate a solution. After reviewing several options, the network technician decided to implement an IoT solution that includes sensors, signs, and a mobile app. IoT sensors were installed to monitor the status of each parking spot. The status of each parking spot was sent to a centralized computer. If a spot were available, signs throughout the garage would provide directions to the exact location on the garage floor to the open parking spot. The status of each parking spot was also available on a mobile app to let people know before entering the garage how many spots were available and on what floors. This IoT solution reduced customer wait times, increased safety, and increased parking garage profits.





NETWORK COMMUNICATIONS – INTERNET OF THINGS (IOT)

Skills Needed for a High-Paying, Rewarding Career

- Advanced computer programming
- Connecting sensors to networks
- Identifying program errors
- Troubleshooting complicated computer networks
- Interpreting detailed schematic diagrams
- Maintaining complex IoT networks
- Configuring and Testing new software instillations
- Maintaining and repairing hardware and peripheral devices
- Developing robust cyber security interfaces

Education

Your local community college provides the advanced technology classes you will need. Skills for building and maintaining network communications networks within the Internet of Things are most often taught within Engineering Technology, Information Technology, or Computer Information Systems programs offering associate degrees and one-year certificates. You will also find the skills applicable in technical specializations, such as cybersecurity, biomedical, energy, environmental, and engineering technologies. Community college course schedules are designed to accommodate the needs of working students and often include online and hybrid delivery formats. Find your nearest community college here.

Future Trends

Current and Future Career Opportunities include working with:

- "Smart home" technologies
- Complex sensors
- Sophisticated user infrastructures
- Industry and government cyber security
- Dynamic mesh computer interface architecture
- Artificial Intelligence applications
- Data brokering
- Informatics
- Robot/human inter-communications

Learn More

The Internet of Things tutorial (includes Career Opportunities)

Free online course: Introduction to the Internet of Things

ABOUT THE PROJECT:
Preparing Technicians for the Future of Work, a project of the National Science Foundation Advanced Technological Education program, recognizes that technicians graduating today need an expanded skill set to remain competitive in the global economy. The project focuses on three skill areas: data knowledge and analysis, advanced digital literacy, and business knowledge and processes. Learn more at preparingtechnicians.org.





NETWORK COMMUNICATIONS – INTERNET OF THINGS (IOT)

What is the Internet of Things (IoT) and how is it related to network communications?

IoT devices are a combination of sensors, software, and electronics that connect to a central location usually in the cloud. They are often connected via a wireless network through which they communicate with one another and feed information to a user's mobile device or computer.

The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects (e.g. car with lane sensors), animals (e.g. livestock with biochip transponders) or people (e.g. heart rate monitors) that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. "Internet of Things (IoT)," TechTarget IoT

Network communication defines a set of protocols (rules and standards) that allow application programs to talk with each other without regard to the hardware and operating systems where they are run. "Basics of Network Communication," IBM Knowledge Center

Scenario 1
Manufacturing Technologies

A manufacturing facility had problems with consistent equipment breakdowns causing the assembly lines to stop working. The equipment was overheating, vibrating, and losing electrical connectivity. The maintenance technicians would find the problems but only after the assembly line broke down. The company was losing money on a weekly basis. The plant manager asked Cynthia, a production technician, to find a solution. After a few days Cynthia reported to her manager she found a solution using IoT. Cynthia's plan was to install IoT devices to monitor the part of the assembly line that was breaking down. The IoT devices were attached to the motors, conveyor belts and electrical systems. and then connected to a central monitoring system. The central monitoring system allowed the maintenance technician to identify and repair parts that were going bad before they failed and shut down the assembly line.

Scenario 2
Energy and Environmental Technologies

IoT is helping people save energy and make money savings decisions about their power usage. Smart meters that attach to buildings and connect to a smart energy grid have become the top IoT device among utility companies. Data from IoT energy smart meters can be sent to a mobile app to monitor how much power has been consumed. It allows people to know exactly how much they are spending so they only use what they can afford. Consumers can use IoT devices attached to appliances to turn off the power to appliances to reduce electrical waste and save money.

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Read More

- "IoT and Biotechnology: A Promising Technology Fusion for Sustainable Development," *Biotech Express Magazine*
- "The Relation between IIOT, SCADA, and HMI Explained," *Schneider Electric Blog*
- "Case Studies in Agtech Smart Farming"

NETWORK COMMUNICATIONS – INTERNET OF THINGS (IOT)

IoT Technician Competencies

- Designing and installing well-functioning computer networks, connections, and cabling
- Troubleshooting system failures and identifying bottlenecks to ensure network efficiency
- Testing and configuring software
- Maintaining and repairing hardware and peripheral devices

Cross-disciplinary IoT Skills

- Using sensors to collect information
- Transferring information to and from the cloud
- Analyzing information provided by internet-connected devices
- Storing information safely
- Applying appropriate digital communication protocols

Read More

IoT Case Studies: Companies Leading the Connected Economy

Workforce Domain Curriculum and Faculty Development Resources for IoT

Activity

This activity is designed to help students think about connected equipment and processes in their field of study. Begin with the guiding questions in the warm up. Students will identify connected devices and the tasks they automate, relative to their field, and illustrate the connections.

Warm-Up

- What equipment are we operating remotely?
- What processes are we monitoring?
- What types of equipment and devices need to communicate with each other?
- What are the critical parameters in which we are working?

Activity Steps

1. List three tasks from your field of study that have been automated
2. Describe how a technician monitors the process for safety, efficiency, and accuracy
3. Identify the central data hub (i.e., cloud, physical server, other)
4. Sketch a diagram showing the network of connected devices
5. Explain why the specific devices are connected.





ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

What Are Artificial Intelligence and Machine Learning?

Artificial Intelligence (AI) is software that allows computers to simulate human reasoning, learning, and problem solving. (source) Machine Learning (ML) is a type of AI that gives a computer the ability to identify patterns to make predictions and decisions without human assistance. (source) ML uses mathematical models of data to help a computer learn without direct instruction. Many consumer products and services, such as autonomous vacuums, navigation apps, and voice-controlled intelligent personal assistants rely on AI. STEM technicians in a variety of fields use AI and ML enabled equipment and processes, from exoskeletons boosting productivity in automotive plants to sensors that detect plant diseases or weeds and decide which chemicals should be applied in precision agriculture.

Vocabulary

- **AI chips**—semiconductors that are designed to handle the computation-heavy algorithms necessary for AI
- **Algorithm**—a series of steps followed in a specific order to perform a task; used to generate a Machine Learning model
- **Chatbot**—provides automated speech recognition and voice synthesis and carries out realistic conversations
- **Deep Learning**—a type of Machine Learning that enables computer systems to learn new knowledge and improve their functionality through experience rather than by being programmed
- **Neural Network**—a series of algorithms that are modeled after the connections in the human brain

How will technicians use AI and ML?

Imagine that every time you got in your car, the car remembered little things like how you took a corner or how you accelerated and braked. It remembered your driving habits and tailored future journeys based on past expeditions. When some machines operate over time, they remember what happened and adjust their next actions. This is how AI and ML enable predictive maintenance.

Manufacturing Scenario

Carlos is a Surface Mount Technician for a manufacturer of small surface-mounted electronic components. Equipped with those components, a pick and place machine that puts electronic components on the motherboard of your new cell phone, for example, might remember position, acceleration and deacceleration speeds, and vacuum nozzle data during the placement. If the vacuum head of the machine is not drawing the exact amount of air to pick up a part, the machine will stop and alert Carlos about the problem through its Human Machine Interface (HMI). Carlos can then stop the process and make adjustments or repairs, but this requires down-time of the machine. In limiting down-time, predictive maintenance is key. Using ML, the pick and place machine can predict there will be a problem even before it happens and alert Carlos to perform preventive maintainence. This saves the company money by minimizing the time the machine is offline.





ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

Skills Needed for a High-Paying Career

- Basic programming
- Using probability and statistics
- Modeling and evaluating data
- Coding simple algorithms
- Employing analytical thinking skills
- Computational thinking
- Applying Machine Learning algorithms

Education

Your local community college provides the advanced technology classes you will need to get started. Currently there are very few associate degree programs in AI, but many of the skills needed are taught within Information Technology or Computer Information Systems programs. You will also find the skills applicable in a variety of technical specializations, such as biomedical, energy, environmental, and engineering technologies. Community college course schedules are designed to accommodate the needs of working students and often include online and hybrid delivery formats. Find your nearest community college here.

Future Trends

The future of Artificial Intelligence and Machine Learning include:

- AI and ML models using expanded datasets
- Increased use of no-code ML
- ML technology offered through the cloud
- AI- and MI-enhanced cybersecurity
- Advanced applications using Natural Language Processing
- Emphasis on ethical and responsible AI
- Connected AI systems enabling ML algorithms to learn continuously
- AI-fueled technology advancements in transportation, healthcare, education, and customer service

Learn More

- Artificial intelligence (AI) vs. machine learning
- Can a neural network learn to recognize doodling?

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ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

What Are Artificial Intelligence and Machine Learning?

Artificial Intelligence (AI) is the simulation of human cognitive processes: learning, reasoning and self-correction. (source) Its foundations include mathematics, logic, philosophy, probability, linguistics, neuroscience, and decision theory. Many technologies use AI, including computer vision, robotics, machine learning, and natural language processing.

Machine Learning (ML) is a subfield of artificial intelligence. Its goal is to enable computers to learn on their own. A machine's learning algorithm enables it to identify patterns in observed data, build models that explain the world, and predict things without having explicit pre-programmed rules and models. (source)

AI and ML Competencies

- Using probability and statistics
- Modeling and evaluating data
- Coding simple algorithms
- Employing analytical thinking skills
- Computational thinking
- Applying Machine Learning algorithms

Cross-disciplinary Skills

- Basic programming
- Using statistical methods
- Data analysis
- Communicating effectively with diverse audiences
- Upholding ethical computing principles

Security Technology Scenario

Tiffany, a Network Technician working with the IT security department at a small company, was assigned to automate the manual tasks involved in monitoring the hundreds of networking devices. Each of the networking devices keeps a log or text file of the status of the network devices. When a security incident occurs the network device logs the attack. Without automation, several employees have to view each network device's log to react to the attack and protect the network. Tiffany installed a Machine Learning application that not only checked each log but also automated the steps necessary to defend the network. ML can also provide predictive analytics to enable early detection and remediation of threats.

Agriculture Technology Scenario

Maelynn is an Agricultural Technician for a major soybean producer. The company is instituting a Precision Agriculture Strategic Plan to use technology to conserve resources, such as fertilizer and water, while increasing crop yields and profitability. As part of this plan, Maelynn was tasked with finding new ways to identify unhealthy plants. She partnered with a data science technician to accomplish this by using a combination of drones and AI software tools. Drones were used to take photos of the soybean fields. The photos were assembled by GPS location and evaluated for dark or unhealthy leaves. The AI tools allowed the software to pinpoint the unhealthy plants in the pictures and send that GPS information to an autonomous tractor in the field. Instead of the autonomous tractor spraying the entire field, the AI software directed the sprayer to only cover the areas where the plants were not healthy. This AI process not only saves the company money on chemicals and water but is also better for the environment.

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

Activity

Students will investigate how Artificial Intelligence (AI) and Machine Learning (ML) could be used to solve problems in their field of study. To begin, they will develop a specific recommendation for how machine learning could contribute to solving one of these problems. Then, they will consider the training data an AI system would need to make this possible.

Warm-Up

Review the definitions of AI and ML. Watch the video Artificial Intelligence Explained in 2 Minutes, followed by Deep Learning to help students think about ways that AI and ML help society solve problems. Explain that today's activity will give them the opportunity to discuss this in the context of industries where technicians work.

Activity Steps

1. Tell students that they will investigate the potential of AI and ML in their field of study. Explain that the goal is to explore one problem where AI or ML technology has potential to innovate.
2. Have students work in pairs to identify a problem in their career field that might be solved using AI or ML.
3. Give students 20 minutes to conduct research on their problem.
4. When there are about 10–15 minutes left in the class period, allow each pair to share their findings.

Tools Available

- Try AutoML Google Cloud
- Scikit-Learn Machine Learning in Python
- Teachable Machine with Google

Read More

- What is Artificial Intelligence?
- An Introduction on Artificial Intelligence and Machine Learning
- Bytes of AI: Short Curriculum

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Preparing Technicians for the Future of Work, funded by the National Science Foundation Advanced Technological Education program, recognizes that technicians need an expanded skill set to remain competitive. The project's Framework for a Cross-Disciplinary STEM Core outlines recommendations for incorporating knowledge and skills in Advanced Digital Literacy, Data Knowledge and Analysis, and Business Knowledge and Processes. Learn more about implementing the Framework at preparingtechnicians.org.

AUTOMATION, ROBOTICS, AND HMI

What Are Automation, Robotics, and HMI?

Automation and robotics are the design, construction, operation, and use of robots, as well as computer systems for their control, sensory feedback, and information processing. These technologies are used to develop machines that can substitute for humans and replicate human actions.

A Human-Machine Interface (HMI) is a panel that that allows a human to control a machine. On modern machines, the interface is often a touch screen like an iPad. The HMI found in industrial environments is software that controls hardware and allows an operator to control machines.

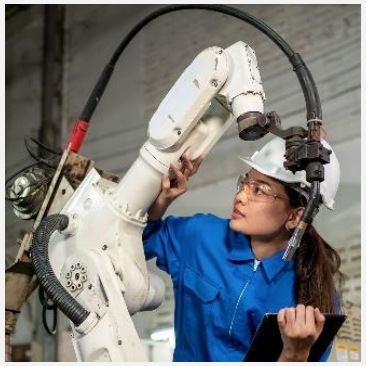
Vocabulary

- **Collaborative robot (cobot)** — robots that can safely work near humans and are intended for direct human-robot interaction
- **Input/Output** — HMI devices or software applications that allow technicians to program and control robots
- **Mechatronics** — a field of study integrating electronics, mechanics, pneumatics, hydraulics and computer controls
- **Pick and place** — a repetitive part transfer task composed of a picking action followed by a placing action
- **Teach pendant** — a hand-held input device with which a robot can be programmed or moved

Automation, Robotics, and HMI

Technicians working with automated systems will use a combination of mechatronics skills such as computer programming and electromechanical knowledge.

Tammy works for a small manufacturing company that designs and creates customized metal parts for the shipping industry. The metal parts are cut and bent from a large piece of steel on a human operated machine then welded by hand. The owner asked Tammy to find out whether a robotic system would make the work safer, faster, and more precise. She met with several companies to discuss the options and cost of implementing robotics on the manufacturing floor. After months of research, the company purchased eight robots to automate the cutting, bending, and welding. Tammy and the technicians that had been doing the work manually were sent to robotics training so they could configure and code the robots using a coding language called Python. After several months of training, the robots were installed, and Tammy was made Production Lead to ensure they were successful. The staff appreciated that the company trained them to maintain the robots and did not eliminate their positions. After the robots were in place for about six months, the company realized a huge cost savings due to the increase in the number of parts that could be assembled during a shift and a significant reduction in parts that did not meet the quality checks.







AUTOMATION, ROBOTICS, AND HMI

Skills Needed for a High-Paying Job

- Applying general mechanical knowledge
- Troubleshooting automation systems
- Interpreting data read-outs from HMIs
- Installing, maintaining, and repairing hardware and peripheral devices
- Programming industrial robots and cobots

Education

Your local community college provides the advanced technology classes you will need. Skills for building and maintaining robotic systems within Automation, Robotics, HMI are most often taught within Mechanical and Robotics Engineering, Information Technology, or Computer Information Systems programs offering associate degrees and one-year certificates. You will also find the skills applicable in technical specializations, such as biomedical, energy, environmental, and engineering technologies. Community college course schedules are designed to accommodate the needs of working students and often include online and hybrid delivery formats.

Find your nearest community college here or search for robotics programs here.

Future Trends

As the adoption of Industrial Internet of Things (IIoT) Industry 4.0 technologies grows, automated systems and their infrastructure will become more sophisticated. Current and future career opportunities include working with:

- Complex sensors that collect more data
- Informatics to translate data into knowledge
- Industry and government cybersecurity
- Dynamic mesh computer interface architecture
- Artificial Intelligence applications
- HMI graphics creation
- Collaborative robots

Learn More

- Here Come the Cobots!
- Robotics Skills, Robotics Careers
- Automation: A Positive Force in the Power Sector
- Understanding the What and Why of HMI

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AUTOMATION, ROBOTICS, AND HMI

What Are Automation, Robotics, and HMI?

An industrial robot is machine controlled by an internal or external computer that can carry out a complex series of movements automatically. Robotic process automation (RPA) is the use of software with artificial intelligence (AI) and machine learning capabilities to handle high-volume, repeatable tasks that previously required humans to perform. (source)

A Human Machine Interface (HMI) is a software application that presents information to an operator about the state of a process and accepts and implements the operator's control instructions. Typically, information is displayed in a graphic format. (source)

Technician Competencies

- Installing and programming automation or robotic systems equipment and HMI software
- Troubleshooting automated production or robotics systems
- Determining causes of operational problems or failure
- Disassembling and reassembling robots or peripheral equipment to make repairs
- Maintaining service and operational records

Cross-disciplinary Skills

- Installing sensors to collect information
- Programming for updating and modifying equipment
- Analyzing information and diagnostics provided by internet-connected devices
- Organizing and communicating information effectively
- Storing data securely

Energy Scenario

Stephanie is a Smart Meter Technician for her local power company. She is responsible for troubleshooting and repairing Smart Meter systems for local commercial and industrial customers. One of her customers, the management company for a 10-story office building, called Stephanie to come to check out their Smart Meter system since it was reporting an error message. Smart Meters enable two-way automated communication between the power company and the customer, the customer and energy suppliers, and are to regulate electricity usage. Smart Meters record energy near real-time with automated communication between the meter and the energy suppliers, allowing it to adjust throughout the day. This enables her customers with better clarity about their energy usage and help them make better business decisions. This is essential for commercial and industrial companies given the amount of energy it takes to run their companies. After troubleshooting the error message, Stephanie was able to fix the problem with the Smart Meter within an hour.

Supply Chain and Logistics Scenario

Oliver, an Agricultural Technician, works at a facility that stores animal feed in large silos needed. He was searching for a way to remotely monitor, analyze, and mix the animal feed since the existing method was manual and time intensive. Oliver had to climb into each silo and physically check the level of the animal feed. The company also provides customized animal feed mixes from multiple silos. Customizing the animal feed required several workers using conveyor belts and it was often mixed improperly. Oliver researched several options that provided a visual representation and remote control for each silo and the conveyor systems. The best option was to install sensors and controls at the industrial facility and attach them to an HMI that can be programmed to display the status of each silo. From one HMI panel a single person is now able monitor and control all the silos and conveyors.

AUTOMATION, ROBOTICS, AND HMI

Activity

This activity asks students to explore industries that are early adopters of robotics and automation and one that has potential for transformation—the construction industry. Begin with the guiding questions in the warm-up. Students will identify familiar HMIs and the tasks they automate, relative to their daily lives and their fields of interest.

Warm-Up

Review the definitions of Automation/Robotics/HMI and the scenarios from the industries they discussed in class.

- Ask students in groups of 3-4 to list the HMIs they encounter on a daily basis.
- What automated processes are the HMIs connected to?
- What graphics do the interfaces display?

Activity Steps

1. Ask students to identify tasks within their technical field of study that used to be performed manually and are now automated.
2. Have student read Top Five Industries That Will Be Transformed by Robotics and Automation. Divide the class into five groups and assign each group an industry. Have them discuss how robotics and automation are transforming the way these industries do business and the changing role of technicians.
3. Have students watch the video What If We Automated Construction?

Discussion questions for the whole group:

4. How do automation and robotics have the potential to transform the construction industry?
5. Why do you think certain industries have been slower to adopt these technologies vs. the ones we read about?
6. What are three technician tasks that have be made safer and more productive using automation and robotics?

Tools for Learning About Robotics

Learn to code basic robot actions on a simulated robot. Complete the interactive learning experience at RoboMind Academy. Hour of Code is recommended for beginners.

Read More

- Top 10 Industrial Automation Trends in 2021
- Understanding the What and Why of HMI
- How IoT and Robotics are Evolving Benefit to the Supply Chain

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BASIC PROGRAMMING: PYTHON

What is Python and how is it related to basic programming?

Basic programming tells a computer what to do using a language (code) it understands. One easy-to-learn programming language is Python. It uses open-source code that can run on a variety of computer systems. Technicians use Python for a variety of applications, including data analysis and visualization, automation, web and mobile app development, software testing and Machine Learning.

Vocabulary

- **Debugging** – the process of finding and removing programming errors
- **Object** – a group of related functions and variables combined into a unit
- **Object-oriented programming** – code written using objects that interact with one another
- **Python Enhancement Proposal (PEP 8)** – a style guide for writing Python code
- **Repository** – a digital archive where all of the files for a project or application are stored along with the history of all changes made to those files
- **Software library** – a digital collection of reusable code developed for specific purposes and shared with programmers
- **Statement** – single line of code written that expresses an action to be carried out
- **String** – a sequence of characters
- **Syntax** – set of rules on how statements can be arranged in order for the program to run
- **Web framework** – a collection of code which allows developers to write web applications more easily

How will technicians use Python for basic programming?

Jamal is Geospatial Information System (GIS) Technician for a civil engineering firm. He is a member of a project team that assists energy and utility clients with where to place power and sewer systems in new commercial developments. Jamal is responsible for the data management and analysis for the team. He had been using Excel but after conducting research on other available tools, he wanted to use Python since it is a more powerful than Excel and is easy to learn. Python has a library called Pandas that is specifically for data management and analysis. Jamal discussed this with the GIS Analyst on the team, who supported this approach. Jamal participated in a coding bootcamp and was able to successfully transition to using Python for his data responsibilities. He found it easy to understand and use and will be demonstrating how he uses Python with the GIS Technicians on other teams at the company.

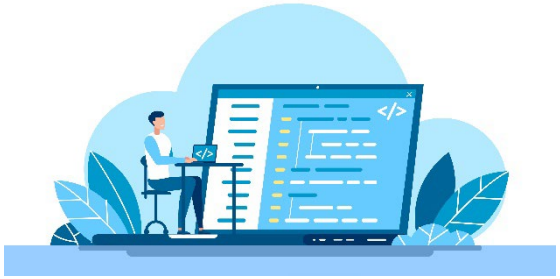




BASIC PROGRAMMING: PYTHON

Skills Needed for a High-Paying Career

- Applying the core concepts of basic programming
- Selecting the Python libraries that match desired outcomes
- Using Python for data analysis
- Thinking critically and asking questions



- Identifying and solving problems
- Communicating effectively with a variety of audiences

Education

Your local community college provides the advanced technology classes you will need. Skills for basic programming and Python are most often taught within Information Technology or Computer Information Systems programs offering associate degrees and one-year certificates. You will also find the skills applicable in technical specializations, such as advanced manufacturing, cybersecurity, biomedical, energy, environmental, and engineering technologies. Community college course schedules are designed to accommodate the needs of working students and often include online and hybrid delivery formats. Find your nearest community college here.

Future Trends

The future of Python will include using it for:

- Artificial Intelligence (AI) and Machine Learning (MI) – With its libraries and frameworks, Python is helping to advance the science of emulating humans
- Cybersecurity – Python can perform a multitude of security tasks, protecting critical systems and information from digital attacks
- Automation – Python will continue to automate tasks traditionally performed by humans
- Data science – With its powerful capabilities, hundreds of libraries and frameworks, using Python for data science will continue to grow
- Blockchain development – Python can be used to create a digital public leger that records online transactions, keeping them secure

Learn More

- Code Academy's Learn How to Code: Basics of Programming
- What is Python Used For? A Beginner's Guide

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BASIC PROGRAMMING: PYTHON

What is Basic Programming in Python?

Basic programming is the set of instructions given to a computer to solve a problem or carry out tasks. This is done through a language it understands called code. Python is a an open-source high level programming language that is free to use for personal or commercial applications and can run on Mac, Windows, Lenox, and Unix systems. Python is beneficial tool for technicians since it is easy to learn and can be used for data analysis and visualization, automating tasks, app development and for writing Machine Learning algorithms.

Basic Programming: Python Competencies

- Applying the core concepts of basic programming
- Selecting the Python libraries that match desired outcomes
- Using Python for data analysis
- Thinking critically and asking questions
- Identifying and solving problems

Cross-disciplinary Skills

- Writing basic programming code
- Applying principles of Machine Learning
- Using statistics
- Analyzing and visualizing data
- Communicating effectively with a variety of audiences
- Continuously improving products, services, or processes

Supply Chain and Logistics Scenario

Don is a Logistics Technician at a temperature-controlled warehouse that stores and delivers food products to local social service agencies, hospitals, and school systems. He is responsible for the computer system used for scheduling, assigning, and routing multiple drivers to serve customers with unique priorities, service time windows, processing times, and geographical locations. Don tried using an off the shelf scheduling and routing system, but it was not providing the flexibility he needed. Don was able to develop a highly targeted software application using Python programming that addressed the unique needs of his company. Not only did this help optimize processes, but given that Python is free and open source, it saved his company money from having to use another off the shelf system.

Biotechnology Scenario

Amara is Biotechnology Technician at an oncology laboratory where they are researching cures for cancer. Amara is part of a team that is piloting bioprinting. Bioprinting is a special type of 3D printer that uses cells and natural or synthetic biomaterials to print layers of living tissue. This approach enables the company to test drugs without having to rely on organ donations or test on humans or animals. This is an emerging field and Amara is excited be part of the team. Given her daily experience with managing and analyzing data, she will be setting the printing parameters and speed, which will need to consider a wide number of variables. She will be using Python programming and researching how she might be able to utilize the PyBioMed library.

BASIC PROGRAMMING: PYTHON

Activity

This activity is designed to provide students the opportunity to explore options for learning Python programming. They will watch a video, read an article, discuss how technicians are using Python, and then select an option for learning Python programming if they choose.

Warm-Up

Review the definition and basic terms for Basic Programming – Python. Have students watch What is Python? Why is it so Popular? Ask the students if they have tried Python programming, and if so, to share their experiences. Discuss how technicians such as those depicted in the scenarios use Python and ask whether students have seen Python used in their fields of study.

Activity Steps

1. Explain that for learning a programming language, our learning styles vary. Some people prefer learning independently through tutorials or videos, whereas others may want to take a class online or in person. Students will have the opportunity to explore options and select one that would be the best match should they need or want to learn Python programming.
2. Have students read Top 13 Resources to Learn Python Programming all the way through.
3. Next, have students skim over the 13 resources and jot down 2-3 that align to their learning style and level of experience with Python programming.
4. For each of the 2-3 selections, student should go to the websites and explore what each approach has to offer.
5. Students select one that is the best match.
6. In groups of 3-4, have students share and explain their best approach for learning Python.

Tools Available

- Python Tutorial Topics
- Microsoft's Python for Beginners (free video series)
- Code Academy's Learn Python 3

Read More

- What Is Python Used For: 10+ Coding Uses for the Python Programming Language
- Why Learn Python? Six Reasons It's So Hot Right Now

ABOUT THE PROJECT

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DIGITAL TWINS

What are digital twins and how are they related to Advanced Digital Literacy?

A digital twin uses a combination of technologies — industrial internet of things (IIoT) technologies, machine learning, sensors, and artificial intelligence— to create a virtual replica of a physical machine. It gathers and analyzes data to predict the impact of actions on that machine and its output. This means that a digital twin can run a simulation to answer questions about what might happen under specific conditions. For technicians, digital twins can improve efficiency and predict problems before they occur. (source)

Vocabulary

- **Artificial Intelligence (AI)** – the computer science involving software that imitates human decision-making, learning, and problem-solving processes
- **Internet of Things (IoT)** – a combination of digitally connected sensors, software, and electronics ("smart" devices) that connect to a central location and communicate with one another; humans often monitor and control using a dashboard on a computer or an app on a mobile device
- **Machine Learning** – the ability of a computer to analyze its own data, identify patterns, make predictions and decisions, and learn from the outcomes of those decisions without human assistance

How will technicians use digital twins in the workplace?

Ahmed is a Supply Chain Technician for a large warehouse that fulfills orders for replacement computer components. Ahmed's company had been receiving many complaints from customers about parts not arriving on time or receiving incorrect parts. He was searching for a more efficient way to identify potential problems before they impacted the customer. He had an inventory management system, but it was limited and did not take into account the bigger picture of the company's whole supply chain. He needed something that would not only provide an overview of the flow of parts to his warehouse but also predict production and transportation bottlenecks that might interfere with on-time delivery.

Ahmed researched a technology vendor that could partner with his company to build a digital twin connecting his inventory and operational data to a virtual model of the facility that would include data on the size, quantity, location, and demand for every item needing production, receiving, storage, and shipping. He was able to bring data from a variety of sources into one system where he could retrieve a complete view of suppliers, his inventory, and other details. The digital twin provided an in-depth view via real-time dashboards using advanced analytics fed to a cloud server. Ahmed was able to input process variables and the digital twin could run a virtual simulation and flag potential problems. This allows Ahmed to anticipate potential problems and adjust processes before the problems occur.

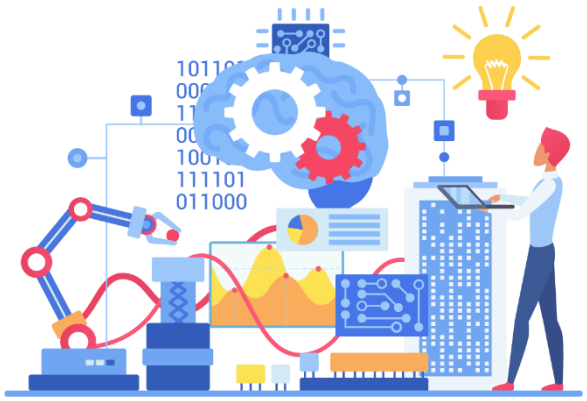




DIGITAL TWINS

Skills Needed for a High-Paying Career

- Troubleshooting wired and wireless networking protocols
- Implementing cybersecurity protocols
- Operating industry-specific technology
- Interpreting data generated through predictive analysis and adjusting processes appropriately
- Applying basic principles of artificial intelligence and machine learning



Education

Your local community college provides the advanced technology classes you will need. Digital twin technology requires a variety of skills which are taught within Electronics Engineering Technology, Computer Information Science, Data Analytics, or Advanced Manufacturing programs offering associate degrees and one-year certificates. Digital twins have applications in many technical fields such as cybersecurity, biomedical, energy, environmental, geospatial, logistics and engineering technologies. Community college course schedules are designed to accommodate the needs of working students and often include online and hybrid delivery formats. **Find your nearest community college here.**

Future Trends

The adoption of digital twins by diverse industries is expected to grow exponentially over the next five years. The technology will continue to evolve with:

- Highly sophisticated and powerful simulations
- Continuous real-time monitoring
- Use of quantum computing
- Integration of systems and data across entire digital ecosystems

Learn More

- Digital Twins (podcast)
- What is a Digital Twin? How Does It Work? (video)

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DIGITAL TWINS

What are Digital Twins?

IBM explains that "a digital twin is a virtual representation of an object or system that spans its lifecycle, is updated from real-time data, and uses simulation, machine learning and reasoning to help decision-making." (source)

A digital twin models the functions of the real-world object or system. Sensors are attached to the physical product and monitor the numerous states of the system during its operation. Data is collected via telemetry and is transmitted to the digital twin where it will be analyzed in real-time. By using machine learning and artificial intelligence, the model can help in predictive analysis, data analytics, troubleshooting and performance.

Digital Twins Competencies

- Applying wired and wireless networking protocols
- Implementing cybersecurity protocols
- Operating industry-specific technology
- Interpreting data generated through predictive analysis and adjusting processes appropriately
- Applying basic principles of artificial intelligence and machine learning

Cross-disciplinary Skills

- Basic programming
- Using sensors to collect data
- Analyzing and visualizing data
- Applying continuous process improvement
- Communicating to internal and external stakeholders

Manufacturing Scenario

Roseline is a Manufacturing Technician for an original equipment manufacturer (OEM) that supplies sensors for an autonomous vehicle manufacturer. This is exciting work for Roseline and something she set out to do after she learned about self-driving cars from a Girls in STEM program in high school. After earning her AAS degree in advanced manufacturing, she secured a position as part of her company's ceramic sensor production team. The end user of her company's sensors has remained at the forefront of autonomous vehicle manufacturing through its use of digital twin technology. By utilizing digital twins, engineers at the vehicle manufacturer can simulate and validate each step of vehicle design, prototyping and development to identify problems and possible failures before producing real parts. Roseline was able to job shadow with the engineering team and found it fascinating to witness how the digital twin was used to test ceramic sensors against conditions such as minute changes in temperature or oxygen levels in real-time. With her associate degree, Roseline has the knowledge and skills to interpret data provided on the dashboard, but she plans to earn her bachelor's degree in engineering so she can continue to advance her skills in the autonomous vehicle manufacturing industry.

Renewable Energy Scenario

Daniel is a Wind Turbine Technician in Nebraska where he is part of team that is responsible for the maintenance and repair of the several hundred wind turbines on his company's wind farm. The company began using digital twin technology last year to predict how turbines function under specific weather conditions and how soon they would need repair. Each wind turbine has multiple sensors which feed data to condition-monitoring systems that then transmit real-time data to a digital twin. Technicians at the company monitor the digital twins and determine overall turbine health using that data and data from other sources that feed into the digital twin. In the past, Daniel would have to repair a turbine in the middle of the night, but since his company started utilizing digital twins, Daniel is able to do his work at scheduled times during the day. The digital twins predict problems before they occur, which enables Daniel's company to prevent significant turbine downtime, increase energy production maintain customer satisfaction.

DIGITAL TWINS

Activity

This activity is designed to help students think about the impact of digital twin technology across industries with significant transformation expected in the next few years. Students will watch a video that describes this transformation in the warm-up, explore use cases for a variety of industries, write their own use cases based on their individual career plans, and share the cases in pairs or small groups.

Warm-Up

Have students watch the video Why Digital Twins Will Be the Backbone of Industry in the Future. Then ask them to explain, in their own words, how digital twins will significantly transform nearly every industry in the future. Point out that trends are pointing to the "future" as being within the next 3-5 years.

Activity Steps

1. Glance over some of the use cases for digital twins technology: 15 Digital Twin Applications: Use Cases by Industry.
2. Select an industry related to your field of study. Be specific. For example, if you are studying to be a manufacturing technician, select the type of manufacturing (e.g., electronics, food products)
3. In 2-3 paragraphs, write your own "use case." Describe how digital twins might be used in your industry.
4. Think about how this impacts technician roles.
5. Share with a partner.

Tools Available

- Microsoft Azure Digital Twins Software (free trial)

Read More

- What is a Digital Twin?
- What is a Digital Twin and Why is it Important to IOT?
- Digital Twins: Bridging the Physical and the Digital

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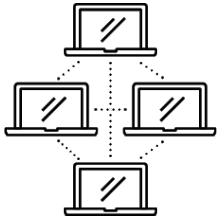
NETWORK ARCHITECTURE

What Is Network Architecture?

Network Architecture is the physical organization and logical design of software, hardware, protocols, and transmission media (wired or wireless). In a network, any connected device with an IP address is called a host. A host is called a client when it is requesting information, a server when it provides information, and a peer when it is able to both request and provide information.

The two most common types of network architectures are:

Peer-To-Peer networks consist of two or more computers linked to facilitate the sharing of information.



- All computers handle tasks and can communicate with each other.
- Small environments (10 or fewer computers)
- No dedicated server

Client/Server networks are configured so that clients access data from a server.

- Clients do not share data with one another directly.
- The server manages all the data, the network, and security.
- Clients communicate with server to request and receive permission to access data.

Vocabulary

- **Hub** – a device that has multiple ports for ethernet cables connecting devices and sending all of them incoming data
- **Logical network diagram** – graphic showing the flow of information through a network
- **Nodes** – connection points in a network (e.g., computers, printers, modems)
- **Protocol** – rules that govern how computers communicate with each other
- **Router** – a networking device connecting devices to each other and the internet
- **Transmission media** – the communication channel between computers

How will network architecture be used in the workplace?

Juan is an HVAC Technician who works with industrial customers who require troubleshooting, repair, and replacement of their HVAC systems. Juan is on the road servicing customers. After he completes his work at each site, he returns home to complete his work log using software installed on his work laptop. He has a router set up to provide high-speed Internet so that his computer can communicate with his company's server to relay this information. Juan's company uses a Client/Server Network so that HVAC technicians can complete their work logs remotely and the completed logs are available to his supervisor and others to view from the corporate office and/or remote locations. This is essential for record-keeping of company compliance with regulations. For example, when Juan replaces HVAC equipment and needs to dispose of the old equipment, the Environmental Protection Agency (EPA) requires a report from the company listing the amount and type of refrigerant disposed. The company's Health & Safety Manager has access to this information through the Client/Server Network and can complete the monthly EPA report.





NETWORK ARCHITECTURE

Skills Needed for a High-Paying Job

- Consulting on network design
- Configuring software on the hosts and infrastructure devices
- Maintaining and repairing host and infrastructure devices
- Preserving high levels of network security
- Troubleshooting network infrastructure problems
- Communicating network access and usage policies
- Staying informed about new network technologies

Education

Your local community college provides the advanced technology classes you will need. Skills for planning and designing communications networks are most often taught within Computer Information Systems programs offering associate degrees. Network architecture skills are also important in other technical fields such as cybersecurity, energy, and engineering technologies. Community college course schedules are designed to accommodate the needs of working students and often include online and hybrid delivery formats. Find your nearest community college here.

Future Trends

The future of network architecture includes:

- Cybersecurity mesh (security perimeter around a person or thing)
- Software-defined networking (SDN) and network functions virtualization (NFV)
- Use of networks as sensors to report and remediate system issues
- Autonomous networks that run, repair, and report without human interaction
- Edge computing (processing data closer to where it originates)
- Expansion of cloud platforms

Learn More

- Basic Networking Concepts-Beginners Guide
- Computer Network Architecture

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NETWORK ARCHITECTURE

What Is Network Architecture?

A network links two or more host devices to facilitate the sharing of information. These networks can be self-contained Local Area Networks (LANs) which are typically in the same building or Wide Area Networks (WANs) which allow organizations to communicate globally. Network Architecture is the design, implementation, and management of four elements that comprise a network.

1. Something to share — the **Services**
   - Documents, databases, media content, messaging, collaboration (using tools such as Zoom)
2. Physical pathways through which the services can be shared — the **Infrastructure**
   - Physical media (twisted pair cable, coaxial cable, or fiber optics) or wireless (WiFi, cellular or satellite)
   - Devices (routers, switches, and access points)
3. Rules to manage the flow of a service's data through the infrastructure — the **Protocols**
   - A common "language" that the hosts and devices use to pass data through the network
   - Security policies and safeguards to protect the data on the network
4. Devices that provide and/or use the services that are to be shared — the **Hosts**
   - Server/Client network model where servers provide network services and clients use the network services
   - Peer-to-Peer network model where most hosts are functioning as both a server and client

Biotechnology Scenario

Sofia is a Biotechnology Technician hired as part of a nationwide research team studying biofuels. Her work in the lab will involve conducting experiments using high tech equipment with specialized software to transfer data from the equipment directly to a database. Her team also needs to share and access data from other biofuels labs across the country. Her lab manager hired a company to design and build a Client/Server network with cloud storage and asked Sofia to brief their network architect on the project's current activities and anticipated network needs. With Sofia's input, the network architect was able to design, build, and configure an integrated network using a diverse set of infrastructure devices, a combination of protocols, and multiple networking services. She also worked closely with the network security administrators to make sure it and all the data that passes through it are secure.

Manufacturing Scenario

Blake is a Controls Technician at a heavy equipment assembly plant and has recently received approval from his supervisor to work from home two days a week using remote monitoring software that he can access via the Internet, 24/7. There is currently poor Internet access where he lives, but a state agency bringing broadband technologies to rural areas has dispatched Keisha, a Broadband Technician, to set up the network infrastructure to remedy that situation. At Blake's house, she installs a small utility box called an optical network terminal (or ONT) inside the home attached to a wall. She then installs cable from a nearby equipment box outside to the ONT, which typically requires running cable along floors or the ceiling inside the home. Once the cable work is done, Keisha sets up the router which connects to the ONT. Before she leaves, she tests the internet connection and confirms that Blake knows how to connect via Wi-Fi to the router from his computer and other devices. After following his company's security protocols for logging in, he can now access real-time sensor data from his home office.

NETWORK ARCHITECTURE

Activity

This activity is designed to help students visualize the basic structure of a network. Begin by showing a network diagram. Next, the students will watch a video on designing a small business or home network. Then they draw their best rendition of how the network is set up at their home or potentially could be designed.

Warm-Up

Review the vocabulary and concepts provided on the student card, then display this diagram of a network: Visual Paradigm Online. Ask student pairs to identify the familiar components of the network shown in the diagram:

1. Identify the network infrastructure and whether it uses physical or wireless media
2. Identify the infrastructure devices (routers, switches, and access points)
3. Identify the hosts (computers, printers, and multimedia devices)
4. Identify the network services used by hosts (file, print, messaging)

Activity Steps

1. Ask students to think about the networks that they are familiar with in homes, classrooms, and workplaces.
2. Have them watch this video, Designing a Basic Small Business or Home Network (5:44), that demonstrates the options for how a small network can be configured.
3. Ask them to reflect on a network discussed in Step 1 and then draw a rough diagram of it.
4. Students can then share and explain their diagrams.

Network Archicture Competencies

- Designing and installing computer networks, connections and cabling
- Troubleshooting system failures and network infrastructure problems
- Configuring software/firmware on the hosts and infrastructure devices
- Maintaining and repairing host and infrastructure devices
- Preserving high levels of network security
- Staying informed about new network technologies

Cross-disciplinary Skills

- Collaborating with others
- Communicating network access and usage policies
- Following industry-specific regulations related to security
- Seeking ongoing process improvements

Read More

- The Fundamentals of Networking

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