Lesson Overview	Career Highlight
Students will be introduced to different types of artificial intelligence and machine learning algorithms, including those used to operate space-based platforms (such as satellites). Students will then learn about jobs relating to the building and continuous improvement of machine learning tools. Throughout this lesson, students will be engaged in mini activities that include learning about coding, problem solving, and working in teams to build their communication skills. By the end of the week, students will play an interactive game to save the world! In teams, students will take on the roles of engineers and scientists to identify and solve anomalies and errors encountered by a deployed satellite system. Together, students will resolve these errors, assigning each to the right STEM professional to make sure that critical data collected by the satellite are sent back to Earth to be used in making high-consequence decisions.	**Guidance, Navigation and Control Engineer**: Designs, manufactures, and tests systems for aircraft/spacecraft. **Flight Dynamics Officer/ Engineer**: Responsible for trajectories, flight paths, and orbital mechanics. Makes sure all parts follow the correct path and physics. **Systems Engineer**: Works with all teams, manufacturers, and designs to ensure product works as advertised. **Communication Engineer/ Specialist**: Researches and designs methods of communication in space with Earth. **Computational Analyst**: Calculates how much memory, data, and what type of data/computer processing will be needed for scenarios.

STEM Course Connections	21st Century Skills	CTE Alignment
High School Engineering High School Earth & Space Science	Collaboration Communication Critical Thinking	Engineering and Design Industry Sector (ED)

Materials

- Paper
- Pencil
- Student Handout

Essential Questions

1. What is Artificial Intelligence? Is machine learning just another word for the same thing?
2. What careers are centered around development and the control of AI and machine learning?
3. Why is AI important to me? What do I use day-to-day that depends on AI and machine learning?
4. How is AI used in space, specifically with satellites?

Prerequisite Knowledge

Concepts developed in a previous lesson, Robotic Satellites, may help students with understanding this lesson, but it is not a necessary prerequisite lesson.

Day 1: *Understanding AI Around Us*

Teacher Note: Students will participate in brainstorming information about where Artificial Intelligence (AI) can be found in their daily lives. They will be introduced to the definitions of AI and Machine Learning (ML).

Section A - What is Artificial Intelligence? (10 mins)

- Teachers will start the lesson by asking students the following introduction questions:
    1. Have you heard the words Artificial Intelligence or AI? *Answers will vary.*
    2. What is AI? *Artificial Intelligence is the science of making machines (like computers or robots) think like humans.*
    3. Can you list things in your life or household items that you interact with that might utilize AI? *Alexa, Siri, Google Maps, Uber/Lyft, Email, Watches, Vacuum, Fitness Mirror, Video games, Thermostats, Ring Camera, Social media, chatbots, etc.*
- After the introductory conversation, teachers will explain to students that Artificial Intelligence is the science of making machines, like computers or robots, "think" like humans. Humans process data to make predictions or do something useful, and we can train a computer to do the same.
- Teachers will then show students a short video and listen to the blog on the definition of AI

Section B - What is Machine Learning? (5 mins)

- Teachers will lead a group discussion on the term Machine Learning. Teachers will then ask students the following guided questions.
    1. What image comes to mind when you hear the term machine learning? *Algorithms, or any variety of science fiction answers.*
    2. Do you think it is the same as AI? OR does AI use Machine Learning? *Answers will vary.*

Teacher Note: Machine Learning is a subfield of AI Just like students in school, machines are given directions, lessons, and answers to questions in order to one day be able to think on their own. Computers and robots can learn to "think"on their own by analyzing data and memorizing algorithms. This video may be helpful, and this gives an example of weather prediction.

- Teachers will then show students a short video to clarify the difference between AI and Machine Learning.
- Teachers will hand out the Student Handout for Day One, "Where's AI?!". Students will work independently, in small groups, or as a whole class. Students will use this resource to map the relationship between AI and ML in Section B of the Student Handout. They will continue to use this diagram in Section B as their note taking strategy.

Section C - Mini-Activity, "Where is AI?!" (10-15 mins)

- The objective is for students to provide examples of household items and objects at school that use AI and Machine Learning.
- Teachers will prompt students to think about times they have encountered AI or Machine Learning in their own lives. The objective is for students to provide examples of objects that use AI and Machine

Learning both inside and outside of school.

- What are some examples of AI or Machine Learning that you have seen in school? *Facial recognition on iPads, Chat GPT*
- What are some examples of AI or Machine Learning that you have seen at home? *Alexa, Siri, Self-Driving Cars, Google Maps, Uber/Lyft, Email, Watches, Vacuum, Fitness Mirror, Video games, Thermostats, Ring Camera, Social media, chatbots, etc.*

Day 2: *How do Satellites "Wave?"*

Teacher Note: Students will perform basic research of satellites, their orbits, specific jobs they perform, and how they relay information back to Earth. Background information Satellites: The Story of Satellites video. Other background resources for students and teachers can be found at Inmarsat.

Section D - What is a Satellite? (10 mins)

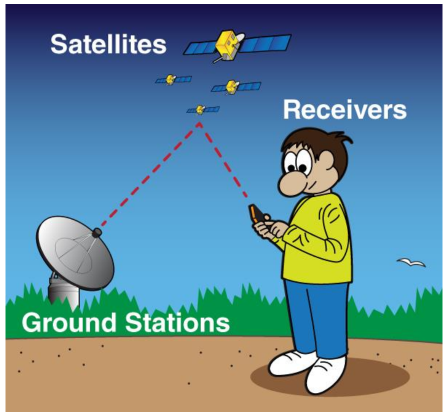
- Teachers will share a video to elicit conversation on how cell phones work. The script prompts the teacher to stop the video and have students discuss how the text messages they create on their phones can be transmitted to another phone.
  - Pause screen 1: Have students think, pair, share on how messages go from one phone and are delivered to the correct phone.
  - Pause screen 2: Have students think, pair, share on what happens when their cell phone loses signal. What causes the cell phone to lose a signal? Answers could include geographical location, weather interferences, too many people using one tower at the same time, or basic bugs in the system when a signal is lost.
- Teachers will guide students in a group discussion on the following guided questions.
  1. Have you ever heard of a Satellite? What is a Satellite? *Things that orbit the earth/something that orbits something else in space.*
  2. Do all Satellites look alike? *The satellites vary depending on what they do.*
  3. Are all Satellites made by humans? *No. Example: the moon*
  4. What is the purpose of Satellites? *Communication (cell phones) GPS, help predict weather*
  5. How many satellites do you think are in orbit right now? *Using NASA's Debris in Space gallery, one can see there are 7,702 ACTIVE satellites orbiting the Earth right now. This does not take into account how many satellites are still in orbit, but NOT active.*
- After the guided discussion, teachers will have students watch a short video as a resource to introduce Satellites.

Section E - Communication with Satellites. (5 mins)

- Teachers will use the following questions to help students discuss how satellites communicate to Earth, and why we use satellites.
  a. How do scientists "talk" to Satellites? *Radio waves, electromagnetic radiation*
  b. What kind of information do we retrieve from satellites? *GPS data, communication data, imaging, weather, etc.*
- After the guided conversation, the instructor will have students watch a short video as a resource to introduce Satellite communication.

Section F - Mini-Activity: How do Satellites "Wave?" (5 mins)

- Teachers will refer to Section F of the Student Handout. Students should draw a version of the following diagram in their own notes.
  - *Answer Key/Drawing:*



Section G - Vocabulary Development (15 mins)

- Building on Section D, E, and F, students will develop some academic vocabulary around satellite communication using Section G of the Student Handout. Use this resource for help.
    - Satellite: *Something that orbits a large object in orbit/space.*
    - Uplink: *Transmission of signal from ground (Earth)to satellite in space*
    - Downlink: *Transmission of signal from satellite in space to ground station (Earth)*
    - Ground Stations: *Designation station on Earth that receives and sends signals to satellites in orbit/space.*

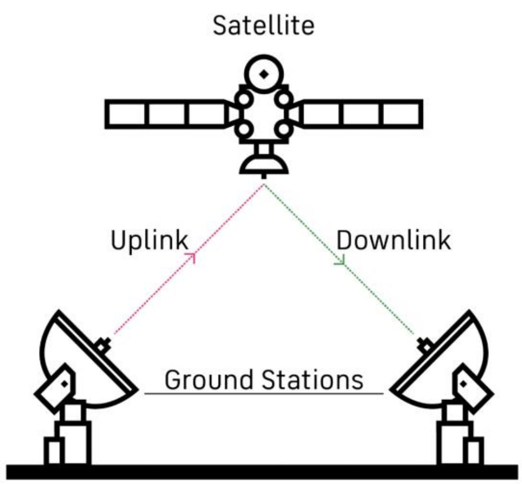


Diagram of a one way communication satellite network consisting of three stages: uplink, transponder and downlink..

Day 3: *I Wear Many Hats*

Section H - What is an Engineer? (10 mins)

- Teachers will guide students in a group discussion on the following guided questions.
    1. What comes to mind when you hear the word, engineer? Write down three ways you would describe an engineer and what they do to a friend. *Problem solver, creator, builder, etc.*
    2. There are several different types of jobs that Engineers have. Introduce students to various job titles and backgrounds using this article.

Section I - Vocabulary Development: Careers (15 mins)

- Building on the engaging activity, students will develop some academic vocabulary around engineering professions using Section I of the Student Handout.
    - **Guidance, Navigation and Control Engineer**: *Designs, manufactures, and tests systems for aircraft spacecraft.*
    - **Flight Dynamics Officer/ Engineer**: *Responsible for trajectories, flight paths, and orbital mechanics. Makes sure all parts follow the correct path and physics.*

- **Systems Engineer**: *Works with all teams, manufacturers, and designs to ensure product works as advertised.*
- **Communication Engineer/ Specialist**: *Researches and designs methods of communication in space with Earth.*
- **Computational Analyst**: *Calculates how much memory, data, and what type of data/computer processing will be needed for scenarios.*

Day 4: *Error Codes*

Throughout this week, students have learned about AI, Machine Learning, how satellites communicate, and the STEM careers that help design, improve, and maintain our satellite communication. Today, students will work in small teams to learn about error codes that could be sent back from satellites to engineers on Earth.

Section J - Introduction to Challenges in Space (10 mins.)

- Teachers will then show the graph below and ask what students notice about it and what questions they have (wonder). They will not yet complete the connections section. Students will record their thinking in Section J of the Student Handout.

Notice	Wonder	Connections
There is a big drop at timestamp 4000 *Most of the data marks are above -6.*	*What happened for there to be such a large drop?* *Why do the data points seem consistent, drop, but then go back to normal?*	*Answers will vary*

Teacher note: This data is a set from a satellite that AI analyzed. The raw data is in blue. The green lines are where AI detected an anomaly in the data. The red dashed lines are true anomalies (which are in the detected anomaly range).

- As a class, discuss what students notice and wonder.
- Share some information about satellites and potential error codes. See the script example below for a real world application on the example of an error code that has to do with acceleration.

Sample Teacher Script: This graph shows the temperature change of a satellite as the rocket launches it into space, shown in blue. As the rocket takes off, data is collected on all its subsystems and all the measurements are logged. This data log will help us to assess the performance of the rocket to see if anything went wrong during take off that we should fix before more rockets are launched.

The first step is to ask the AI to detect anomalies – patterns that look different or unexpected. You can see the places *the AI detected anomalies in green.*

The next step is for humans to look more closely at the AI flagged anomalies to determine if they indicate an error - something going wrong during take-off. We don't want to spend time fixing things that don't indicate true errors or affect performance, that would be a waste of time and energy. In order to determine the presence of an error, we might compare this data to data from similar rockets.

If humans determine this anomaly did indicate an error, we have to pinpoint the source of that error so that the right person can be notified to fix the error.

- Students will reflect on how the information might connect to what they've learned in the previous 3 days and record their thinking in the Connections column of Section J of the Student Handout.

Section K - Introduction to Challenges in Space Continued (10 mins.)

- Next, teachers will ask students to work in groups of three to five to brainstorm ideas of errors that satellites could experience in space in Section K of Student Handout.
    - *Teacher note: Some examples might include: acceleration issues, something overheating, running low on fuel, power error, or thermal error.*
- In Section K of Student Handout, students will match the type of error with the job description(s) that would be the most likely to respond to the error.
    a. Acceleration issues - flight dynamics engineer
    b. Overheating - systems engineer
    c. Running low on fuel - guidance engineer, flight dynamics engineer, systems engineer
    d. Power error - systems engineer, computational analyst
    e. Thermal error - systems engineer
    f. Communications delay - communications engineer
    g. Software malfunction - computational analyst, control engineer
- Once the error is determined, reports are sent to the expert engineer, who can fix the issue.
- Teachers will then return to the graph shown previously and ask students to critically think in their groups to determine if they can find the moment the error occurred onboard this particular satellite. *Where the detected anomaly, anomaly window, and true anomaly all overlap (timestamp 4000).*

Day 5: *Solve the Code. Save the World!*

Throughout this week, students have gained knowledge about AI, Machine Learning, and how satellites communicate. They have also learned about the STEM careers that design, improve, repair, and work together to maintain our satellite communication. Today, students will work in small teams, and will be given a story plot to save the world! Each team will use their Student Handout to guide their progress through the coding activity. Students will work together to solve all three error codes to restore lost communication with a satellite. Are your students up to the task?

Section L - Introduction to Solve the Code Game (5 mins.)

- Teachers will start the lesson by reviewing content from Days 1, 2, and 3. *Teacher Note: The term list below contains the pertinent information from the previous lessons.*

- **Term List:**
  - **Artificial Intelligence, (AI):** The science of making machines (like computers or robots) think like humans.
  - **Machine Learning:** A subset of A.I that involves teaching a machine how to think.
  - **Satellite:** A man-made or natural object that moves around a larger object.
  - **Ground Station:** A technological station placed on Earth to collect and stream satellite data.
  - **Receiver:** The destination that receives the communication or data from the satellite.

Teacher Note: One person should be designated the "AI in room". This should either be the teacher, or an individual capable of checking all students' work. This individual will also be in charge of the answer key.

Section M - Play the Game! (10 mins.)

- Students will record the error and the correction for each of the 4 error codes in Section M of the Student Handout.
- Answer Key: *Be sure to share this with the "AI in room" if not the teacher*

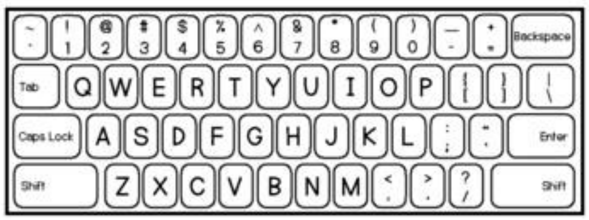
Code 1:

12#34%56&78*90

Answer: The * is the error in code.

Correct code: 12#34%56&78(90

12[shift 3 = #]34[shift 5 = %]56[shift 7 = &]78[shift 9 = ( ]90



Code 2:

💙🌻 + ☔🦓 = ?

52 + 89 = 141

🌀🌵 / 🌀 = ?

14 / 1 = 14

🐼🍉 X 🌻 = ?

36 x 2 = 72

1	2	3	4	5	6	7	8	9
🌀	🌻	🐼	🌵	💙	🍉	🦕	☔	🦓

Code 3:

Message: OCEJKPG NGCTKPI

Answer: Machine Learning

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B

Error Message: Oops, message has been intercepted! Send a decrypted message to grant access.

Caesar Cipher: A type of cipher that shifts letters in a message to make it unreadable if intercepted. To decrypt, reverses the shift.

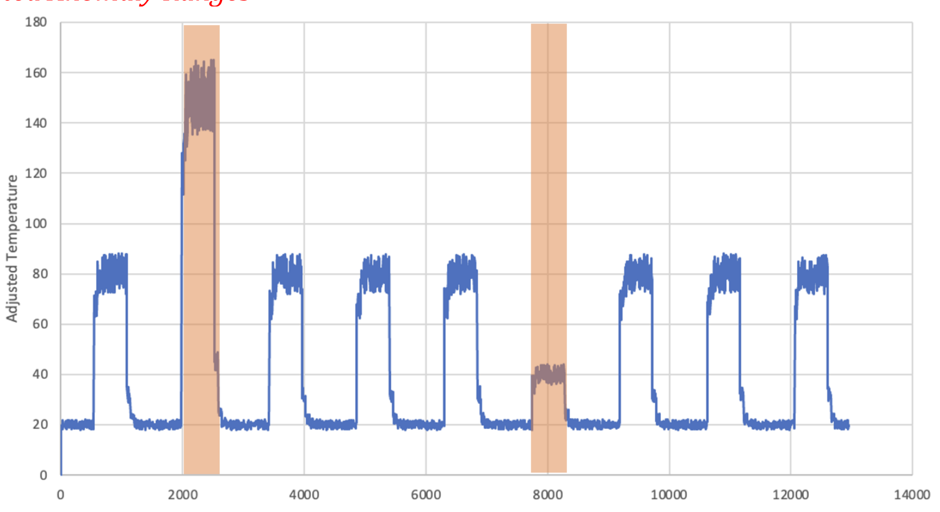
2 letter shift : K=I

Section N - Debrief of Game (20 mins.)

- The instructor will go over the answer key with students.
- The instructor will conclude the lesson with the following guided questions-
    1. Was your team able to solve all codes? *Answers will vary.*
    2. What were your team's strengths? Weaknesses? *Answers will vary.*
    3. Do you feel your team was able to communicate and collaborate together effectively? *Answers will vary.*
    4. How was the role of AI useful? What would have made it more useful? *It was useful because it identified correct or incorrect error codes. It could have been more useful if it told you why a specific code was an error.*
    5. What was the value of using human interactions in this activity instead of relying solely on AI? *The AI in the room was only able to provide confirmation (or lack of confirmation) of an identified error. The human responsibility is to determine why there was a specific error.*
    6. If you could program the AI in the room to learn from these codes, what would be the next most logical step to teach? *Identifying patterns in previously recognized codes compared to other sequences of events would help with predicting why there is a particular error.*
    7. How might this type of machine learning be useful in an aerospace environment? *For example, if a particular error code was repeatedly found after a series of actions had taken place, it might indicate why there is a system failure.*

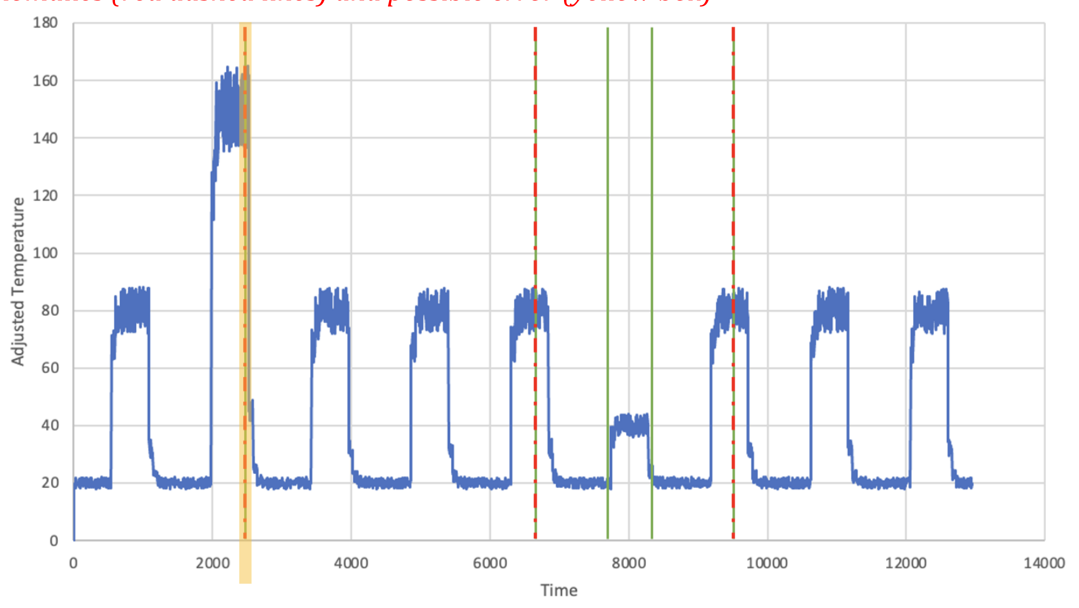
Section O - Apply to Data (20 mins.)

- Teacher will start the lesson by reviewing the different [jobs that Engineers have](#).
- Students will work individually to determine the detected anomaly window in the data in Section O of the [Student Handout](#).
    - *Detected Anomaly Ranges*



- After students check their work for detected anatomy windows, they will move on to the rest of the section.

- *True anomalies (red dashed lines) and possible error (yellow box)*



- Given that this data was obtained from a telescope attached to a satellite in low earth orbit, who (what type of engineer) would you alert the error to and what type of error are they looking at? *Systems engineer for overheating or thermal error*

Section P - Debrief (10 mins.)

- As a whole class, students should review the responses to Section O.
- Students can journal on a blank piece of paper that can be submitted as an exit ticket.
  - Journal prompt: *How has your thinking about AI and machine learning changed throughout this lesson?*
- As a whole class, discuss the ideas that were developed by individuals and look for trends within the class. Address any additional questions that arise and encourage students to continue looking for career paths in this field if there is interest.

CA NGSS Standards
HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. **HS-ESS3-5.** Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. **HS-ETS1-2.** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

CTE Alignment
B6.0 Employ the design process to solve analysis and design problems. B8.0 Understand fundamental control system design and develop systems that complete preprogrammed tasks.

Resources

Apollo Guidance, Navigation, and Control Systems. Wikipedia. (n.d.-a). https://sk.wikipedia.org/wiki/Súbor:CSIRO_ScienceImage_4350_CSIROs_Parkes_Radio_Telescope_with_moon_in_the_background.jpg

Argo's World. (2020, August 21). What is ARTIFICIAL INTELLIGENCE? - Argo's World | STEM for Kids (Science, Tech, Engineering, Math). https://www.youtube.com/watch?v=HdIppwUJ0f8

Bouallegue, R. (n.d.). *Communication via satellite uplink - researchgate*. Communication Via Satellite Uplink. https://www.researchgate.net/figure/Communication-via-satellite-uplink_fig1_47860725

Cadence PCB Solutions. (2023, October 12). *Uplink and downlink frequency*. Uplink and Downlink Frequency. https://resources.pcb.cadence.com/blog/2023-uplink-and-downlink-frequency

GCF Learn Free. (2018, February 22). *What is Machine Learning?*. YouTube. https://www.youtube.com/watch?v=QghjaS0WQQU

How to become a Communication Engineer. CollegeDekho. (n.d.). https://www.collegedekho.com/careers/communication-engineer

How to become a Computer Systems Analyst: A career analysis. GetEducated. (2022, March 24). https://www.geteducated.com/career-center/detail/computer-systems-analyst/#/

Inmarsat Global LTD.. *A Straightforward Introduction to Satellite Communications*. https://www.inmarsat.com/en/insights/corporate/2023/a-straightforward-introduction-to-satellite-communications.html

Leishman, J. G. (2023, January 1). *Aircraft equations of motion*. Introduction to Aerospace Flight Vehicles. https://eaglepubs.erau.edu/introductiontoaerospaceflightvehicles/chapter/aircraft-equations-of-motion/

NASA. (n.d.). *Ares*. NASA. https://orbitaldebris.jsc.nasa.gov/photo-gallery/

NASA. (2019, June 27). *How Does GPS Work?*. NASA. https://spaceplace.nasa.gov/gps/en/

Parkes Observatory . Wikipedia. (n.d.). https://sk.wikipedia.org/wiki/Súbor:CSIRO_ScienceImage_4350_CSIROs_Parkes_Radio_Telescope_with_moon_in_the_background.jpg

Ready Jet Go! (2023, December 7). *How Do Satellites Work?: Ready Jet Go!*. PBS LearningMedia. https://ca.pbslearningmedia.org/resource/ready-get-go-how-do-satellites-work/how-do-satellites-work-ready-jet-go/

Science Trek. (2020, November 2). *Satellites: The Story of Satellites | Science Trek*. YouTube. https://www.youtube.com/watch?v=_IiPMG43L54

Search the california content standards. CA Content Standards (CA Dept of Education). (n.d.). https://www2.cde.ca.gov/cacs/science?c3=1%2C2%2C4&order=0&page=0&perpage=10&mingrade=9&maxgrade=12&dl=0

State Center Consortium. (n.d.). *CAREER OPPORTUNITIES IN ENGINEERING AND DESIGN INDUSTRY SECTOR*. WhoDoYouWant2Be.com. https://rec.cusd.com/Downloads/Engineering_Industry_Career_Packet.pdf..pdf

The role of systems engineer. Michael Page UK. (2023, September 29). https://www.michaelpage.com.au/advice/job-description/technology/systems-engineer