The CENTRE for EDUCATION
in MATHEMATICS and COMPUTING

Autonomous Vehicles

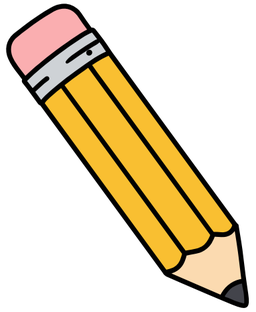
A CS and Society resource addressing social and ethical issues within the realm of digital technology and computing

This resource will:

- shed light on what it means for a vehicle to be autonomous, and
- expose you to a variety of opinions and perspectives regarding the potential risks and rewards of advancing this technology.

What Is an Autonomous Vehicle?

Autonomous Vehicle (AV)
A vehicle that uses technology to sense its surroundings, enabling it to navigate and operate with little to no input from a human driver.



With a partner, compile a list of objects and conditions that an autonomous vehicle might need to sense in its surroundings. Share your list with the rest of the class.

Sensing Surroundings

Autonomous vehicles need to identify and respond to a multitude of objects and conditions that could potentially be present in their environment. For example:

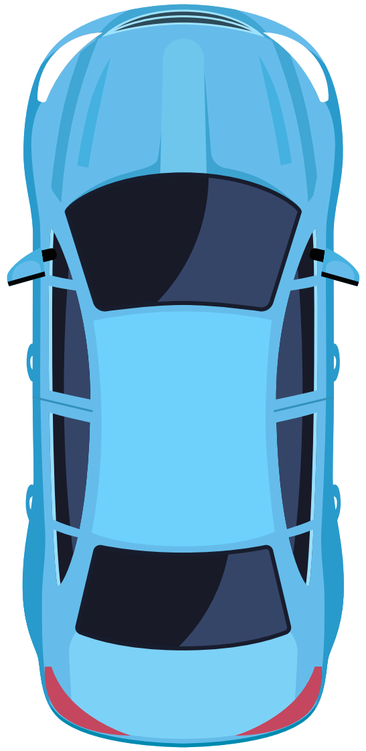
- Road Signs
- Traffic Lights
- Lane Markings
- Emergency Vehicles
- Pedestrians
- Cyclists
- Animals
- Other Vehicles
- Construction
- Road Debris
- Weather Conditions
- Amount of Light

Smart Technologies

AVs use smart technologies in order to sense their surroundings, including:

Cameras
Use machine learning to identify objects such as road signs and lane markings

GPS (Global Positioning System)
Enables vehicles to know where they are located and plan their driving routes



Radar (Radio Detection and Ranging)
Sensors send out radio waves to measure the distance and speed of nearby objects

Lidar (Light Detection and Ranging)
Sensors use light beams (lasers) to create a 3D map around the vehicle

Levels of Autonomy: Level 0

The Society of Automotive Engineers (SAE) defines six levels of autonomy for vehicles. The levels are a measure of how much automation a vehicle has and how much responsibility is placed on a human driver.

Level 0

A Level 0 vehicle has no driving automation. The driver is responsible for all driving tasks. The vehicle may provide warnings, such as blind spot detection, but the vehicle is not able to independently take action.

Levels of Autonomy: Levels 1 and 2

Level 1

The driver of a Level 1 vehicle remains fully in control, though the vehicle can provide driving assistance through *one* automated feature. For example, it may oversee accelerating/braking through adaptive cruise control, or it may steer using the lane centering feature.

Level 2

The driver of a Level 2 vehicle remains fully engaged and attentive, though the vehicle can now provide driving assistance through *two* automated features, such as *both* steering and accelerating/braking.

Levels of Autonomy: Levels 3 and 4

Level 3

A Level 3 vehicle can drive autonomously, but a human driver must be present, and the driver must be able to immediately take control of the vehicle if and when necessary.

Level 4

A Level 4 vehicle can drive autonomously without any attention or assistance from a human driver. Such vehicles may be designed without pedals or a steering wheel. The operation of these vehicles is restricted to set boundaries, such as driverless taxis working in geofenced areas.

Levels of Autonomy: Level 5

Level 5

A Level 5 vehicle is one that can perform *all* driving tasks fully autonomously, and in *all* situations without any conditions or restrictions. As of the end of 2025, no vehicles have reached Level 5 automation.

Discussion Questions:

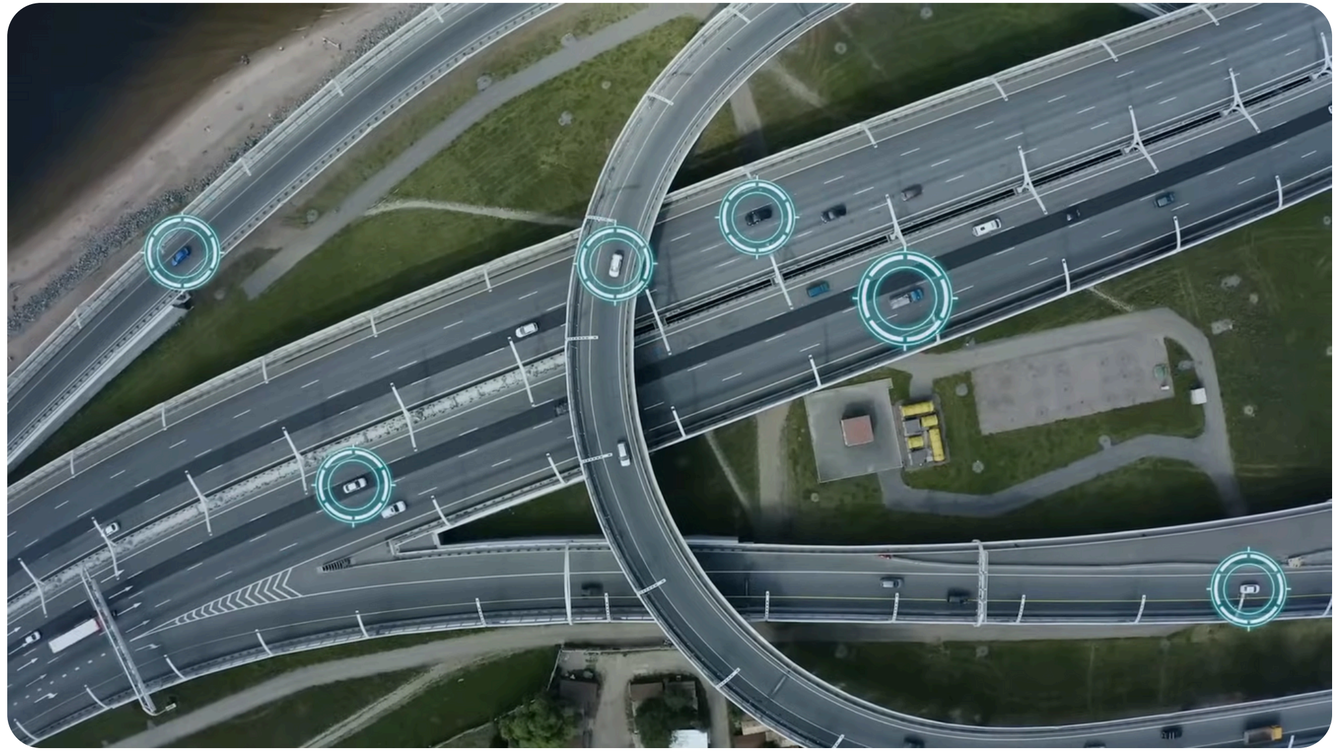
1. What challenges might be hindering vehicles from reaching Level 5 automation? E.g. public trust, road infrastructure, ...
2. What is the highest level of vehicle autonomy that you would be comfortable with as a passenger?

History of Autonomous Vehicles

Autonomous vehicles sound like an idea that came straight out of the future, but they actually have a long and interesting past.

Watch the following video and then complete the autonomous vehicles timeline found under additional materials.

VIDEO



Video Project: Helpful or Harmful?

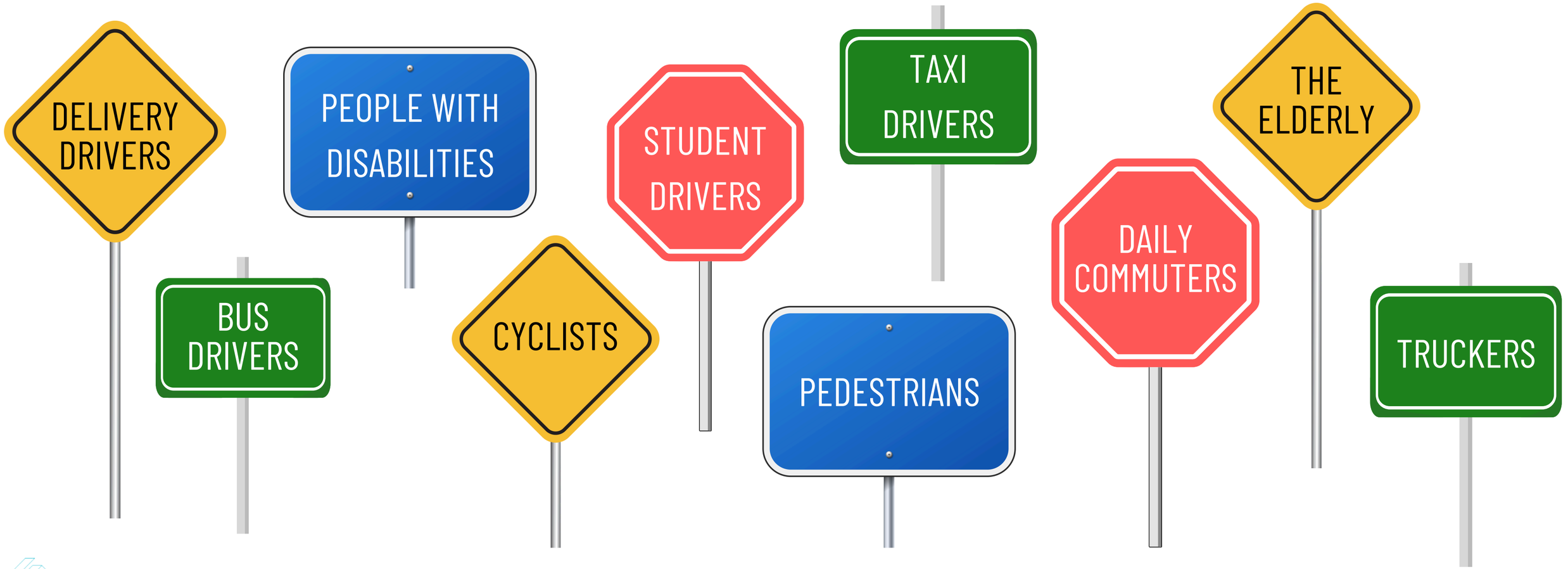
Autonomous vehicles have the power to dramatically alter people's lives. Is this a positive or a negative change?

Select a population subgroup that is impacted by autonomous vehicles. Research and reflect on the ways in which AVs could *help* and/or *harm* this population subgroup. Present your findings by creating a short video that provides facts and statistics along with your impressions and opinions.

Personally interview a member of your chosen population subgroup as part of your video!

Video Project: Population Subgroups

Examples of population subgroups that are impacted by autonomous vehicles:



Autonomous Vehicles and Ethics

The advancement of AVs raises complex ethical questions about safety, liability, and decision-making. Explore these dilemmas by watching the following videos.

VIDEO A

VIDEO B

Discussion Questions: AVs and Ethics

1. Are reactions different from decisions, even when they lead to the same outcome? Explain your reasoning.
2. Should AVs behave as human drivers *do*, or as human drivers *should*? Defend your position.
3. Are driving decisions universal around the world, or do they vary by location and context? How might AVs adapt to different environments?
4. Who should be responsible for determining how AVs make driving decisions – governments, developers, manufacturers, owners, or the vehicles themselves? What other options might there be?
5. Is it ethical to deploy AVs on public roads before they can be guaranteed to be completely safe? Why or why not?

The Moral Machine

In his Ted Talk, Iyad Rahwan refers to the Moral Machine website. Try it out for yourself by acting as the judge in all 13 scenarios. Then, write a 500 to 700 word reflection in response to the following prompts:

RESOURCE

- Did you align more with Bentham (minimize total harm) or with Kant (do not take action that explicitly harms)?
- How did factors such as species, age, gender, fitness, law-abidingness, and social value influence your choices?
- To what extent is the Moral Machine experiment useful?

More Information and Resources

Past & Present

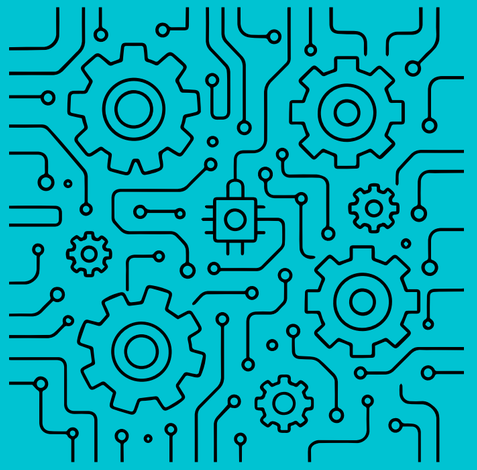
- Computer History Museum
- Kiddle
- HowStuffWorks
- World Economic Forum
- Bloomberg Aspen Initiative

In The News

- (NBC) Teslas and Trains
- (CBC) Delivery Robots
- (The Verge) Driverless Freight Trucks
- (NBC) Hit-and-Runs
- (CBC) New Driver Road Tests

Build Your Own

- Science Buddies
- STEM 101



Additional Materials

Autonomous Vehicles Timeline

Use the 100 Years of Autonomous Vehicles video to identify the significance associated with the following cars, robots, and people.

THE AMERICAN WONDER

1925

GM FIREBIRDS

1950s

STANFORD CART

1960s

ERNST DICKMAN

1980s

NAVLAB 5

1990s

TESLA MODEL S

2010s

Activity to accompany slide: History of Autonomous Vehicles

Autonomous Vehicles Timeline

Use the 100 Years of Autonomous Vehicles video to identify the significance associated with the following cars, robots, and people.

THE AMERICAN WONDER

A radio-controlled car that drove through New York City. The car's antenna received signals from a remote control. It could start, move, change gears, and toot its horn.

1925

GM FIREBIRDS

Cars that could detect current flowing through a wire embedded in the road. The cars could be steered by manipulating the current.

1950s

STANFORD CART

Originally designed as a lunar rover. It could identify and follow a line on the ground using cameras. A version in 1979 could cross a room full of obstacles without any assistance.

1960s

ERNST DICKMAN

German engineer considered the pioneer of autonomous cars. He designed cars equipped with cameras, sensors, and microprocessors that could recognize road markings.

1980s

NAVLAB 5

Carnegie Melon University used neural networks to process visual data. Their car successfully drove from Pittsburgh to San Diego with a bit of help with speed and braking.

1990s

TESLA MODEL S

The "autopilot" software update allowed cars to autonomously drive and park themselves. In 2016 a car in autopilot mode failed to break and caused a fatal crash.

2010s