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English coursebook for third-year students of the Faculty of Mechanics and Mathematics

(optional course)

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Посібник з англійської мови за професійним спрямуванням для студентів III курсу механіко-математичного факультету (факультативний курс)

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Друкується за ухвалою Вченої ради ННІФ

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PREFACE

The coursebook is intended for use within an elective course offered at the Faculty of Mechanics and Mathematics. It has been developed with consideration of the educational needs of students in this field and is aimed at deepening their knowledge of professional English. Modern texts on mathematics, statistics, computer mathematics and mechanics are offered for all-round study.

The content of this coursebook covers seven topic-based units. We hope this course will develop all four language skills, thus giving the students an opportunity to succeed in a professional environment and will broaden their knowledge of the history of mathematics and the latest achievements in AI technologies. As a result, they will make progress in their use of English for Specific Purposes at level B2.

CONTENTS

Unit 1

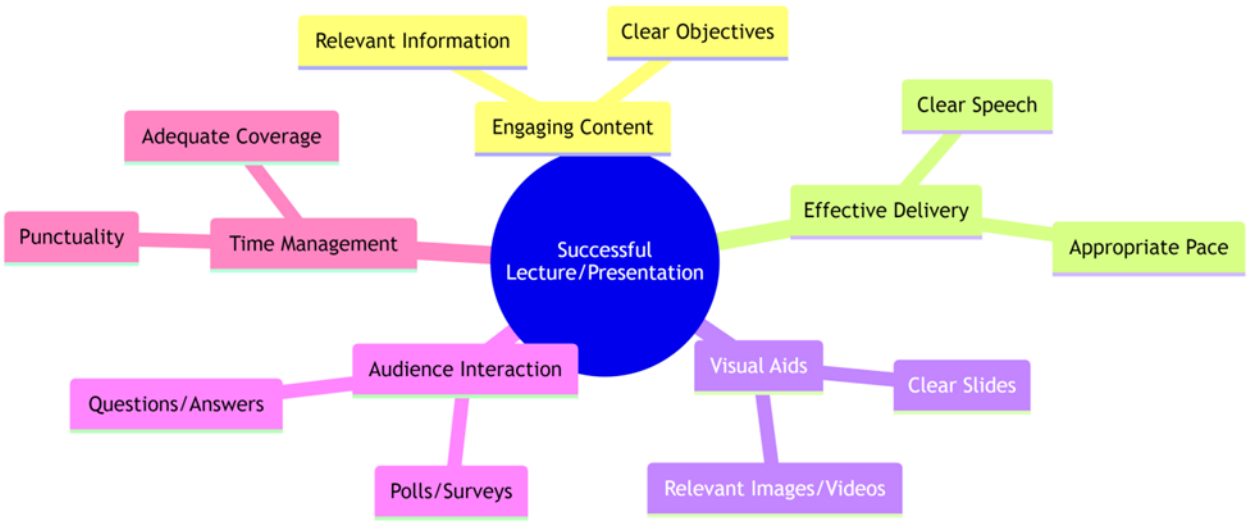
Successful Presentations

Lead-in

1. Paraphrase the following quotations. Which do you agree with? Why?

- ✓ *The success of your presentation will be judged not by the knowledge you send but by what the listener receives. (Lilly Walters)*
- ✓ *If you can't explain it simply, you don't understand it well enough. (Albert Einstein)*
- ✓ *Make sure you have finished speaking before your audience has finished listening. (Dorothy Sarnoff)*
- ✓ *Designing a presentation without an audience in mind is like writing a love letter and addressing it 'to whom it may concern. (Ken Haemer)*

2. Read the text "Hints for effective speaking", and explain in what way(s) you find it useful for your learning experience.



HINTS FOR EFFECTIVE SPEAKING

An effective speech is one in which the speaker accomplishes his purpose of communicating ideas to an audience in a manner pleasing to them. The speaker should strive to make a good first impression.

He must never communicate any apprehension to his hearers. Of course, he must be sincere. There must be honesty in composition as well as in delivery if the speaker is to win over his audience.

Preparation is the best known guaranty against a poor performance. Its lack is the most common cause of stage fright. The preparation ought to begin long in advance of the speaking date and the work on the speech should be frequent. It is hard to force the development of a talk; speeches grow and should be given time to ripen.

When a speech has been carefully prepared, the speaker can face his audience with confidence and assurance that his purpose will be attained.

The actual method of preparation varies with the speaker. Some write out their speeches word for word and then commit the entire speech to memory. Too often the memorized speech results in a stilted, inflexible presentation. Others think through their ideas carefully, writing down only the barest skeleton of an outline. The best course is carefully to plan the speech and to outline it in detail. Writing out a complete draft is helpful but the wording should not be committed to memory. The speaker should practice his speech out loud, choosing his words each time as he goes along.

By practicing a variety of words the speaker will develop a flexibility of expression. The outline should be used to fix firmly in mind the sequence of ideas. With practice the gist and order of the speech will be impressed upon his mind.

As the speaker practices he may feel impelled at various points to gesture and to emphasize certain words and thoughts. Gestures and emphasis so added are all to the good. The value of gestures is that they assist in the communication of ideas, help to hold the audience's attention and serve as an outlet for the speaker's tension, thereby increasing his self-confidence.

To help make a good impression, the speaker should look directly at his hearers. Just as he would do in speaking to a group of three or four, he will turn from one member of the audience to another taking in as many as he can. The speaker must convey the impression that he is talking to his audience individually and not gazing

over their heads. The audience want to feel a sense of personal relationship as if the speaker were engaging them in a conversation. Nothing is quite so important a means of establishing personal contact with the audience as the simple device of looking them in the eye.

Getting across to the audience the central theme or idea is a matter that overshadows practically all else.

Clear organization of the speech is the first essential. If the speaker is making his point in an earnest and enthusiastic way, the audience will not only listen but will overlook many faults in form. The speaker should use specific data and examples of the point he is trying to make. He must be precise. An audience is not likely to accept vaguely expressed ideas.

If the object of the speech is to inform, the main purpose is to increase the audience's store of knowledge. To do this effectively the speaker must present enough concrete examples and precise information to avoid becoming vague and dry.

The first impression is a prime concern of the speaker, but the last impression is also important. In the closing sentences, if the speech is to gain action, the speaker will ask the audience to do something, to contribute to some worthy cause, or to participate in some activity. [1]

Multiple Choice

3. For questions 1-5 choose the right answer, A, B, C or D.

1. What is the most common cause of stage fright?

A) Lack of preparation

B) Overthinking the speech

C) Fear of the audience's judgment

D) Lack of confidence in the topic

2. What is the primary reason for the importance of looking directly at the audience?

A) To establish a personal connection with the audience

B) To ensure the audience is paying attention

C) To make the speaker feel more confident

D) To convey the speaker's authority

3. What is the most important factor in making a lasting impression on the audience?

A) Using specific data and examples

B) Delivering the speech with enthusiasm

C) Making a strong first impression

D) Leaving the audience with a clear call to action

4. Why can memorizing a speech word-for-word be detrimental?

A) It can make the speech less engaging for the audience.

B) It can make the delivery sound unnatural and stiff.

C) It can lead to forgetting parts of the speech.

D) It can distract the speaker from connecting with the audience.

5. Why can gestures be beneficial for a speaker?

A) Gestures help to convey emotions and make the speech more engaging.

B) Gestures help to emphasize key points and make the speech more memorable.

C) Gestures help to break the monotony of standing still and keep the audience interested.

D) Gestures help to release tension and increase the speaker's confidence.

Over to you

4. Answer the comprehension questions:

1. Explain the relationship between preparation and stage fright, as described in the text.

2. What is a specific method of speech preparation? Describe it, highlighting its key elements.

3. What is the primary purpose of using specific data and examples in a speech?

4. What is the most important factor in establishing a personal connection with the audience?

5. The text states that "the speaker should strive to make a good first impression." What are the specific actions a speaker can take to achieve this?

5. Comment on the following points in the text:

1. the main characteristics of a good speech
2. the importance of careful preparation
3. methods of preparations
4. flexibility of expression
5. the value of gestures
6. a sense of personal relationship
7. clear organization of speech
8. precision of speech: the use of concrete examples and precise information

6. Questions for discussion:

1. What makes a good presentation?

2. Think of a good presentation you have ever seen. Why was it successful?

3. A man who cannot speak well will never make a career. Do you agree with this statement?

7. Fill in the gaps with the proper form of the words from the box.

contagious	enunciate	tailor	uncluttered	attire	allotted	compelling

1. Mutual respect requires clear, objective, and honest presentations with breadth and depth ___ to the target audience.
2. This concern gets wide agreement among researchers, even when they disagree about whether our gadgets are actually addictive, or merely ___.
3. They would not be human if their previously ___ minds had not slowly been filled with thoughts about technique and form.
4. Both of her readings are fluent, color fully intoned, and with carefully ___ literary standard pronunciation.
5. I liked him all the better for his plain ___ and the easy manner he put on with it.
6. I didn't understand until recently that wit, emotions and feelings could be so ___.
7. While I could answer most of the questions on the practice exam, I was slow, needing double or triple the ___ time.

8. Read the text. Fill in the gaps with the proper preposition from the table. Some prepositions can be used more than once.

on	per	at	by	with	due to	of	over	in	through

What is effective communication?

Effective communication is the process ___ exchanging ideas, thoughts, opinions, knowledge, and data so that the message is received and understood ___ clarity and purpose. When we communicate effectively, both the sender and receiver feel satisfied.

Communication occurs ___ both verbal and non-verbal forms, such as written, visual, and listening. It can occur ___ person, ___ the internet (___ forums, social media, and websites), ___ the phone (___ apps, calls, and video), or ___ mail.

While the effectiveness ___ communication can be difficult to measure, its impact is hard to deny. According to one study, surveyed companies ___ the United States and United Kingdom ___ ___ least 100,000 employees lost $62.4 million

___ year ___ average ___ poor communication. ___ the flip side, companies led ___ effective communicators had nearly 50 percent higher total returns ___ shareholders ___ companies ___ less effective communicators ___ the helm. [2]

Over to you

- What kind of talks have you already given? Was it a success? Who was your audience?
- What if you were to give a short presentation on how to make a good one?

9. Watch the video *How to Give a Presentation.*

Point out the specific features of the introductory part, the middle section and the conclusion. Pay attention to the formal/informal style. Work in pairs; share your ideas of how to give a successful presentation.

https://youtu.be/fzIxD1jXn44?si=cAd28A0CWUsGOmom [3]

10. Watch the video *Good Presentation VS Bad Presentation*.

Give your constructive feedback, taking into account the above-mentioned information about requirements for successful presentations.

What are its benefits and drawbacks?

https://youtu.be/V8eLdbKXGzk?si=hS4oOyAIeK9fIrd4 [4]

11. Work in groups. Questions for discussion:

Choose a subject you feel strongly about and prepare a short presentation on it taking into account the tips given above. Spend 10 minutes making some notes. The template below may help. Try to make you main points as graphic and dramatic as possible.

Presentation template. Work individually or with a partner. Use the template to develop a short presentation with a strong opening, a strong ending and three main stages in between. Make a note of: the main points you want to make; key topic vocabulary you think you may need; expressions that may help you at each stage of

the presentation (e.g. I'd like to focus on..., Feel free to interrupt if you have any questions, I'll give a brief overview of..., To sum up,...); signpost language to transition from one stage to the next.(e.g. "To move on", "Turning to the question of..., Getting back to ...")

12. Work in two teams. You are members of a conference committee. You are going to organize a conference on the topic "Why Math is important?" As a group make a list of research problems to be discussed within different workshops or an information bulletin containing a brief summary of all the workshop discussion points to attract prospective participants.

The videos might help you:

https://youtu.be/KX608C2RZek?si=0ih267IwfR4RsOBH

https://youtu.be/a19A04HMTVo?si=4caP4cS3bhpBwFCG

https://youtu.be/a19A04HMTVo?si=ZB57OyABS-jV1xq1

40 Phrases for Presenting in English

https://youtu.be/MZAhgsQdTHg Effective Public Speaking techniques

13. Web research task

Watch two films about secrets to great public speaking**,** note down the most interesting tips and make a short presentation.

https://www.ted.com/talks/chris_anderson_ted_s_secret_to_great_public_speaking

If you want something extra

Read the text: 10 Tips for Improving Your Public Speaking Skills

https://professional.dce.harvard.edu/blog/10-tips-for-improving-your-public-speaking-skills/

Effective Speaking

https://www.skillsyouneed.com/ips/effective-speaking.html#:~:text=Speaking%20effectively%20is%20defined%20as,means%20your%20choice%20of%20words

UNIT 2

Scientific Theory

Lead-in

1. Paraphrase the following quotations. Which do you agree with? Why?

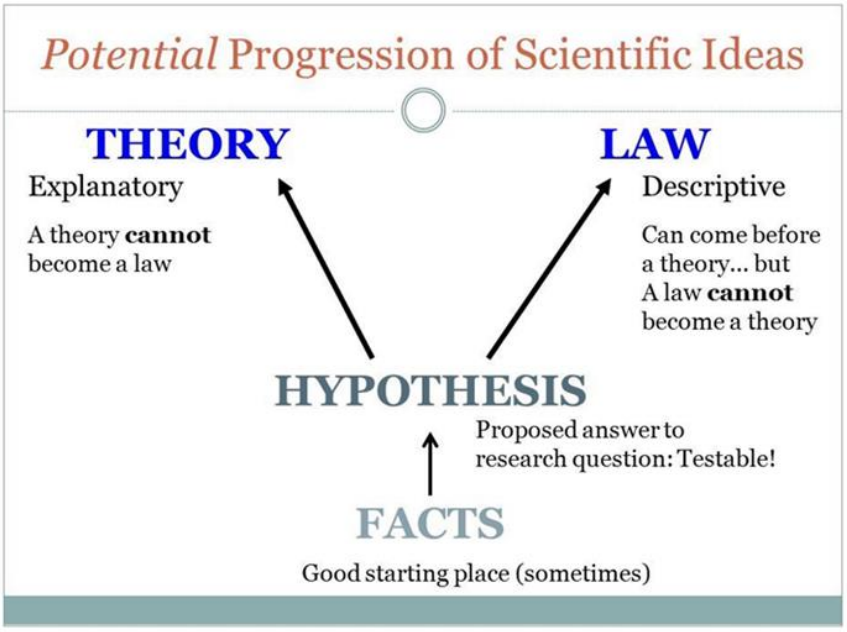
- ✓ *Scientific theory is a contrived foothold in the chaos of living phenomena. (Wilhelm Reich)*
- ✓ *The greatest discoveries of science have always been those that forced us to rethink our beliefs about the universe and our place in it. (Robert L. Park)*
- ✓ *Science invites us to let the facts in, even when they don't conform to our preconceptions. It counsels us to carry alternative hypotheses in our heads and see which best match the facts. (Carl Sagan)*

2. Watch the videos and illustrate the terms "fact," "hypothesis," "theory," and "law" with examples.

https://youtu.be/lqk3TKuGNBA?si=dp2TZVVZNt2sGz82

https://youtu.be/35tQz_X7KD4?si=njvYKj-q9FE2K6Ic

https://youtu.be/0EoD5qsAZGI?si=aagpvaBhw64Cnxje



3. Read the text.

What's the difference between a fact, a hypothesis, a theory, and a law in Science?

Science uses specialized terms that have different meanings than everyday usage. These definitions correspond to the way scientists typically use these terms in the context of their work. The words "fact," "hypothesis," "theory," and "law" have very specific meanings in the world of science, and they don't exactly match the ones we use in everyday language.

Fact: In science, an observation that has been repeatedly confirmed and for all practical purposes is accepted as "true." Truth in science, however, is never final and what is accepted as a fact today may be modified or even discarded tomorrow. Everything in science comes with a level of uncertainty, so nothing is ever scientifically "true" beyond a shadow of a doubt.

Hypothesis: A tentative statement about the natural world leading to deductions that can be tested. It's just a starting point for further investigation. Any one observation usually comes with an array of hypotheses. You can investigate all of those hypotheses and come away with the one that's most supported by the evidence, if any. If the deductions are verified, the hypothesis is provisionally corroborated. If the deductions are incorrect, the original hypothesis is proved false and must be abandoned or modified. Hypotheses can be used to build more complex inferences and explanations.

Law: Scientific law is a descriptive generalization of naturally occurring phenomena in the world, about how some aspect of the natural world behaves under stated circumstances. It does not explain why something happens or its existence, it explains how something happens. Laws are expressed using mathematical formulas or equations. They can be proved and require empirical data to support the findings.

Theory: In science, a well-substantiated and widely accepted explanation of some aspect of the natural world based on a body of facts that have been repeatedly confirmed through observation, inference and experiment. Scientific theories begin as

hypotheses. Over time, as a hypothesis is tested, verified, and generalized, it may assume the status of being an accepted theory, providing a set of propositions that can be used to make predictions about future outcomes.
https://ncse.ngo/definitions-fact-theory-and-law-scientific-work
https://www.discovery.com/science/Difference-Between-Fact-Hypothesis-Theory-Law-Science [5]

Multiple Choice

4. For questions 1-7 choose the right answer, A, B, C or D.

1. What distinguishes a scientific law from a scientific theory?

A) A scientific law explains why something happens, while a scientific theory describes how something happens.

B) A scientific law is a descriptive generalization of how something happens, while a scientific theory is a well-substantiated explanation of why something happens.

C) A scientific law is based on tentative statements, while a scientific theory is based on mathematical formulas.

D) A scientific law is subject to modification, while a scientific theory is considered final and unchangeable.

2. Which of the following statements best describes the role of a hypothesis in scientific investigation?

A) A hypothesis is a proven explanation of a natural phenomenon.

B) A hypothesis is a starting point for further investigation that can be tested through deductions.

C) A hypothesis is a descriptive generalization expressed through mathematical formulas.

D) A hypothesis is an observation that has been repeatedly confirmed and accepted as true.

3. What is the scientific understanding of a 'fact' and how does it differ from its everyday usage?

A) In science, a fact is an absolute truth that cannot be changed, unlike its everyday usage.

B) In science, a fact is an observation that has been repeatedly confirmed and accepted as 'true' for practical purposes, but it is subject to modification or discard, unlike its everyday usage.

C) In science, a fact is a tentative statement that leads to deductions, unlike its everyday usage.

D) In science, a fact is a descriptive generalization of naturally occurring phenomena, unlike its everyday usage.

4. Which of the following statements best describes the relationship between hypotheses, theories, and laws in the scientific process?

A) Hypotheses are derived from established theories and are used to formulate scientific laws.

B) Laws are tentative statements that, when repeatedly confirmed, become hypotheses, which then evolve into theories.

C) Hypotheses can evolve into theories through testing and verification, while laws are descriptive generalizations that do not explain why phenomena occur.

D) Theories are initial observations that, when proven, become laws, which then guide the formation of new hypotheses.

5. What conclusion can be drawn about the certainty of scientific knowledge?

A) Scientific knowledge is considered absolutely true and unchanging once it is established through repeated confirmation.

B) Scientific knowledge is always subject to a degree of uncertainty and potential modification, regardless of how well-established it may seem.

C) Scientific knowledge is only uncertain at the hypothesis stage but becomes completely certain once it is elevated to the level of a theory or law.

D) Scientific knowledge is more certain in the realm of theories than in the realm of laws, due to the explanatory nature of theories.

6. Which statement best describes the relationship between a hypothesis and a theory in scientific methodology?

A) A hypothesis is a proven explanation, while a theory is an initial guess.

B) A hypothesis is a starting point that, through testing and verification, can evolve into a widely accepted theory.

C) A hypothesis and a theory are interchangeable terms used to describe scientific laws.

D) A hypothesis is a complex explanation, while a theory is a simple observation.

7. What is the key distinction between a scientific 'fact' and a scientific 'theory' in terms of their stability and potential for revision?

A) A scientific fact is an observation repeatedly confirmed and accepted as 'true' for practical purposes but can be modified or discarded, while a scientific theory is a well-substantiated explanation based on confirmed facts.

B) A scientific fact is considered permanently true and is never subject to revision, whereas a scientific theory is always open to modification.

C) A scientific fact is a tentative statement that leads to deductions, whereas a scientific theory is a descriptive generalization of naturally occurring phenomena.

D) A scientific fact is based on mathematical formulas, while a scientific theory is based on observation, inference, and experiment.

Over to you

5. Answer the comprehension questions:

1. What is the role of empirical data in establishing a scientific law?
2. Describe the process by which a hypothesis may evolve into a scientific theory.
3. What is the primary purpose of a scientific law, and how is this purpose achieved?
4. What is the difference between a 'fact' in everyday language and a 'fact' in the context of science, and what implications does this distinction have for scientific understanding?
5. How does the scientific definition of 'theory' differ from its everyday usage, and why is this distinction important for understanding scientific concepts?

6. Work in groups. Questions for discussion:

1. Consider a scientific 'law' that you find particularly interesting or relevant. Explain the law in your own words, and discuss its impact on our understanding of the natural world.

2. Discuss the relationship between 'hypotheses' and 'theories' in the scientific process. How do hypotheses contribute to the development of theories, and why is this iterative process essential for advancing scientific knowledge?

3. Reflect on the importance of uncertainty in scientific understanding. How does embracing uncertainty affect your approach to learning and problem-solving in both scientific and non-scientific contexts?

Occam's Razor

Pre-Reading

1. Read the following quotations. Which opinion do you agree with most?

- ✓ *It is vain to do with more what can be done with less.*
- ✓ *The explanation requiring the fewest assumptions is most likely to be correct.*
- ✓ *When you have two competing theories that make exactly the same predictions, the simpler one is the better. (William of Ockham)*

2. Read the text and fill in the gaps with the proper form of the words from the box.

edge	**observe**	**theory**	**gravitation**	**simplicity**	**relativity**
hypothesis	**subject**	**discrepancy**	**accept**	**accurate**	**know**

We regard as "true" the simplest explanation that satisfies all the data we have about any given thing. This principle is known as Occam's Razor; it is named after a 14th century British philosopher who originally proposed it. Without this rule, we would always be ___ to such complicated questions that we would accept nothing as ___. Occam's Razor, sometimes called the Principle of ___, is a razor in the sense that it is a cutting ___ that allows distinction to be made between theories.

Science is based on Occam's Razor, though we don't usually think about it. Sometimes, something that we call "true" might be more ___ described as a theory. The scientific method is based on hypotheses and theories. A ___ is an explanation of why something happens or happened. When it is shown that the hypothesis actually explains most of the facts known, then we may call it a ___. We usually test a theory by seeing whether it can predict things that were not previously ___, and then by trying to confirm whether the predictions are valid.

An example of a theory is the Newtonian theory of ___, which for many years explained almost all the planetary motions. Only a small ___ in the orbit of Mercury remained unexplained. In 1916, Albert Einstein presented a general theory of ___ as a better explanation of gravitation. The theory explained the discrepancy in Mercury's orbit. When his predictions were verified, his theory was widely ___.

Is Newton's theory "true"? Yes, in most regions of space. Is Einstein's theory "true"? We say so, although we may also think that one day a new theory will come along that is more general than Einstein's in the same way that Einstein's is more general than Newton's.

https://kc.pnu.edu.ua/wp-content/uploads/sites/11/2021/02/Foreign-English-language-by-prof.-direction-chemistry.pdf [6]

3. *If you want something extra.* Watch the videos:

https://youtu.be/d47hI5o2QxY?si=6RkQAbbubgHjwrKh

What is Ockham's Razor? Definition and Meaning

https://youtu.be/Ie53YZiRZy0?si=RNTjvU7MU3w5ATtS

Occam's Razor Explained

4. Work in groups. Questions for discussion:

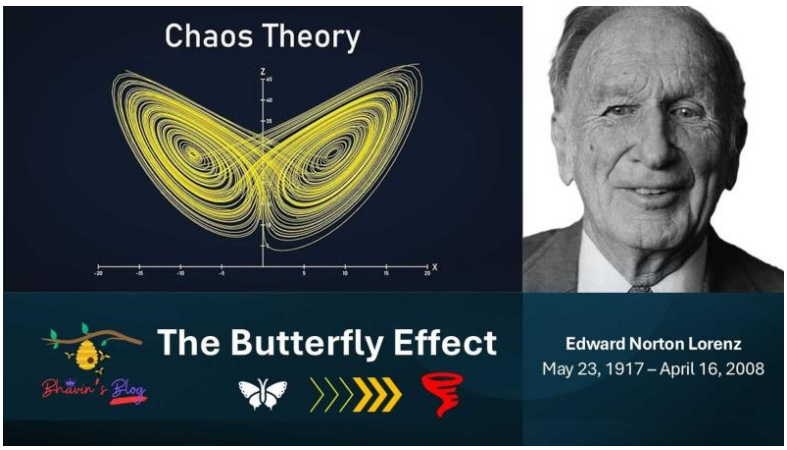
- Do you accept the Principle of Simplicity/Parsimony?
- How can you justify it? Give your examples.

A simple guide to chaos theory

Pre-Watching

1. Work in pairs and answer the questions:

1. What is chaos theory in human life?
2. What is chaos in math?
3. Is chaos theory a paradox?



2. Watch the video. Decide whether these statements are true or false.

https://youtu.be/r_ahZOgPTsk?si=mzuYFYG_fGUhLZ8y [7]

- Chaos theory suggests that even small changes in initial conditions can lead to vastly different outcomes, ensuring successful long-term predictions.

- The butterfly effect, a manifestation of chaos theory, highlights the interconnectedness and unpredictability of complex systems.
- Chaos theory reveals patterns and underlying order within seemingly chaotic systems, offering insights into various fields like economics, medicine, and social behavior, it also shows our ability to predict the future with absolute certainty.

3. a) Match the words to their definitions.

1. manifestation	a) believing that everything that happens must happen as it does and could not have happened any other way
2. deterministic	b) a substance that allows some electricity to flow through it, used in making electronic devices
3. trajectory	c) to reach a conclusion (often logically) through reasoning and evidence, especially from something known or assumed.
4. semiconductor	d) a state of complete disorder and confusion, characterized by a lack of order, structure, or control
5. deduce	e) a state in which objects or conditions are in no particular order; lack of system or planned organization
6. disorder	f) an outward expression, embodiment, or visible form of a particular condition
7. chaos	g) the path followed by a projectile or other moving object, especially a curved path

b) Fill in the gaps with the words from the table.

1. It would prove impossible to ___ a physical theory from such purely formal theorems.

2. There are many ___ of the role of the score within the model.

3. Even in the regime of quantum ___, the computer can be used reliably for some time, although it is eventually destroyed.

4. More important than the first-order approximation are the random fluctuations around the deterministic ___ of the delay equation.

5. The whole office was in a state of ___.

6. The rapid advancement in ___ technology has led to the miniaturization of electronic devices.

7. The optimal results obtained from these ___ formulations may not serve the real purpose of modelling the problem.

Multiple Choice

4. For questions 1-4 choose the right answer, A, B, C or D.

1. According to the text, what is the main idea behind Chaos Theory?

A) Chaos Theory suggests that the universe is completely random and unpredictable.

B) Chaos Theory proposes that even small changes can have significant and unpredictable consequences over time.

C) Chaos Theory argues that Newton's laws of physics are inaccurate and need to be revised.

D) Chaos Theory emphasizes the importance of precise measurements in predicting future events.

2. What specific example does the text use to illustrate the butterfly effect in human behavior?

A) The text uses the example of a banker's car malfunction to illustrate the butterfly effect in human behavior.

B) The text uses the example of a butterfly's wings flapping to illustrate the butterfly effect in human behavior.

C) The text uses the example of Albert Einstein's death to illustrate the butterfly effect in human behavior.

D) The text uses the example of trolling on social networks to illustrate the butterfly effect in human behavior.

3. What is the significance of the difference in the numbers entered by Lorenz and his computer in his weather forecasting model?

A) The difference highlights the importance of using accurate data in scientific models.

B) The difference demonstrates that even minute variations can lead to drastically different outcomes.

C) The difference proves that weather forecasting is an unreliable science.

D) The difference suggests that computers are more accurate than humans in scientific calculations.

4. According to the text, what is the primary reason why long-term weather prediction remains challenging despite advancements in scientific understanding?

A) The complexity of weather systems makes it impossible to account for all variables.

B) The butterfly effect demonstrates that even minor changes can significantly alter weather patterns.

C) The limitations of current technology prevent accurate long-term weather forecasting.

D) The unpredictable nature of the atmosphere makes it impossible to predict future weather conditions.

Over to you

5. Answer the comprehension questions:

1. How does the text explain the difference between Chaos Theory and classical physics?

2. What is the significance of the butterfly effect in the context of the stock market, as described in the text?

3. What does the text suggest about the limitations of our understanding of the universe in relation to Chaos Theory?

6. Work in groups. Questions for discussion:

1. Chaos theory suggests that the universe is not entirely predictable, and that even with our best understanding of the laws of physics, there are limits to our knowledge. How do you navigate these uncertainties and the unknown in your own life?

2. The text highlights the application of chaos theory in various fields, including finance, medicine, and social behavior. Consider how the principles of chaos theory might apply to your own chosen field of study or career path. How might understanding the concept of 'butterfly effect' influence your approach to problem-solving or decision-making?

3. The text explores the idea that even seemingly insignificant events can have profound consequences. Reflect on a time in your life when a small action or decision led to an unexpected and significant outcome. How did this experience shape your understanding of cause and effect, and how might the idea of interconnectedness and unpredictability influence your approach to life?

If you want something extra

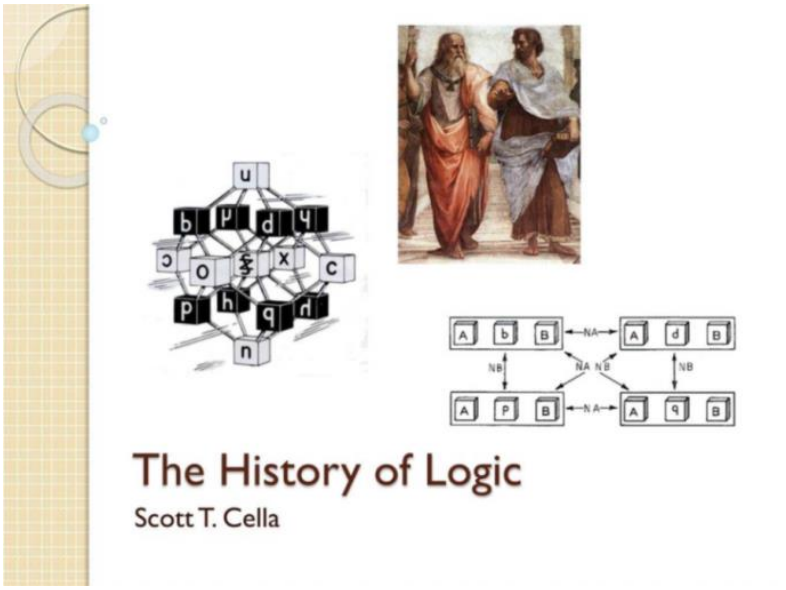
- https://www.britannica.com/topic/philosophy-of-science/Discovery-justification-and-falsification

Unit 3
Mathematical Logic

Lead-in

1. Paraphrase the following quotations. Which do you agree with? Why?

- ✓ *Pure mathematics is, in its way, the poetry of logical ideas. (Albert Einstein)*
- ✓ *Logic is the hygiene the mathematician practices to keep his ideas healthy and strong. (Hermann Weyl)*



2. Read the text

A Brief History of Mathematical Logic

Logic formalises the concepts we often take for granted in mathematics: **proofs**, **truth**, and **statements** are some of these core foundations, upon which we build all mathematical research. This article explores the history of mathematical logic — we trace a path from the work of ancient scholars to our present, diverse branches of study.

The Ancient East

Developments in Ancient Eastern mathematical logic were largely clustered in just two countries, **China** and **India**.

"Who really knows? Who will here proclaim it? Whence was it produced? Whence is this creation? The gods came afterwards, with the creation of this universe. Who then knows whence it has arisen?" — Nasadiya Sukta, on the origins of the universe.

India

Indian logicians were generally motivated by religion. **Vaisheshika** and **Nyaya** were two of six contemporary Hindu schools of philosophy; Vaisheshika proposed that all objects in the universe were reducible to a finite number of atoms, much like how complex plane Euclidean geometry theorems are constructible from just five fundamental axioms, while the Nyaya school distinguished itself by accepting testimonies and analogies as valid in logical argument. **Catuṣkoṭi**, also known as the **tetralemma**, was a system refined by the Buddhist philosopher Nagarjuna and was a predecessor of our modern Boolean logic. **Jain** and **Buddhist** logic tended to be concerned with the nature of knowledge **— how is knowledge derived**, and **when is it reliable?**

China

In China, the **Mohist** school of thought reigned supreme. Founded by the philosopher Mozi, it dealt with issues relating to **valid inference** and the **conditions of correct conclusions**. Mohism was special in its preference for **rhetorical analogies** over mathematical reasoning; persuasive arguments and speech were preferred over drawing conclusions from the rigorous examination of evidence, which may sound familiar to the politically astute reader of the present. Later on, the **Logicians** grew out of Mohism **—** they're often credited with discovering **formal logic**, which abstracted away finicky particulars and allowed a mathematical study of reasoning for the first time.

The Ancient West

"Valid reasoning has been employed in all periods of human history."

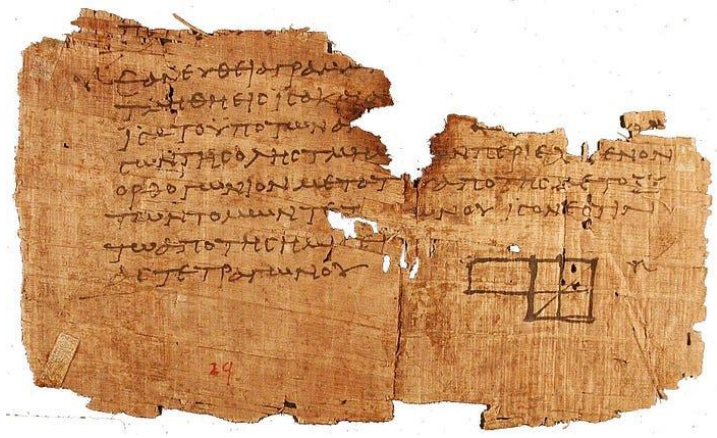
Egypt and Babylon

The origins of mathematical logic in the West can be reasonably traced back to **geometry**. The word stems from the **ancient Greek** γεωμέτρης, meaning '**land measurers**', which speaks to the practical testing of geometric formulas which were being discovered at the time **—** logic may have developed as a more abstract version of this demonstration to show the **validity** of conclusions.

Equally, skilled mathematicians in **ancient Egypt** and **Babylon** may have developed precursors to modern mathematical logic. **Esagil-kin-apli**, the chief scholar of a Babylonian king in the 11th century BCE, produced a medical diagnostic handbook based on assumptions that we would now generally refer to as **axioms**. At the same time, **Babylonian astronomers** were using internal logic **—** collections of consistent rules and reasoning **—** to predict where planets would be in the night sky.

Mathematical Logic in Greece

Ancient Greece heralded the start of empirical methods being replaced with actual proof. **Thales** and **Pythagoras** were Greek philosophers who emphasised the connection between proving concepts and **mathematical development**: once you could prove abstract mathematical truths, it was acceptable to use those theorems to prove more complex ideas. This idea was very similar to the concept of **deductive systems**, in which one starts with given truths and considers what can be worked out. Fragments of early proofs are still preserved in the works of Euclid:



A fragment of Euclid's Elements, one of the seminal mathematical texts of classical antiquity. (Wikipedia)

Euclid of Alexandria came up with three basic principles of geometry, the abstraction of which forms a basis for mathematical logic:

- Certain propositions (statements) **must be accepted as true without demonstration**; such a proposition is known as an **axiom** of geometry.
- Every proposition that is not an axiom of geometry must be **demonstrated as following from the axioms** of geometry; such a demonstration is known as a **proof** or a "derivation" of the proposition.

- The proof must be **formal**; that is, the derivation of the proposition must be **independent of the particular example** in question.

"Let no one ignorant of geometry enter here." — Inscribed over the entrance to Plato's Academy.

Plato was a fourth-century philosopher raised three questions about philosophical logic:

1. What is it that can properly be called **true** or **false**?
2. What is the nature of the connection between the **assumptions** of a valid argument and its **conclusion**?
3. What is the nature of **definition**?

Plato suggested that the necessary connection between the assumptions of a valid argument and its conclusion corresponds to a necessary connection between "forms", expanded upon in a philosophical concept aptly named the **Theory of Forms**. His works generally concern the search for a definition of some important concept — justice, peace, goodness, for example — and it is likely that he was impressed by how important definitions were in mathematics. Plato considered every definition to be a **Platonic Form**: the common nature present in different particulars. In mathematical logic, we understand this idea to be linked to abstraction; a theorem, once proved, can be applied to any appropriate context.

Aristotle

The works of **Aristotle** have had enormous influence in contemporary Western thought, being translated into Latin in the Middle Ages and employed as standard texts in many of Europe's universities. He was the first **formal logician**, demonstrated the principles of reasoning by employing **variables** to show the underlying logical form of an argument.

"If it is rainy, then I will get wet if I'm outdoors" becomes "A implies B"; A and B are the variables corresponding to these statements, allowing a further abstraction that allows us to consider the logical argument context-free. He was also the first to distinguish the **validity** of these relations from the **truth of the premises themselves**,

which could be false — as long as the reasoning is consistent, we consider the statements to be sound.

In addition, he produced a collection of logical works called the **Organon**, the earliest formal study of logic, discussed and analysed what makes a **syllogism** (a valid argument), and considered non-formal logic — the study of constructs including **fallacies**, which are invalid deductive arguments.

Medieval Europe and the Middle East

The works of **Al-Kindi**, **Al-Farabi**, **Avicenna**, **Al-Ghazali**, **Averroes** and other Muslim logicians were based on Aristotelian logic and were important in communicating the ideas of the ancient world to the medieval West. They explored **conditional syllogisms**, which were forms of valid argument based on conditions.

If I don't wake up, then I can't go to work. If I can't go to work, then I won't get paid. Therefore, not waking up means that I won't get paid.

In Medieval Europe, Aristotle's work was also the foundation of new insights. Christian philosopher **Boethius** contributed heavily to the development of **Scholastic logic**, a form of Aristotelian logic that was developed between 1200 and 1600 CE. Because Christianity was widespread at the time, these developments led to the application of logical techniques to attempt to prove **theological concepts** such as the **existence of God**.

The Rise of Modern Logic

In the **mid-19th century**, inspired by the methods of proof used in mathematics, there was a renewed interest in logic. **Rigor** was at the heart of this renaissance, leading to the names "**symbolic**" or "**mathematical**" logic that we employ today.

Modern logic's rules of operation are determined only by the **axioms** and **rules of valid inference** we apply to them; we don't start with ordinary language and try to find an equation which matches it — **we start with abstract mathematics**, draw conclusions, and then try to express our conclusions in ordinary language.

World War II led to an explosion of mathematical logic. It was too large and burgeoning to contain within just one field; logic diversified into **model theory**, **proof**

theory, **computability theory**, and **set theory**, leading to a picture of logic today that is the composite of various intersecting disciplines.
https://josephjojoe.medium.com/a-brief-history-of-mathematical-logic-7ec7a69e7862 [8]

3. a) Match the words to their definitions.

1. abstraction	a) The process of reaching a conclusion based on evidence and reasoning, drawing a logical connection between premises and a conclusion.
2. axioms	b) Growing or developing rapidly.
3. inference	c) Self-evident truths or principles that are accepted without proof, forming the foundation of a system of reasoning or knowledge.
4. premises	d) Excessively concerned with details or fussy about standards.
5. syllogism	e) The process of considering something independently of its concrete details or specific instances, focusing on its general or essential qualities.
6. burgeoning	f) A type of logical argument that consists of three parts: a major premise, a minor premise, and a conclusion, where the conclusion is logically derived from the premises.
7. finicky	g) Statements or propositions that are assumed to be true and form the basis for an argument or deduction.

b) Fill in the gaps with the words from the table.

1. In Euclidean geometry, the ___ state fundamental truths about points, lines, and planes, upon which all other theorems are built.
2. The ___ tech industry is creating many new jobs.

3. The ___ of the argument were that all humans are mortal and that Socrates is a human, leading to the conclusion that Socrates is mortal.
4. The intercept was assumed to be random in order to take within-subject correlations of the dependent variables into account for statistical ___.
5. But he was a past-master in the art, notwithstanding he had not officiated before in the presence of so "___" an assemblage.
6. A ___ cannot be explained by anything, except another ___.
7. The concept of 'justice' is an ___, representing a general idea rather than a specific act or situation.

4. Decide whether these statements are true or false.

1. Mathematical logic has a long history, with roots in ancient China, India, and Greece, where theologians and mathematicians explored concepts like proof, truth, and the nature of knowledge.
2. Key figures in the development of logic include Aristotle, who established axioms and proofs in geometry, and Euclid, who formalized the principles of reasoning.
3. Modern logic emerged in the 19th century with a focus on rigor and abstraction, and has since diversified into various branches, including model theory, proof theory, and set theory.

Multiple Choice

5. For questions 1-7 choose the right answer, A, B, C or D.

1. Which of the following is NOT a branch of logic that emerged from the explosion of mathematical logic during World War II?

A) Model theory

B) Proof theory

C) Computability theory

D) Number theory

2. What is the main difference between the Mohist school of thought and the Logicians in ancient China?

A) The Mohists focused on rhetorical analogies while the Logicians emphasized formal logic and mathematical reasoning.

B) The Mohists were more interested in practical applications of logic, while the Logicians focused on theoretical concepts.

C) The Mohists were influenced by Buddhist philosophy, while the Logicians were influenced by Confucianism.

D) The Mohists were a more ancient school of thought, while the Logicians emerged later.

3. What is the significance of the statement "Let no one ignorant of geometry enter here" inscribed over the entrance to Plato's Academy?

A) It emphasizes the importance of geometry in understanding the world.

B) It suggests that Plato believed geometry was the foundation of all knowledge.

C) It highlights the connection between geometry and logic, as both involve deductive reasoning.

D) It indicates that Plato's Academy was a place for advanced mathematical studies.

4. What was the main motivation for Indian logicians in developing their systems of logic?

A) To understand the nature of the universe.

B) To provide a framework for religious beliefs and practices.

C) To develop a system for proving mathematical theorems.

D) To create a language for communicating complex ideas.

5. What is the significance of the "Tetralemma" in the development of mathematical logic?

A) It was a system of logic that focused on the nature of knowledge and its reliability.

B) It was a system of logic that was based on the principles of geometry.

C) It was a system of logic that was developed by the Mohist school of thought.

D) It was a system of logic that was used to prove the existence of God.

6. How did the work of Thales and Pythagoras contribute to the development of mathematical logic in Ancient Greece?

A) They emphasized the importance of proving concepts through mathematical reasoning.

B) They developed the first formal system of logic based on axioms and proofs.

C) They introduced the concept of deductive systems, which laid the foundation for modern logic.

D) They were the first to use variables to represent logical statements.

7. What is the main difference between the "Tetralemma" and modern Boolean logic?

A) The Tetralemma was a system of logic developed in India, while Boolean logic was developed in the West.

B) The Tetralemma was a system of logic that focused on the nature of knowledge, while Boolean logic is a system of logic that deals with truth values.

C) The Tetralemma was a system of logic that was based on religious beliefs, while Boolean logic is a system of logic that is based on mathematical principles.

D) The Tetralemma was a system of logic that was developed by Buddhist philosophers, while Boolean logic was developed by Christian philosophers.

Over to you

6. Answer the comprehension questions.

1. What is the connection between geometry and the development of mathematical logic in the West?
2. How did the work of Aristotle contribute to the development of formal logic?
3. What was the impact of the renewed interest in logic in the mid-19th century?
4. What is the significance of Euclid's three basic principles of geometry in the development of mathematical logic?
5. How did the works of Muslim logicians like Al-Kindi, Al-Farabi, and Avicenna contribute to the development of mathematical logic in the Medieval West?
6. What is the significance of the Nasadiya Sukta in the context of Indian mathematical logic?

7. How did the rise of modern logic in the mid-19th century differ from the approaches to logic in previous eras?

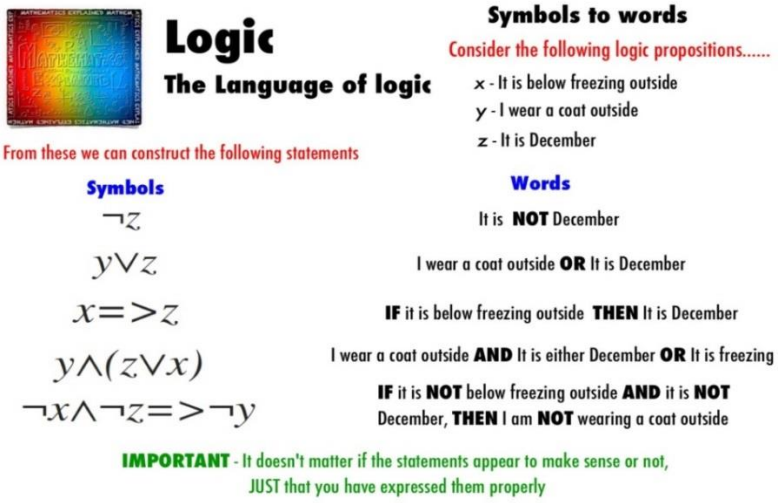
7. Work in groups. Questions for discussion:

1. The text highlights the influence of different cultures and philosophies on the development of logic. How have different perspectives and experiences shaped your own understanding of reasoning and truth?
2. The text mentions the use of logic in fields like geometry, astronomy, and medicine. How do you see logic being applied in your own field of study or area of interest?
3. The text describes the shift from informal reasoning to formal logic. How has this shift impacted the way we communicate and understand information in the modern world?

Mathematical Logic

Pre-Reading

1. Look at the picture. How are the symbols and words related? Discuss it in pairs.



2. Read the text

Mathematical logic is best understood as a branch of logic or mathematics. Mathematical logic really refers to two distinct areas of research: the first is the application of the techniques of formal logic to mathematics and mathematical

reasoning, and the second, in the other direction, the application of mathematical techniques to the representation and analysis of formal logic.

Mathematical logic is often divided into the subfields of model theory, proof theory, set theory and recursion theory. Research in mathematical logic has contributed to, and been motivated by, the study of foundations of mathematics, but mathematical logic also contains areas of pure mathematics not directly related to foundational questions.

One unifying theme in mathematical logic is the study of the expressive power of formal logics and formal proof systems. This power is measured both in terms of what these formal systems are able to prove and in terms of what they are able to define. Thus it can be said that "mathematical logic has become the general study of the logical structure of axiomatic theories."

Earlier names for mathematical logic were **symbolic logic** (as opposed to philosophical logic) and **metamathematics**. The former term is still used (as in the Association for Symbolic Logic), but the latter term is now used for certain aspects of proof theory.

Mathematical logic was the name given by Giuseppe Peano to what is also known as symbolic logic. In its classical version, the basic aspects resemble the logic of Aristotle, but written using symbolic notation rather than natural language. Attempts to treat the operations of formal logic in a symbolic or algebraic way were made by some of the more philosophical mathematicians, such as Leibniz and Lambert; but their labors remained little known and isolated. It was George Boole and then Augustus De Morgan, in the middle of the nineteenth century, who presented a systematic mathematical way of regarding logic. The traditional, Aristotelian doctrine of logic was reformed and completed; and out of it developed an instrument for investigating the fundamental concepts of mathematics. It would be misleading to say that the foundational controversies that were alive in the period 1900–1925 have all been settled; but philosophy of mathematics was greatly clarified by the "new" logic.

While the Greek development of logic put heavy emphasis on *forms of arguments*, the attitude of current mathematical logic might be summed up as *the combinatorial study of content*. This covers both the *syntactic* and the *semantic* dimensions. *Syntactic* has to do with the correct or formal structure of a string of symbols in a formal language, as, for example, sending a string from a formal language to a compiler program to write it as sequence of machine instructions. *Semantic* has to do with interpretation or use of a string of symbols, as, for example, constructing specific models or whole sets of them, in model theory. This study of mathematics from the outside is known as metamathematics.

[Some landmark publications were the *Begriffsschrift* by Gottlob Frege, *Studies in Logic* by Charles Peirce, *Principia Mathematica* by Bertrand Russell and Alfred North Whitehead, and *On Formally Undecidable Propositions of Principia Mathematica and Related Systems* by Kurt Gödel].

Formal Logic

At its core, mathematical logic deals with mathematical concepts expressed using formal logical systems. The system of first-order logic is the most widely studied because of its applicability to foundations of mathematics and because of its desirable properties. Stronger classical logics such as second-order logic or infinitary logic are also studied, along with nonclassical logics such as intuitionistic logic.

Fields of Mathematical Logic

Barwise's "*Handbook of Mathematical Logic*" (1977) divides mathematical logic into four parts:

Set theory is a branch of mathematical logic that studies sets, which can be described informally as abstract collections of objects. Although any object can be compiled into a set, set theory, set theory symbols as a branch of mathematics, is mostly concerned with those that are relevant to mathematics in general. The basic concepts of set theory such as subset and relative complement are often called **naive set theory**. Modern research is in the area of **axiomatic set theory**, which uses logical methods to study which propositions are provable in various formal theories such as Zermelo-Frankel set theory, known as ZFC, or New Foundations set theory, known as NF.

Proof theory is a major branch of mathematical logic, the study of formal proofs in various logical deduction systems. These proofs are represented as formal mathematical objects, facilitating their analysis by mathematical techniques. Frege worked on mathematical proofs and formalized the notion of a proof.

Proofs are typically presented as inductively defined data structures such as plain lists, boxed lists, or trees that are built according to the logical system's axioms and rules of inference. As a result, proof theory is syntactic in nature, whereas model theory is semantic in nature. Structural proof theory, ordinal analysis, provability logic, reverse mathematics, proof mining, automated theorem proving, and proof complexity are some of the major areas of proof theory.

Model theory studies the models of various formal theories. A model is a simplified or reduced version of a theory. Models can be thought of as theories with a more narrowly defined scope of explanation. A model is descriptive, whereas a theory is both descriptive and explanatory.

Model theory is the study of the models of various formal theories. A theory is a set of equations with a particular formal logic and signature, whereas a model is a framework that provides a tangibly interpretable interpretation of the theory.

The set of all models of a particular theory is called an elementary class. Classical model theory seeks to determine the properties of models in a particular elementary class, or determine whether certain classes of structures form elementary classes. The method of quantifier elimination is used to show that models of particular theories cannot be too complicated.

Recursion theory, also called **computability theory**, studies the properties of computable functions and the Turing degrees, which divide the uncomputable functions into sets which have the same level of uncomputability. The field has grown to include the study of generalized computability and definability. In these areas, recursion theory overlaps with proof theory and effective descriptive set theory. The computability of functions from positive integers to natural numbers is the subject of classical recursion theory. Using Turing machines, calculus, and other systems, the essential results construct a robust, canonical Class of computable

functions with several independent, equivalent characterizations. Two more advanced conclusions are the structure of Turing degrees and the lattice of recursively enumerable sets.

The border lines between these fields, and also between mathematical logic and other fields of mathematics, are not always sharp; for example, Gödel's incompleteness theorem marks not only a milestone in recursion theory and proof theory, but has also led to Loeb's theorem, which is important in modal logic. The mathematical field of category theory uses many formal axiomatic methods resembling those used in mathematical logic, but category theory is not ordinarily considered a subfield of mathematical logic.

https://www.newworldencyclopedia.org/entry/Mathematical_logic#google_vignette [9]

3. a) Match the words to their definitions.

1. recursion	a) a statement or assertion that expresses a judgment or opinion
2. uncomputable	b) relating to the study of combinations and permutations, which are ways of arranging or selecting objects from a set
3. proposition	c) the study of the foundations and methods of mathematics, including the nature of mathematical proof, the consistency of mathematical systems, and the limits of mathematical knowledge
4. overlap	d) the application of a function to its own values to generate an infinite sequence of values
5. axiomatic	e) to extend over or partly cover something else
6. combinatorial	f) not capable of being calculated or determined by a computer or other mechanical device
7. metamathematics	g) relating to or based on axioms, which are fundamental principles or assumptions that are taken to be true without proof

b) Fill in the gaps with the words from the table.

1. One of the earliest and perhaps most famous ___ functions is known as the Halting Problem.

2. Several topics of these two courses ___ .

3. The philosopher presented a series of ___ about the nature of reality.

4. The theory of Euclidean geometry is based on a set of ___ principles that define the properties of points, lines, and planes.

5. ___ allows humans to link various parts of our experience.

6. ___ mathematics is used to solve problems involving the arrangement of objects, such as the number of ways to choose a committee from a group of people.

7. Gödel's incompleteness theorems are a fundamental result in ___ , showing that any consistent formal system that includes arithmetic must contain statements that are true but unprovable within the system.

Multiple Choice

4. For questions 1-7 choose the right answer, A, B, C or D.

1. What are the two main areas of research that fall under the umbrella of mathematical logic?

A) The application of formal logic to mathematics and the application of mathematical techniques to formal logic.

B) The study of sets and the study of proofs.

C) The analysis of models and the analysis of computable functions.

D) The development of axiomatic theories and the analysis of their expressive power.

2. According to the text, what is the primary focus of mathematical logic?

A) Developing new mathematical theories.

B) Solving complex mathematical problems.

C) Understanding the logical structure of axiomatic theories.

D) Creating new formal systems for representing logical concepts.

3. What is the difference between the syntactic and semantic dimensions of mathematical logic?

A) Syntactic refers to the meaning of symbols, while semantic refers to their structure.

B) Syntactic refers to the structure of symbols, while semantic refers to their meaning.

C) Syntactic refers to the application of logic to mathematics, while semantic refers to the application of mathematics to logic.

D) Syntactic refers to the formal proofs, while semantic refers to the models.

4. Which historical figure is credited with introducing the term "mathematical logic" and is also known for their work in symbolic logic?

A) George Boole

B) Giuseppe Peano

C) Augustus De Morgan

D) Gottlob Frege

5. According to the text, what is the significance of Gödel's incompleteness theorem?

A) It established the limits of formal systems in proving all true statements.

B) It proved that all mathematical problems can be solved using formal systems.

C) It demonstrated the equivalence of set theory and recursion theory.

D) It provided a definitive solution to the problem of the foundations of mathematics.

6. How does the text describe the relationship between mathematical logic and category theory?

A) Category theory is a subfield of mathematical logic.

B) Category theory is a completely separate field with no connection to mathematical logic.

C) Category theory is a more advanced branch of mathematical logic.

D) Category theory uses similar formal methods as mathematical logic but is not considered a subfield.

7. According to the text, what is the significance of the "new" logic in the period 1900-1925?

A) It led to the development of new mathematical theories.

B) It helped to clarify the foundations of mathematics.

C) It resolved all the foundational controversies of the time.

D) It provided a new way of understanding the nature of logic itself.

Over to you

5. Answer the comprehension questions.

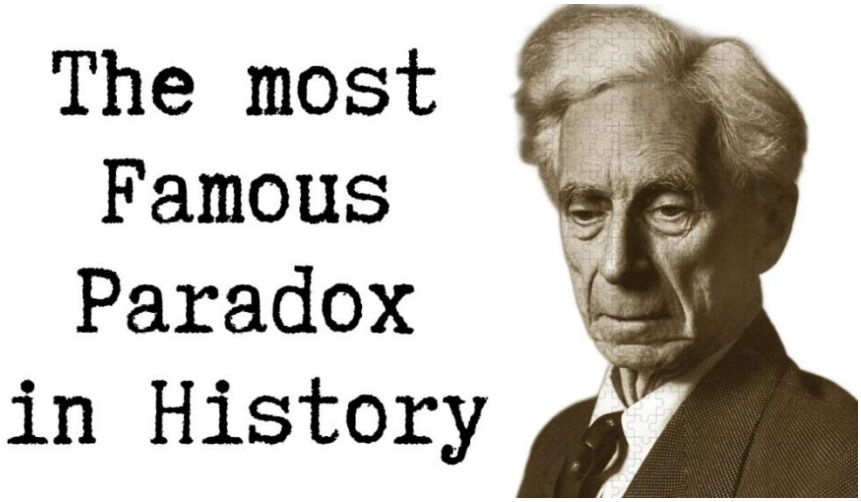
1. What is the difference between a theory and a model in model theory?
2. What is the significance of Gödel's incompleteness theorem in the context of mathematical logic?
3. What is the significance of the 'new' logic in the period 1900-1925, and how did it contribute to the philosophy of mathematics?
4. What is the difference between 'symbolic logic' and 'metamathematics'?
5. How does the text define the concept of 'expressive power' in the context of formal logics and proof systems?
6. What is the difference between 'naive set theory' and 'axiomatic set theory' as described in the text?
7. What is the primary focus of research in recursion theory, and how does it relate to other branches of mathematical logic?

6**. Work in groups. Questions for discussion:**

1. The text highlights the importance of 'models' in understanding formal theories. How do you use models or simplified versions of complex ideas in your own thinking and learning? How do these models help you to make sense of the world?
2. The text discusses the use of formal languages and symbols in mathematical logic. How do you think the use of formal languages impacts our understanding of concepts, and how might it be both helpful and limiting in our communication and reasoning?
3. The text describes mathematical logic as a field that explores the 'logical structure of axiomatic theories.' How might this concept of 'logical structure' be applied to other areas of human endeavor, such as social systems, political structures, or even personal relationships?

4. The text describes how mathematical logic is used to study the expressive power of formal systems. Think about a formal system you use in your own life, such as a programming language or a musical notation system. How does the expressive power of this system affect your ability to communicate your ideas?

5. The text discusses the concept of 'uncomputable functions' in recursion theory. Can you think of any real-world situations where you might encounter a problem that is fundamentally uncomputable? How might you approach such a problem?



1. Read the text.

John T. Baldwin and Olivier Lessmann of the Department of Mathematics, Statistics and Computer Science at the University of Illinois at Chicago offer the following explanation.

Russell's paradox is based on examples like this: Consider a group of barbers who shave only those men who do not shave themselves. Suppose there is a barber in this collection who does not shave himself; then by the definition of the collection, he must shave himself. But no barber in the collection can shave himself. (If so, he would be a man who does shave men who shave themselves.)

Bertrand Russell's discovery of this paradox in 1901 dealt a blow to one of his fellow mathematicians. In the late 1800s, Gottlob Frege tried to develop a foundation for all of mathematics using symbolic logic. He established a correspondence between formal expressions (such as x=2) and mathematical properties (such as even

numbers). In Frege's development, one could freely use any property to define further properties.

Russell's paradox, which he published in Principles of Mathematics in 1903, demonstrated a fundamental limitation of such a system. In modern terms, this sort of system is best described in terms of sets, using so-called set-builder notation. For example, we can describe the collection of numbers 4, 5 and 6 by saying that x is the collection of integers, represented by n, that are greater than 3 and less than 7. We write this description of the set formally as x = { n: n is an integer and 3 < n < 7} . The objects in the set don't have to be numbers. We might let y ={x: x is a male resident of the United States }.

Seemingly, any description of x could fill the space after the colon. But Russell (and independently, Ernst Zermelo) noticed that x = {a: a is not in a} leads to a contradiction in the same way as the description of the collection of barbers. Is x itself in the set x? Either answer leads to a contradiction.

When Russell discovered this paradox, Frege immediately saw that it had a devastating effect on his system. Even so, he was unable to resolve it, and there have been many attempts in the last century to avoid it.

Russell's own answer to the puzzle came in the form of a "theory of types." The problem in the paradox, he reasoned, is that we are confusing a description of sets of numbers with a description of sets of sets of numbers. So Russell introduced a hierarchy of objects: numbers, sets of numbers, sets of sets of numbers, etc. This system served as vehicle for the first formalizations of the foundations of mathematics; it is still used in some philosophical investigations and in branches of computer science.

Zermelo's solution to Russell's paradox was to replace the axiom "for every formula A(x) there is a set y = {x: A(x)}" by the axiom "for every formula A(x) and every set b there is a set y = {x: x is in b and A(x)}." What became of the effort to develop a logical foundation for all of mathematics? Mathematicians now recognize that the field can be formalized using so-called Zermelo-Fraenkel set theory. The formal language contains symbols such as e to express "is a member of," = for equality and ¿

to denote the set with no elements. So one can write formulas such as B(x): if y e x then y is empty. In set-builder notation we could write this as y = {x : x = ¿} or more simply as y = {¿}. Russell's paradox becomes: let y = {x: x is not in x}, is y in y? https://www.scientificamerican.com/article/what-is-russells-paradox/ [10]

2. a) Match the words to their definitions.

1. contradiction	a) a system or organization in which people or things are ranked one above the other according to status or authority
2. paradox	b) the act of examining something carefully, esp. to discover the truth about it
3. hierarchy	c) a statement that is the opposite of another statement, making both statements impossible to be true at the same time
4. formalization	d) a statement or proposition that is regarded as being self-evidently true and is used as a starting point for reasoning and argument.
5. set-builder	e) a statement or proposition that, despite apparently valid reasoning from true premises, leads to a seemingly self-contradictory or logically unacceptable conclusion
6. axiom	f) a notation used in set theory to define a set by specifying the properties that its elements must satisfy
7. investigation	g) the process of making something more precise, structured, or systematic

b) Fill in the gaps with the words from the table.

1. The company has a strict ___ , with the Chief Executive Officer (CEO) at the top and the employees at the bottom.

2. The ___ of the company's policies led to greater clarity and consistency.

3. A ___ of personal data is that both keeping the information secret and exchanging the information can be done under the banner of security.

4. ___ notation is one of the ways of representing sets in the most convenient and concise way.

5. Several companies are under ___ for fraud.

6. The witness's testimony presented a ___ to the suspect's alibi.

7. The simulation process is accomplished by deduction with logical ___ , describing abnormal behaviour, and assumed (abnormal) states.

3. Decide whether these statements are true or false.

- Russell's paradox shows that you define a set that includes all sets that contain themselves, because it leads to a contradiction.
- Russell's paradox challenged the work of Gottlob Frege, who was trying to create a foundation for all of mathematics using logic.
- Mathematicians have since developed a system called Zermelo-Fraenkel number theory to avoid Russell's paradox and provide a foundation for mathematics.

Multiple Choice

4. For questions 1-7 choose the right answer, A, B, C or D.

1. What was the main impact of Russell's paradox on Frege's work?

A) It proved Frege's system was flawed and could not be used to build a foundation for all of mathematics.

B) It confirmed Frege's system was sound and could be used to build a foundation for all of mathematics.

C) It had no impact on Frege's work.

D) It led Frege to abandon his work on mathematics and pursue a career in philosophy.

2. What is the main idea behind Russell's theory of types?

A) It suggests that sets can be organized into a hierarchy based on their complexity.

B) It proposes that all sets are equal and should be treated the same.

C) It argues that sets are not real and only exist in our minds.

D) It claims that sets are only useful for describing numbers.

3. What is the significance of the symbol '¿' in the context of Zermelo-Fraenkel set theory?

A) It represents the set of all numbers.

B) It represents the set of all sets.

C) It represents the set with no elements.

D) It represents the set of all possible properties.

4. Who was the mathematician who tried to develop a foundation for all of mathematics using symbolic logic?

A) John T. Baldwin

B) Gottlob Frege

C) Bertrand Russell

D) Ernst Zermelo

5. What is the name of the book where Russell published his paradox?

A) From Frege to Godel

B) Principles of Mathematics

C) Zermelo-Fraenkel Set Theory

D) The Theory of Types

6. What was the main problem that Russell's paradox exposed in Frege's system of mathematics?

A) It showed that Frege's system could not handle sets that contained themselves.

B) It proved that Frege's system was too complex and difficult to understand.

C) It revealed that Frege's system was based on faulty logic.

D) It demonstrated that Frege's system was not applicable to real-world problems.

7. What is the main difference between Russell's and Zermelo's solutions to Russell's paradox?

A) Russell's solution focused on organizing sets into a hierarchy, while Zermelo's solution focused on limiting the types of sets that could be defined.

B) Russell's solution was more complex than Zermelo's solution.

C) Russell's solution was based on logic, while Zermelo's solution was based on observation.

D) Russell's solution was accepted by mathematicians, while Zermelo's solution was rejected.

Over to you

5. Answer the comprehension questions:

1. What is the basic idea behind Russell's paradox?
2. How did Russell's paradox affect the development of mathematics?
3. What is the significance of Zermelo's solution to Russell's paradox?
4. What is the analogy used in the text to illustrate Russell's paradox?
5. What is the significance of the set-builder notation in understanding Russell's paradox?

6. Work in groups. Questions for discussion:

1. The text discusses Russell's paradox, which shows that some sets cannot be defined without leading to contradictions. Think about a time when you tried to define something, but your definition led to a confusing or contradictory result. How did you resolve the issue?

2. The text explains how Russell's paradox challenged the work of Gottlob Frege, who was trying to create a foundation for all of mathematics. How do you usually react to the challenge? Do you change your plan, or do you find a way to work around the obstacle?

3. The text describes how mathematicians have developed different ways to avoid Russell's paradox. Have you ever faced a problem that seemed impossible to solve? What strategies do you use to overcome such an obstacle?

4. The text mentions that Russell's paradox was discovered in 1901, but it took many years for mathematicians to find a solution. Think about a time when you faced a problem that took a long time to solve. What kept you motivated to keep working on the problem? What did you learn about the importance of perseverance?

If you want something extra

- *Russell's and Frege's correspondence on Russell's discovery of the paradox can be found in From Frege to Godel, a Source Book in Mathematical Logic, 1879-1931, edited by Jean van Heijenoort, Harvard University Press, 1967.*
- https://www.britannica.com/topic/Russells-paradox

Fuzzy Logic: An Introduction

Pre-Reading

1. Work in pairs and answer the questions.

1. What is fuzzy logic and how does it work?
2. Is fuzzy logic binary?
3. Where is fuzzy logic used?

2. Read the text and find the synonyms of the words in the table

vagueness	***regulate***	***disagreement***	***resolve***	***demand***
navigate	***embody***	***pliability***	***ubiquitous***	***facilitate***

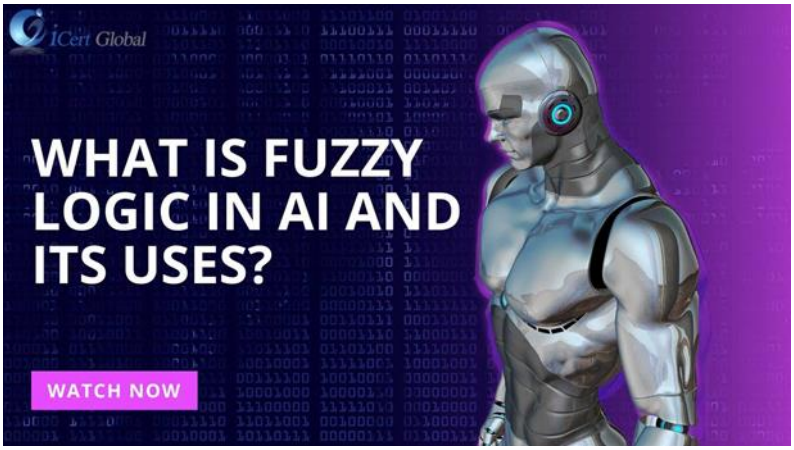
Fuzzy logic is a unique approach to reasoning and decision-making that allows for varying degrees of truth rather than a strict true or false dichotomy. Developed in the 1960s by Lotfi Zadeh, a professor at the University of California, Berkeley, fuzzy logic aims to enable computers to better mimic human thought processes, which often involve uncertainty and ambiguity. Unlike traditional Boolean logic, which operates on absolute values like yes or no, fuzzy logic incorporates a range of values between 0 and 1, allowing for nuanced classifications and interpretations.

For instance, rather than categorizing someone simply as tall or short, fuzzy logic could determine that a person is "somewhat tall" based on various contextual factors. This flexibility extends to real-world applications in artificial intelligence (AI), which can adjust their functions based on varying input parameters. The

underlying mechanism includes "if-then" rules that guide the system in processing information and responding appropriately to changes, making it adaptable and user-friendly. As fuzzy logic technology evolved in the late 20th century, it became more prevalent in Japan and has since found widespread use in systems that require a degree of intelligent automation. (Published in: 2024 By: Sheposh, Richard) https://www.ebsco.com/research-starters/engineering/fuzzy-logic [11]

3. Watch the video. What are the applications and benefits of fuzzy logic in AI?

What is Fuzzy Logic in AI and its uses?



https://youtu.be/JyyLzgxt3Uo?si=4ppl3fvCJnWpqtWn [12]

4. Decide whether these statements are true or false.

- Fuzzy logic is used in various AI applications, including control systems, pattern recognition, decision making, and robotics, enhancing their performance and adaptability.
- Fuzzy logic is a form of mathematical reasoning that allows AI to handle precise information, like traditional binary logic which is absolute.
- Fuzzy logic offers benefits such as handling uncertainty, making better decisions, and providing flexibility, making AI systems more human-like in their reasoning and problem-solving.

Multiple Choice

5. For questions 1-5 choose the right answer, A, B, C or D.

1. How does fuzzy logic differ from traditional binary logic?

A) Fuzzy logic uses degrees of truth, while binary logic is absolute (true or false).

B) Fuzzy logic is based on complex algorithms, while binary logic uses simple calculations.

C) Fuzzy logic is used in AI, while binary logic is used in traditional computers.

D) Fuzzy logic is more efficient than binary logic.

2. What is a key component of fuzzy logic that enables it to handle uncertainty?

A) Fuzzy inference system

B) Fuzzy sets

C) Linguistic variables

D) All of the above

3. Which of the following is NOT a benefit of using fuzzy logic in AI?

A) Fuzzy logic can handle incomplete data.

B) Fuzzy logic can make decisions more like humans.

C) Fuzzy logic can be used to create more efficient algorithms.

D) Fuzzy logic can capture the complexities of human reasoning.

4. What is a key advantage of fuzzy logic in robotics, specifically related to its ability to handle uncertainty?

A) Fuzzy logic allows robots to perform complex tasks with greater precision.

B) Fuzzy logic enables robots to adapt to changing environments and unexpected situations.

C) Fuzzy logic helps robots to communicate more effectively with humans.

D) Fuzzy logic makes robots more efficient in terms of energy consumption.

5. Considering the description of fuzzy logic's ability to handle uncertainty, how might this technology be applied to the field of finance, specifically in areas like stock market prediction or risk assessment?

A) Fuzzy logic is not applicable to finance, as it deals with abstract concepts and not concrete data.

B) Fuzzy logic could be used to analyze complex financial data and identify potential trends, even in the presence of incomplete or uncertain information.

C) Fuzzy logic could be used to automate all financial transactions, eliminating the need for human intervention.

D) Fuzzy logic could be used to create more accurate and reliable financial models, eliminating the need for human judgment.

Over to you

6. Answer the comprehension questions:

1. What are some specific examples of how fuzzy logic is used in control systems?
2. Explain how fuzzy logic is used in pattern recognition.
3. How does fuzzy logic contribute to the development of more intelligent and adaptive robots?
4. Based on the text, how does fuzzy logic's ability to handle uncertainty make it particularly well-suited for real-world applications?
5. Compare and contrast the use of fuzzy logic in AI with the way humans make decisions in complex situations. How does fuzzy logic mimic human reasoning?

7. Work in groups. Questions for discussion:

- The text describes fuzzy logic as a 'humanlike' way of reasoning. How do you see fuzzy logic reflected in your own decision-making processes? Provide some examples from your life.
- The text highlights the use of fuzzy logic in robotics. How might fuzzy logic impact the way we interact with and perceive these machines?
- The text describes fuzzy logic as a way to handle uncertainty and incomplete data. How can fuzzy logic help you in this situation when you have to make a decision with limited information?

If you want something extra

- https://youtu.be/QEBBOBm1Va4?si=3YqRStkbexmWEScu

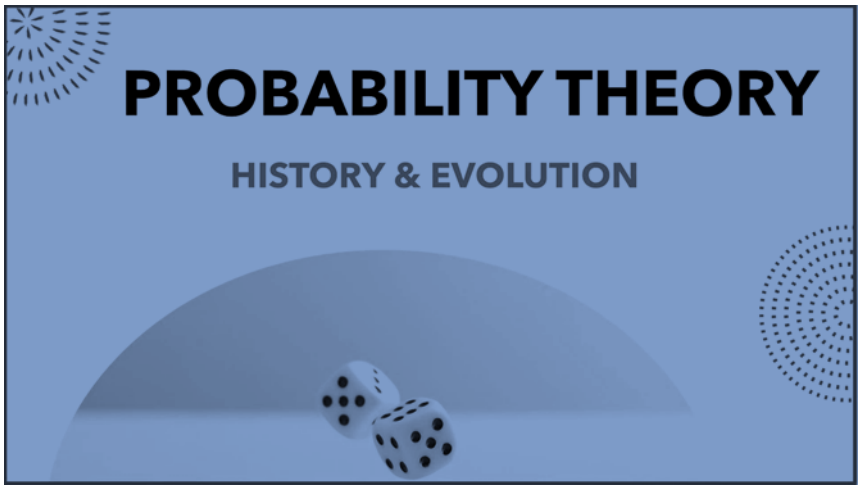
Unit 4

Probability and Statistics

Lead in

1. Paraphrase the following quotations. Which do you agree with? Why?

- ✓ *Statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write. (H.G.Wells)*
- ✓ *Statistics is the grammar of science. (Karl Pearson)*
- ✓ *Those who ignore Statistics are condemned to reinvent it. (Brad Efron)*
- ✓ *Data is the sword of the 21st century, those who wield it well, the Samurai. (Jonathan Rosenberg)*



History of Probability

2. Read the text

Throughout history, humans have used many methods to try to predict the future. Some believed that the future was already laid out for them by a divine power or fate, while others seem to have believed that the future was uncertain. There are still debates on the extent to which people were able to speculate on the future prior to the development of statistics in the seventeenth and eighteenth centuries. Some assert that such speculations were impossible, yet other historical evidence suggests that at least some people must have been able to perceive the world in terms of risks or chances, even if it was not in quite the same way as later mathematicians and

statisticians. The Greek philosopher Aristotle proposed that events could be divided into three groups: deterministic or certain events, chance or probable events, and unknowable events. The idea of "randomness" is often used to indicate completely unknowable events that cannot be predicted. In mathematics, the long-term outcomes of random systems are, in fact, "knowable" or describable using various rules of probability. Probability distributions, expressed as tables, graphs, or functions, show the relationship between all possible outcomes of some experiment or process, like rolling a die, and the chance that those outcomes will happen.

Early History

Archaeological evidence, such as astragalus bones found at ancient sites, suggests that games of chance have been around for several millennia or longer. Egyptian tomb paintings show astragali being used for games like Hounds and Jackals, much like the way twenty-first-century game players use dice. The ideas of randomness that underlie probability were often closely tied to philosophy and religion. Many ancient cultures embraced the notion of a deterministic fate. The Greek pantheon was among those that included deities associated with determinism, literally known as the Fates. The popular goddess Fortuna in the Roman pantheon suggests a recognition of the role of chance in the world. Jainism is an Indian religion with ancient roots, whose organized form appears to have originated sometime between about the ninth and sixth centuries b.c.e. The Jainist logic system known as syadvada includes concepts related to probability; its sanskrit root word syat translates variously as "may be" or "is possible." Probability is also a component of the body of Talmudic scholarship; for example, the notion of casting lots, used in some temple functions. Babylonians had a type of insurance to protect against the risk of loss for sea voyages, called "bottomry," as did the Romans and Venetians.

Origins of Study in the Seventeenth Century

There is relatively little evidence of broad mathematical research on probability before about the fifteenth century, though some analyses for specific cases survive. Historians tend to agree that the systematic mathematical study of probability as it is now known originated in the seventeenth century. At the time, considerable tensions

still existed between the philosophies of religion, science, determinism, and randomness. Determinists asserted that the universe was the perfect work of a divine creator, ruled by mathematical functions waiting to be discovered, and that any apparent randomness was because of faults in human perception. Many emerging scientific theories, like the heliocentric model of the universe advocated by mathematician and astronomer Nicolaus Copernicus, challenged this view by explicitly exploring and quantifying variation and deviations in observations. Astronomy and other sciences, along with the rise of combinatorial algebra and calculus, would ultimately prove to be very influential in the development of probability theory. Changes in business practices also challenged notions of risk, requiring new methods by which likelihood and payoffs could be determined. However, the most popular story for the origin of probability theory concerns gambling questions posed to mathematician Blaise Pascal by Antoine Gombaud, Chevalier de Méré.

In 1654, the Chevalier de Méré presented two problems. One concerned a game where a pair of six-sided dice was thrown 24 times, betting that at least one pair of sixes would occur. Méré's attempts at calculation contradicted the conventional wisdom of the time and purportedly led him to lose as great deal of money. The second problem, now called the Problem of Points or Problem of Stakes, concerned fair division for a pot of money for a prematurely terminated game between equally skilled players where the winner of a completed game would normally take the whole pot. Pascal and Pierre Fermat exchanged a series of letters in which they formulated the fundamental principles of general probability theory.

At the time of its development, Pascal and Fermat's burgeoning theory was commonly referred to as "the doctrine of chances." Inspired by their work, mathematician and astronomer Christian Huygens published De Ratiociniis in Ludo Aleae in 1657, which discussed probability issues for gambling problems. Jakob (also known as James) Bernoulli explored probability theory beyond gambling into areas like demography, insurance, and meteorology and he composed an extensive commentary on Huygen's book. One of his most significant contributions was the

Law of Large Numbers for the binomial distribution, which stated that observed relative frequencies of events become more stable, approaching the true value, as the number of observations increases. Prior definitions based on gambling games tended to assume that all outcomes were equally likely, which was generally true for games with inherent symmetry like throwing dice. This extension allowed for empirical inference of unequal chances for many real-world applications. Bernoulli also wrote Ars Conjectandi. Influenced by this work, mathematician Abraham de Moivre derived approximations to the binomial probability distribution, including what many consider to be the first occurrence of the normal probability distribution, and his The Doctrine of Chances was the primary probability textbook for many years.

Objective and Subjective Approaches

Historically and philosophically, many people have asserted that to be objective, science must be based on empirical observations rather than subjective opinion. Estimating probabilities through direct observations is usually called the "frequentist approach." The method of inverse or inductive probability, which allows for subjective input into the estimation of probabilities, is traced back to the posthumously published work of eighteenth-century minister and mathematician Thomas Bayes. Conditional probabilities had already been explored by de Moivre, providing the basis for what is known as "Bayes theorem" (or "Bayes rule"). In Bayes's inductive framework, there is some probability that a binary event occurs. A frequentist would make no assumptions about the probability and carry out experiments to attempt to determine the true probability value. Using Bayes's approach, some probability value can be arbitrarily chosen, and then experiments conducted to ascertain the likelihood that the value is in fact the correct one. In later interpretations and applications of the method, the initial value might be chosen according to experience or subjective criteria. Bayesian methods have generated much discussion and saw a great resurgence in the latter twentieth century.

Applications

Like Bernoulli, Pierre de Laplace extended probability to many scientific and practical problems, and his probability work led to research in other mathematical

areas such as difference equations, generating functions, characteristic functions, asymptotic expansions of integrals, and what are called "Laplace transforms." Some call his 1812 book, Théorie Analytique des Probabilités, the single most influential work in the history of probability. The Central Limit Theorem, named for George Pólya's 1920 work and sometimes called the DeMoivre–Laplace theorem, was critical to the development of statistical methods and partly validated the common practice at the time (still used in the twenty-first century) of calculating averages or arithmetic means of observations to estimate location parameters. Error estimates were usually assumed to follow some symmetric probability distribution, such as rectangular, quadratic, or double exponential. While they had many useful properties, they were mathematically problematic when it came to deriving the sampling distributions of means for parameter estimation. Laplace's work, which he proved for both direct and inverse paradigms, rectified the problem for large-sample cases and formed the foundation for large sample theory.

Normal Distribution

The normal distribution is among the most central concepts in probability theory and statistics. Many other probability distributions may be approximated by the normal because they converge to the normal as the number of trials or sample sizes approach infinity. Some of these include the binomial and Poisson distributions, the latter named for mathematician Simeon Poisson. The Central Limit Theorem depends on this principle. Mathematician Karl Friedrich Gauss is often credited with "inventing" the normal (or Gaussian) distribution, though others had researched it and Gauss's own notes refer to "the elegant theorem first discovered by Laplace."

The fact that Laplace and Gauss worked on both direct and inverse probability was unusual from some perspectives, given the philosophical divide between frequentist and Bayesian practitioners even at the start of the twenty-first century. Other mathematicians, such as Poisson and Antoine Cournot, criticized inverse methods, while Robert Ellis and John Venn proposed defining probability as the limit of the relative frequency in an indefinite series of independent trials—essentially, the frequentist approach. The maximum likelihood estimation method proposed by

Ronald Fisher in the early twentieth century was interpreted by some as melding aspects of frequentist and inverse methods, though he adamantly denied the notion, saying, “The theory of inverse probability is founded upon an error, and must be wholly rejected.”

Mathematician and anthropometry pioneer Adolphe Quetelet brought the concept of the normal distribution of error terms into the analysis of social data in the early nineteenth century, while others like Francis Galton advanced the development of the normal distribution in biological and social science applications in the latter half of the same century. Many mathematicians, statisticians, scientists, and others have contributed to the development of probability theories, far too many to exhaustively list, though recognized probability distributions are named for many of them, such as Augustin Cauchy, Ludwig von Mises, Waloddi Weibul, and John Wishart. Pafnuty Chebyshev proved the important principle of convergence in probability, also called the Weak Law of Large Numbers. Andrei Markov’s work on stochastic processes and Markov chains would lead to a broad range of probabilistic modeling techniques and assist with the resurgence of Bayesian methods in the twentieth century.

One difficulty in developing a comprehensive mathematical theory of probability, despite such a long history and so many broad contributions, was difficulty agreeing upon one definition of probability. In the first half of the twentieth century, mathematician Andrey Kolmogorov outlined the axiomatic approach that formed the basis for much of subsequent mathematical theory and development. Later, Cox’s theorem would assert that any measure of belief is isomorphic to a probability measure under certain assumptions. It is used as a justification for subjectivist interpretations of probability theory, such as Bayesian methods. There are variations or extensions on probability with many applications. Shannon entropy is used in the lossless compression of data. Martingale stochastic (random) processes, introduced by mathematicians such as Paul Lévy, recall the kinds of betting problems that challenged de Méré and inspired the development of probability theory. Chaos theories, investigated by mathematicians including

Kolmogorov and Henri Poincaré, sometimes offer alternative explanations for seemingly probabilistic phenomena. Fuzzy logic, derived from mathematician and computer scientist Lotfali Zadeh's fuzzy sets, has been referred to as "probability in disguise". https://www.ebsco.com/research-starters/mathematics/history-probability [13]

2. a) Match the words to their definitions.

1. speculate	a) statistical methods used to update the probability for a hypothesis as more evidence or information becomes available; it incorporates prior beliefs or knowledge into the analysis; to compute and update probabilities after obtaining new data
2. randomness	b) to form a theory or conjecture about a subject without firm evidence
3. deterministic	c) a perspective in statistics that defines probability as the limit of the relative frequency of an event after a large number of trials; it relies on objective data and empirical observations to estimate probabilities
4. binomial distribution	d) based on, concerned with, or verifiable by observation or experience rather than theory or pure logic; typically involve systematic collection and analysis of data
5. frequentist approach	e) believing that everything that happens must happen as it does and could not have happened any other way, or relating to this belief
6. Bayesian methods	f) the state of lacking a pattern or principle of organization; unpredictability
7. empirical	g) a probability distribution that summarizes the likelihood that a value will take one of two independent values under a given set of parameters or assumptions

b) Fill in the gaps with the words from the table.

1. This theory needs to be backed up with solid ___ data/evidence.

2. In the ___ ___ to hypothesis testing, the p-value represents the probability of observing the data, or more extreme data, if the null hypothesis were true.

3. ___ ___ are increasingly used in machine learning to update model parameters based on new data, allowing the model to adapt and improve its predictions over time.

4. The ___ ___ is useful for modeling the probability of getting a certain number of heads when flipping a coin multiple times, assuming each flip is independent.

5. The idea of "___" is often used to indicate completely unknowable events that cannot be predicted

6. The optimal results obtained from these ___ formulations may not serve the real purpose of modelling the problem.

7. There are still debates on the extent to which people were able to ___ on the future prior to the development of statistics.

Multiple Choice

3. For questions 1-7 choose the right answer, A, B, C or D.

1. What was the primary focus of Jakob Bernoulli's exploration of probability theory beyond gambling?

A) Bernoulli focused on applying probability theory to areas such as demography, insurance, and meteorology.

B) Bernoulli focused on refining probability calculations for complex card games.

C) Bernoulli focused on using probability theory to predict stock market fluctuations.

D) Bernoulli focused on developing new dice games with more predictable outcomes.

2. What was Ronald Fisher's stance on inverse probability and how did he view its relationship to his maximum likelihood estimation method?

A) Fisher supported inverse probability as a valid method for subjective probability estimation.

B) Fisher believed that inverse probability was essential for refining frequentist approaches.

C) Fisher considered his maximum likelihood estimation method to be a combination of frequentist and inverse methods.

D) Fisher rejected inverse probability entirely, considering it founded upon an error, and denied any connection to his method.

3. How did changes in business practices contribute to the development of probability theory in the seventeenth century?

A) Business practices remained unchanged and had no impact on the development of probability theory.

B) Changes in business practices led to a decline in the study of mathematics and statistics.

C) Changes in business practices created a need for new methods to determine likelihood and payoffs, challenging existing notions of risk.

D) Business practices focused solely on deterministic models, ignoring the role of chance and probability.

4. What was the significance of the Central Limit Theorem in the development of statistical methods?

A) It provided a new method for calculating the probability of specific events in small sample sizes.

B) It validated the practice of calculating averages to estimate location parameters and formed the foundation for large sample theory.

C) It demonstrated that all probability distributions converge to the binomial distribution as sample sizes increase.

D) It disproved the usefulness of arithmetic means in estimating location parameters, leading to new statistical methods.

5. How does the discussion of the Chevalier de Méré's gambling problems contribute to the reader's understanding of the origins of probability theory?

A) It proves that Pascal and Fermat were primarily interested in solving gambling problems rather than developing a general theory.

B) It suggests that the Chevalier de Méré was the first person to develop probability theory.

C) It demonstrates that gambling was the only significant factor in the development of probability theory.

D) It illustrates how practical questions and challenges in gambling led to the development of fundamental principles in probability theory.

6. What was a key contribution of Jakob Bernoulli to probability theory beyond its application to gambling?

A) He disproved the Law of Large Numbers, arguing that empirical observations are unreliable.

B) He limited the scope of probability theory to only gambling-related scenarios.

C) He extended probability theory to areas like demography, insurance, and meteorology, including the Law of Large Numbers.

D) He focused solely on developing the mathematical formulas for dice games.

7. How did the work of mathematicians like Laplace and Gauss, who contributed to both direct and inverse probability, challenge the philosophical divide between frequentist and Bayesian approaches?

A) Their work had no impact on the philosophical divide, as frequentist and Bayesian approaches remained entirely separate.

B) Their contributions demonstrated that only one approach, either frequentist or Bayesian, could be correct.

C) Their involvement in both approaches highlighted the potential for integrating empirical observations with subjective input, despite philosophical differences.

D) Their work proved that subjective probabilities are more accurate than those derived from empirical observations.

Over to you

4. Answer the comprehension questions:

1. What evidence suggests that games of chance existed in ancient times?

2. What was the 'doctrine of chances,' and who was inspired by Pascal and Fermat's work to discuss probability issues for gambling problems?
3. What is the 'frequentist approach' to estimating probabilities, and how does it differ from Bayes's approach?
4. What was Aristotle's classification of events, and how does the concept of 'randomness' fit into this classification?
5. How does the evolution of probability theory, from ancient games of chance to modern statistical methods, enrich or deepen the understanding of the interplay between human curiosity, mathematical innovation, and real-world problem-solving?

5. Work in groups. Questions for discussion:

1. The text mentions the debate between objective (frequentist) and subjective (Bayesian) approaches to probability. How much do you rely on objective data versus your own personal experiences or beliefs, and how does this influence your conclusion?
2. The normal distribution is described as a central concept in probability and statistics, with applications in various fields. Can you think of a real-world phenomenon or dataset that might follow a normal distribution? What insights could be gained by analyzing it using statistical methods based on the normal distribution?
3. Discuss a situation where you encountered uncertainty or ambiguity, and how you tried to make sense of it. Did you find yourself relying on intuition, logic, or a combination of both, and what were the limitations of your approach?
4. The text touches on various extensions and variations of probability, such as Shannon entropy, martingale stochastic processes, chaos theories, and fuzzy logic. Explore a situation where you encountered complexity or unpredictability, and how you might apply one of these alternative approaches to better understand or manage the situation. What are the potential benefits and drawbacks of using such methods?

6. Read the text and find the synonyms of the words in the table

endeavor	scheme	encourage	transform	investigation
eminent	dissimilar	accentuate	attitude	grasp

The history of probability is a rich exploration of humanity's attempts to understand and quantify uncertainty and chance. Early concepts of probability were intertwined with philosophical and religious beliefs, as ancient cultures grappled with the ideas of fate and randomness. The formal study of probability began to take shape in the seventeenth century, spurred by mathematicians such as Blaise Pascal and Pierre Fermat, who addressed gambling problems and laid the groundwork for modern probability theory. Over time, significant developments arose, including Jakob Bernoulli's Law of Large Numbers and Pierre-Simon Laplace's influential works that expanded probability's applications to areas like demographics and insurance.

Throughout history, probability has evolved into distinct approaches, notably the frequentist perspective, which relies on empirical data, and the subjective Bayesian approach, which incorporates personal belief and prior knowledge. Key contributions from mathematicians like Thomas Bayes and Karl Friedrich Gauss further refined probability concepts, leading to important distributions like the normal distribution. The field has since found applications in diverse areas, from genetics to finance, reflecting its integral role in various scientific and practical disciplines. Despite its long history, the definition and interpretation of probability remain subjects of debate, highlighting the complexity and ongoing intrigue of this foundational concept in mathematics and science. (Published in: 2022 By: Greewald, Sarah J. | Thomley, Jill E.) https://www.ebsco.com/research-starters/mathematics/history-probability [13]

7. Watch the video *A Brief History of Probability Theory*

https://youtu.be/1BdtCQuH27w [14]

8. Summarize the main points from the text and video.

The Power of Data: Understanding Statistics

Pre-Reading

1. Work in pairs and answer the questions:

1. What is the role of data?

2. What is the role of data analyst?

3. What are the responsibilities and duties of data collection?

2. Read the text

Statistics, a branch of applied mathematics, delves into the intricate world of data. It encompasses the systematic collection, organization, analysis, and interpretation of quantitative information, ultimately drawing meaningful conclusions from it. This discipline relies heavily on sophisticated mathematical frameworks, including calculus, linear algebra, and probability theory, to provide a robust foundation for its methodologies.

Statisticians, the practitioners of this field, are adept at extracting valuable insights from seemingly random data. Their primary focus lies in understanding how to make reliable inferences about large populations or general events based on the analysis of smaller, representative samples. These samples act as microcosms, providing a window into the characteristics and behaviors of the broader group they represent.

Key Concepts in Statistics

Statistics encompasses two primary areas: *descriptive statistics* and *inferential statistics*. Descriptive statistics focuses on summarizing and characterizing the properties of data sets, providing a clear picture of the central tendencies, variability, and distribution of the information. Inferential statistics, on the other hand, takes this descriptive information a step further, employing it to test hypotheses, draw conclusions, and make predictions about the larger population from which the sample was drawn.

The level of measurement used in statistics plays a crucial role in the type of analysis that can be conducted. Data can be categorized into four distinct levels:

Nominal-level: This level simply assigns labels or categories to data points, without any inherent numerical value or ranking. For example, classifying individuals by their gender (male, female) or their favorite color (blue, green, red) would fall under nominal-level measurement.

Ordinal-level: This level introduces an order or ranking to the data, but the differences between values are not necessarily meaningful. For instance, ranking students based on their performance in a class (first, second, third) provides an order but doesn't indicate the precise difference in their scores.

Interval-level: This level allows for meaningful comparisons between data points, as the differences between values are consistent. However, there is no true zero point, meaning ratios between values are not meaningful. For example, measuring temperature on the Celsius scale allows for comparisons between different temperatures, but a temperature of 0 degrees Celsius does not represent the absence of heat.

Ratio-level: This level represents the highest level of measurement, providing both meaningful differences and a true zero point. This allows for meaningful ratios between values. For example, measuring height in meters provides a true zero point (no height) and allows for meaningful comparisons of height differences and ratios.

Sampling Techniques: A Window into the Population

Since analyzing an entire population can be impractical or impossible, statisticians rely on various sampling techniques to create representative subsets for analysis. These techniques include:

Simple Random Sampling: This technique ensures that every member of the population has an equal chance of being selected for the sample. This is often achieved through random number generators or lottery-style selection.

Systematic Sampling: This technique selects individuals at regular intervals from a list of the population, starting with a randomly chosen individual. This method is efficient and can be used when the population is ordered in a meaningful way.

Stratified Sampling: This technique divides the population into subgroups based on shared characteristics, then selects a random sample from each subgroup in proportion to its representation in the overall population. This ensures that the sample accurately reflects the diversity of the population.

Cluster Sampling: This technique divides the population into clusters, then randomly selects entire clusters for analysis. This method is particularly useful when the population is geographically dispersed or when it is impractical to sample individuals directly.

The Applications of Statistics: A Wide-Ranging Impact

Statistics plays a vital role in a multitude of fields, influencing decision-making and shaping our understanding of the world around us. Here are some key areas where statistics are indispensable:

Finance and Investing: Statistics are used to analyze market trends, assess investment risks, and evaluate the performance of financial assets. Key metrics include average trading volume, 52-week highs and lows, beta, and correlation between assets.

Economics: Statistics are used to track economic indicators, such as GDP growth, unemployment rates, inflation, and consumer spending. This data helps economists understand the health of the economy and make informed policy recommendations.

Marketing: Statistics are used to analyze customer behavior, measure the effectiveness of marketing campaigns, and optimize advertising strategies. Key metrics include conversion rates, click-through rates, search quantities, and social media engagement.

Accounting: Statistics are used to analyze financial statements, assess the financial health of a company, and make informed decisions about resource allocation. Key metrics include liquidity, solvency, and profitability ratios.

Information Technology: Statistics are used to analyze network performance, optimize system efficiency, and ensure data security. Key metrics include bandwidth, network latency, and hardware utilization.

Human Resources: Statistics are used to analyze employee turnover, assess employee satisfaction, and determine fair compensation levels. Key metrics include employee retention rates, employee engagement scores, and average salary comparisons.

The Importance of Statistical Literacy

Understanding statistics is crucial for navigating the modern world, where data is constantly being generated and analyzed. Statistical literacy empowers individuals to:

Critically evaluate information: By understanding statistical concepts, individuals can discern reliable information from misleading or biased data.

Make informed decisions: Statistics provide a framework for making data-driven decisions, whether in personal or professional settings.

Understand research findings: Statistical methods are used in research across various disciplines, allowing individuals to interpret research results and draw meaningful conclusions.

Statistics is a powerful tool for understanding and interpreting data, providing insights that can inform decision-making in a wide range of fields. From analyzing financial markets to understanding social trends, statistics plays a vital role in shaping our understanding of the world around us. By developing a strong foundation in

statistical concepts, individuals can become more informed and empowered citizens in a data-driven world.

https://www.investopedia.com/terms/s/statistics.asp [15]

3. a) Match the words to their definitions.

1. robust	a) a basic structure underlying a system, concept, or text
2. indispensable	b) to make a deep or thorough investigation into a subject or problem
3. framework	c) to include or contain as part of a larger whole
4. adept	d) strong and healthy; able to withstand stress or pressure
5. delve	e) very skilled or proficient at something
6. encompass	f) absolutely necessary; essential

b) Fill in the gaps with the words from the table.

1. This system is more ___ at representing in terms of rules and underlying principles.

2. The historian ___ into the archives to find evidence for his theory.

3. The company's ___ financial performance reassured investors.

4. Obviously, when such properties are of interest, operational methods are ___.

5. His account of signs is an ambitious one, ___ forms of communication is diverse as language, music and the visual arts.

6. He develops a constructive ___ for proving equalities about programs, and shows how to derive the free theorems in a purely syntactic way.

Multiple Choice

4. For questions 1-6 choose the right answer, A, B, C or D.

1. Which of the following is NOT a key concept in statistics as described in the text?

A) Descriptive statistics

B) Inferential statistics

C) Predictive statistics

D) Level of measurement

2. According to the text, what is the primary focus of statisticians?

A) Developing new mathematical frameworks

B) Collecting and organizing data

C) Drawing conclusions about large populations based on samples

D) Creating visualizations of data

3. Which sampling technique is described as dividing the population into subgroups based on shared characteristics and then selecting a random sample from each subgroup?

A) Simple Random Sampling

B) Systematic Sampling

C) Stratified Sampling

D) Cluster Sampling

4. Which of the following is NOT a sampling technique discussed in the text?

A) Quota Sampling

B) Simple Random Sampling

C) Systematic Sampling

D) Stratified Sampling

5. According to the text, what is the primary benefit of developing statistical literacy?

A) It allows individuals to create their own statistical models.

B) It helps individuals to understand and interpret data in a variety of contexts.

C) It enables individuals to predict future trends with certainty.

D) It provides individuals with the skills to become professional statisticians.

6. According to the text, what is the primary advantage of using stratified sampling?

A) It is the most efficient method for large populations.

B) It ensures that the sample accurately reflects the diversity of the population.

C) It is the easiest method to implement.

D) It is the most accurate method for predicting population trends.

Over to you

5. Answer the comprehension questions:

1. What are the four levels of measurement used in statistics, and how do they differ in terms of the type of data they represent?
2. Explain the difference between descriptive statistics and inferential statistics, providing examples of each.
3. What are the key areas where statistics play a vital role, and how do they influence decision-making in these fields?

6. Work in groups. Questions for discussion:

1. The text emphasizes the importance of statistical literacy in navigating a data-driven world. How has your own experience with data and statistics shaped your understanding of the world around you? Provide specific examples to illustrate your points.
2. The text highlights the wide-ranging applications of statistics in different fields. Choose one of these fields and discuss how statistics are used to make decisions and solve problems in that area. How does this application of statistics relate to your own interests or aspirations?
3. The text emphasizes the importance of statistics in understanding research findings. Choose a research study or experiment that you have encountered and discuss how statistical methods were used to analyze the data and draw conclusions. How did the use of statistics impact your understanding of the research findings?

ROLE OF STATISTICS IN ARTIFICIAL INTELLIGENCE

1. Read the text.

AI is the simulation of human intelligence in machines that are programmed to think and act like humans. The goal of AI is to create intelligent machines that can perform tasks that typically require human intelligence, such as recognizing speech, image, and text, understanding natural language, playing games, and driving cars. Statistics is the branch of mathematics that deals with data collection, analysis, interpretation, presentation, and organization. Statistical methods are used to analyze and interpret data to make inferences about populations from samples. AI relies heavily on statistical methods to learn from data and make predictions. Statistical methods enable AI systems to detect patterns, identify relationships, and infer conclusions from data.

STATISTICAL METHODS IN ARTIFICIAL INTELLIGENCE

Regression analysis Regression analysis is a statistical method used in AI to identify the relationship between a dependent variable and one or more independent variables. The method is used in AI to model and predict outcomes based on a set of input variables.

Bayesian Statistics Bayesian Statistics is a statistical method used in AI to estimate the probability of an event based on prior knowledge and new data. The method is used in AI to classify data, make predictions, and optimize decision making.

Machine learning algorithms Machine learning algorithms are statistical methods used in AI to learn from data without being explicitly programmed. The algorithms are used in AI to identify patterns, classify data, and make predictions.

Neural networks Neural networks are a type of machine learning algorithm used in AI to mimic the structure and function of the human brain. Neural networks are used in AI for image and speech recognition, natural language processing, and robotics.

APPLICATIONS OF STATISTICS IN ARTIFICIAL INTELLIGENCE

Natural language processing Natural language processing (NLP) is a field of AI that deals with the interaction between computers and humans using natural language. Statistics is used in NLP to understand and interpret the meaning of natural language, classify text, and generate responses.

Computer vision Computer vision is a field of AI that deals with the interpretation of visual data from the world. Statistics is used in computer vision to classify images, recognize objects, and track movements.

Robotics Robotics is a field of AI that deals with the design, construction, operation, and use of robots. Statistics is used in robotics to control robot movements and optimize robotic systems.

Data analytics Data analytics is a field of AI that deals with the analysis of large and complex data sets. Statistics is used in data analytics to identify patterns, trends, and relationships in the data.

BENEFITS OF INTEGRATING STATISTICS IN ARTIFICIAL INTELLIGENCE

Improved accuracy and precision Integrating Statistics in AI can improve the accuracy and precision of the predictions made by AI systems.

Increased efficiency Integrating Statistics in AI can increase the efficiency of the AI systems by reducing the number of errors and improving the time taken to make a prediction.

Enhanced data management Statistics can enhance the management of data in AI by identifying patterns, trends, and relationships in the data.

Improved decision-making Integrating Statistics in AI can improve the decision-making process by providing insights into the data and enabling the machine to make predictions based on the data.

CHALLENGES AND LIMITATIONS

Data quality and completeness The quality and completeness of the data used in AI can impact the accuracy and reliability of the predictions made by the system.

Bias and ethical considerations Integrating Statistics in AI can raise concerns about bias and ethical considerations, as the AI system may make decisions based on data that is biased or unethical.

Validity and reliability of models The validity and reliability of the statistical models used in AI can impact the accuracy and precision of the predictions made by the system.

Computing power constraints The size and complexity of the data used in AI can put constraints on the computing power required to process the data.

FUTURE DIRECTIONS

Advances in technology Advances in technology such as quantum computing and big data analytics are expected to revolutionize the field of AI.

Integration of multiple disciplines The integration of multiple disciplines such as computer science, mathematics, statistics, and engineering is expected to lead to new developments in AI.

Potential applications AI has the potential to be applied in various fields such as healthcare, finance, and transportation.

Challenges and opportunities The challenges and opportunities associated with integrating Statistics in AI are expected to shape the future direction of the field.

https://www.ijeast.com/papers/96-98,%20Tesma0712,IJEAST.pdf [16]

2. a) Match the words to their definitions.

1. bias	a) a model of a set of problems or events that can be used to teach someone how to do something, or the process of making such a model
2. simulation	b) to improve the quality, amount, or strength of something
3. inference	c) the quality of being exact, the level of agreement of a particular measurement with itself when it is repeated.
4. explicitly	d) something that limits the range of a person's actions or freedom

5. precision	e) in a way that is clear and exact
6. enhance	f) the fact of allowing personal opinions to influence your judgment in an unfair way
7. constraint	g) a guess that you make or an opinion that you form based on the information that you have

b) Fill in the gaps with the words from the table.

1. It should be ___ stated exactly what the grant covers.

2. His change of mind was recent and sudden, the ___ being that someone had persuaded him.

3. The manager prepared a computer ___ of likely sales performance for the rest of the year.

4. Understanding the ___ introduced by human annotation of data is a crucial problem in AI research.

5. Hybrid strategies applied to formation control could help to ___ formation control performance in some robotic tasks.

6. The calculation of these functions is based on the objective parameters, and takes into account the ___ acting on the robot.

7. The randomness coming from the binomial random variables is irrelevant for the order of ___ we are after.

Multiple Choice

3. For questions 1-8 choose the right answer, A, B, C or D.

1. What is the primary function of statistical methods in AI systems?

A) To collect and organize data for future analysis.

B) To provide a framework for understanding human intelligence.

C) To enable AI systems to learn from data and make predictions.

D) To create simulations of human behavior in machines.

2. Which statistical method is used in AI to estimate the probability of an event based on prior knowledge and new data?

A) Regression analysis

B) Bayesian Statistics

C) Machine learning algorithms

D) Neural networks

3. How does the integration of Statistics in AI contribute to improved decision-making?

A) By automating the decision-making process.

B) By providing insights into the data and enabling predictions based on it.

C) By eliminating the need for human intervention in decision-making.

D) By creating a more efficient and faster decision-making process.

4. What is the main goal of AI, as described in the text?

A) To create machines that can think and act like humans.

B) To develop advanced statistical models for data analysis.

C) To improve the efficiency of data collection and organization.

D) To enhance human capabilities through technological advancements.

5. Which of the following is NOT a benefit of integrating statistics into AI systems?

A) Improved accuracy and precision of predictions.

B) Increased efficiency by reducing errors and prediction time.

C) Enhanced data management through pattern identification.

D) Elimination of bias and ethical concerns in AI decision-making.

6. How does statistics contribute to the field of natural language processing (NLP)?

A) By developing algorithms for speech recognition.

B) By providing a framework for understanding human language.

C) By analyzing and interpreting the meaning of natural language.

D) By creating simulations of human conversations.

7. What is one of the challenges associated with integrating statistics in AI, as mentioned in the text?

A) The lack of readily available data for training AI systems.

B) The difficulty in developing accurate statistical models.

C) The potential for bias and ethical concerns in AI decision-making.

D) The limited computing power available for processing large datasets.

8. According to the text, what is one potential future direction for the field of AI?

A) The development of AI systems that can learn and adapt independently.

B) The integration of AI with other disciplines like computer science and engineering.

C) The creation of AI systems that can understand and respond to human emotions.

D) The use of AI to solve complex problems in fields like healthcare and finance.

Over to you

4. Answer the comprehension questions:

1. What are the three main areas of AI where statistics plays a crucial role?
2. Identify two challenges associated with integrating statistics in AI.
3. Explain how the integration of statistics in AI can enhance data management.
4. What is the role of regression analysis in AI, and how is it used to model and predict outcomes?
5. Explain how neural networks, a type of machine learning algorithm, contribute to AI's capabilities in areas like image and speech recognition.

5. Work in groups. Questions for discussion:

1. The text discusses how AI relies heavily on statistical methods to learn from data and make predictions. How do you use data to make decisions in your own life, and how can this process be compared to the way AI systems learn?
2. The text highlights the potential benefits of integrating statistics into AI, including improved accuracy, efficiency, and decision-making. How do you gather information and analyze data when you have to make a difficult decision? How could the principles of statistics and various applications of statistics in AI help you in this process?
3. There are some challenges and limitations of integrating statistics into AI, such as data quality, bias, and computing power constraints. Have you ever faced situations where data was incomplete, biased, or difficult to analyze? How did it affect your understanding of the situation and your ability to make informed decisions?

WHY IS STATISTICS ALWAYS MISLEADING?

1. Watch the video https://www.youtube.com/watch?v=Iop2NwGaGh0 [17]

2. a) Match the words to their definitions.

1. causation	a) difficult to understand or interpret, obscure, especially because things have been intentionally kept secret or made complicated
2. opaque	b) likely to do or achieve what is intended
3. malicious	c) in a way that is severe and sudden or has very noticeable effects
4. workable	d) the process of causing something to happen or exist
5. sufficiently	e) intended to do harm or upset other people; to cause damage to a computer system, or to steal private information from a computer system
6. drastically	f) to a degree that is enough; adequately

b) Fill in the gaps with the words from the table.

1. Our communication environment has changed ___ in the last 10 years.
2. The hacker spread a ___ virus that infected thousands of computers.
3. I'm not ___ versed in computers to understand what you're saying.
4. It might occasionally be the case that we humans can understand where the evolution of the universe is taking us only by using future-to-past ___.

5. Governments have been able to maintain ___ and discriminatory procurement practices.

6. They're ___ models; they are not models that provide the grand scientific foundations for things.

Multiple Choice

3. For questions 1-6 choose the right answer, A, B, C or D.

1. What is the main lesson to be learned from the work of Francis Anscombe and Justin Mateka?

A) Statistical analysis alone is insufficient to understand data; visualization is crucial.

B) Correlation always implies causation, even when common sense suggests otherwise.

C) Open-source data can be manipulated to create false correlations.

D) Statistical properties are not reliable indicators of data distribution.

2. What is the main reason why visualizing data is crucial, especially when dealing with high-dimensional datasets?

A) Visualization helps identify patterns and relationships that might be missed by statistical analysis alone.

B) Visualization makes data more appealing and easier to understand for non-experts.

C) Visualization is necessary for creating accurate statistical models.

D) Visualization is the only way to ensure data confidentiality.

3. What is the primary implication of the example of Justin Mateka's work with dinosaur images in the context of data analysis?

A) Data transformations can be used to create misleading visualizations.

B) Images are inherently more complex than one-dimensional datasets.

C) Statistical properties alone cannot fully represent the true nature of a dataset.

D) The use of open-source data can lead to ethical concerns.

4. What specific example illustrates the potential for data anonymization to fail, highlighting the importance of robust privacy measures?

A) The misuse of statistics by Tyler Vegan to create absurd correlations.

B) The work of Francis Anscombe demonstrating the limitations of statistical analysis.

C) The transformation of a dinosaur image by Justin Mateka while maintaining statistical properties.

D) The Netflix contest where researchers were able to identify users despite anonymization.

5. What specific example demonstrates how statistical properties can be maintained even while the underlying data undergoes significant transformations?

A) The work of Francis Anscombe showing four different datasets with identical statistical matrices.

B) The Netflix contest where researchers were able to identify users despite anonymization.

C) The misuse of statistics by Tyler Vegan to create absurd correlations.

D) The transformation of a dinosaur image by Justin Mateka while preserving statistical properties.

6. They argue that statistics can be both a problem and a solution in the context of data confidentiality. What specific example is used to illustrate this duality?

A) The misuse of statistics by Tyler Vegan to create absurd correlations.

B) The work of Francis Anscombe demonstrating the limitations of statistical analysis.

C) The use of statistical techniques to anonymize data while preserving its analytical value.

D) The transformation of a dinosaur image by Justin Mateka while maintaining statistical properties

Over to you

4. Answer the comprehension questions:

1. Explain the concept of "correlation does not imply causation" and how it relates to the misuse of statistics.
2. What is the main lesson the author draws from the examples of Tyler Vegan and Justin Mateka's work?
3. How does the author connect the concept of data visualization to the challenges of working with high-dimensional data sets?

5. Work in groups. Questions for discussion:

1. It is discussed how data can be manipulated to create misleading correlations. Think about a time when you were presented with data that seemed convincing but later turned out to be inaccurate or incomplete. How did this experience change your perspective on interpreting data?
2. They argue that data visualization is crucial for understanding data, especially in high-dimensional spaces. Explain how the example of an Instagram image illustrates this point. How does the use of tools from differential geometry, vector calculus, and topology help us grasp the complexity of such data?
3. There exist potential dangers of relying solely on statistical measures like mean, median, and correlation. Explain how the examples of Tyler Vegan's absurd correlations and Francis Anscombe's four data sets demonstrate the limitations of these measures. How can visualization help us overcome the limitations of relying solely on statistical measures?

6. Work in three groups.

Watch a video chosen and make a short presentation.

1. Definitions, Notation, and Basic Concepts in Statistics
https://youtu.be/lCpE-kk-2FM
2. Random variables
https://youtu.be/3v9w79NhsfI
3. Demystifying Probability and Statistics
https://youtu.be/6DiOJ12Udc8

If you want something extra

- 10 Best AI Tools for Statistics

https://julius.ai/articles/10-best-ai-tools-for-statistics

- Statistics: Definition, Types, and Importance

https://www.investopedia.com/terms/s/statistics.asp#:~:text=Statistics%20is%20a%20branch%20of,linear%20algebra%2C%20and%20probability%20theory.

- Statistics

https://www.britannica.com/science/statistics

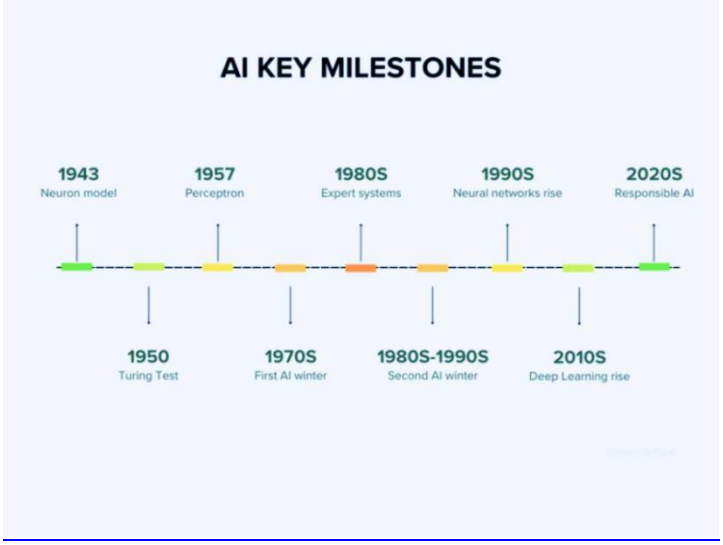
Unit 5

Artificial Intelligence

Lead-in

1. Paraphrase the following quotations. Which do you agree with? Why?

- ✓ *One machine can do the work of fifty ordinary men. No machine can do the work of one extraordinary man. (Elbert Hubbard)*
- ✓ *Success in creating AI would be the biggest event in human history. Unfortunately, it might also be the last, unless we learn how to avoid the risks. (Stephen Hawking)*
- ✓ *We will have for the first time something smarter than the smartest human. It's hard to say exactly what that moment is, but there will come a point where no job is needed. (Elon Musk)*



Pre-Reading

1. Look at the picture. What do you know about the history of AI?

A short history of AI

2. Read the text and listen to this story https://www.economist.com/schools-brief/2024/07/16/a-short-history-of-ai [18]
https://www.economist.com/media-assets/audio/057%20Schools%20brief%20-%20Artificial%20intelligence-4a78f09db50e7cf7d1edbe1222e70253.mp3

Over the summer of 1956 a small but illustrious group gathered at Dartmouth College in New Hampshire; it included Claude Shannon, the begetter of information theory, and Herb Simon, the only person ever to win both the Nobel Memorial Prize in Economic Sciences awarded by the Royal Swedish Academy of Sciences and the Turing Award awarded by the Association for Computing Machinery. They had been called together by a young researcher, John McCarthy, who wanted to discuss "how to make machines use language, form abstractions and concepts" and "solve kinds of problems now reserved for humans". It was the first academic gathering devoted to what McCarthy dubbed "artificial intelligence". And it set a template for the field's next 60-odd years in coming up with no advances on a par with its ambitions.

The Dartmouth meeting did not mark the beginning of scientific inquiry into machines which could think like people. Alan Turing, for whom the Turing prize is

named, wondered about it; so did John von Neumann, an inspiration to McCarthy. By 1956 there were already a number of approaches to the issue; historians think one of the reasons McCarthy coined the term artificial intelligence, later ai, for his project was that it was broad enough to encompass them all, keeping open the question of which might be best. Some researchers favoured systems based on combining facts about the world with axioms like those of geometry and symbolic logic so as to infer appropriate responses; others preferred building systems in which the probability of one thing depended on the constantly updated probabilities of many others.

The following decades saw much intellectual ferment and argument on the topic, but by the 1980s there was wide agreement on the way forward: "expert systems" which used symbolic logic to capture and apply the best of human know-how. The Japanese government, in particular, threw its weight behind the idea of such systems and the hardware they might need. But for the most part such systems proved too inflexible to cope with the messiness of the real world. By the late 1980s AI had fallen into disrepute, a byword for overpromising and underdelivering. Those researchers still in the field started to shun the term.

It was from one of those pockets of perseverance that today's boom was born. As the rudiments of the way in which brain cells—a type of neuron—work were pieced together in the 1940s, computer scientists began to wonder if machines could be wired up the same way. In a biological brain there are connections between neurons which allow activity in one to trigger or suppress activity in another; what one neuron does depends on what the other neurons connected to it are doing. A first attempt to model this in the lab (by Marvin Minsky, a Dartmouth attendee) used hardware to model networks of neurons. Since then, layers of interconnected neurons have been simulated in software.

These artificial neural networks are not programmed using explicit rules; instead, they "learn" by being exposed to lots of examples. During this training the strength of the connections between the neurons (known as "weights") are repeatedly adjusted so that, eventually, a given input produces an appropriate output. Minsky himself abandoned the idea, but others took it forward. By the early 1990s neural

networks had been trained to do things like help sort the post by recognising handwritten numbers. Researchers thought adding more layers of neurons might allow more sophisticated achievements. But it also made the systems run much more slowly.

A new sort of computer hardware provided a way around the problem. Its potential was dramatically demonstrated in 2009, when researchers at Stanford University increased the speed at which a neural net could run 70-fold, using a gaming pc in their dorm room. This was possible because, as well as the "central processing unit" (CPU) found in all pcs, this one also had a "graphics processing unit" (GPU) to create game worlds on screen. And the GPU was designed in a way suited to running the neural-network code.

Coupling that hardware speed-up with more efficient training algorithms meant that networks with millions of connections could be trained in a reasonable time; neural networks could handle bigger inputs and, crucially, be given more layers. These "deeper" networks turned out to be far more capable.

The power of this new approach, which had come to be known as "deep learning", became apparent in the ImageNet Challenge of 2012. Image-recognition systems competing in the challenge were provided with a database of more than a million labelled image files. For any given word, such as "dog" or "cat", the database contained several hundred photos. Image-recognition systems would be trained, using these examples, to "map" input, in the form of images, onto output in the form of one-word descriptions. The systems were then challenged to produce such descriptions when fed previously unseen test images. In 2012 a team led by Geoff Hinton, then at the University of Toronto, used deep learning to achieve an accuracy of 85%. It was instantly recognised as a breakthrough.

By 2015 almost everyone in the image-recognition field was using deep learning, and the winning accuracy at the ImageNet Challenge had reached 96%—better than the average human score. Deep learning was also being applied to a host of other "problems…reserved for humans" which could be reduced to the mapping of

one type of thing onto another: speech recognition (mapping sound to text), face-recognition (mapping faces to names) and translation.

In all these applications the huge amounts of data that could be accessed through the internet were vital to success; what was more, the number of people using the internet spoke to the possibility of large markets. And the bigger (ie, deeper) the networks were made, and the more training data they were given, the more their performance improved.

Deep learning was soon being deployed in all kinds of new products and services. Voice-driven devices such as Amazon's Alexa appeared. Online transcription services became useful. Web browsers offered automatic translations. Saying such things were enabled by AI started to sound cool, rather than embarrassing, though it was also a bit redundant; nearly every technology referred to as AI then and now actually relies on deep learning under the bonnet.

Chat GPT and its rivals really do seem to "use language and form abstractions" In 2017 a qualitative change was added to the quantitative benefits being provided by more computing power and more data: a new way of arranging connections between neurons called the transformer. Transformers enable neural networks to keep track of patterns in their input, even if the elements of the pattern are far apart, in a way that allows them to bestow "attention" on particular features in the data.

Transformers gave networks a better grasp of context, which suited them to a technique called "self-supervised learning". In essence, some words are randomly blanked out during training, and the model teaches itself to fill in the most likely candidate. Because the training data do not have to be labelled in advance, such models can be trained using billions of words of raw text taken from the internet.

Mind your language model Transformer-based large language models (LLMs) began attracting wider attention in 2019, when a model called gpt-2 was released by Open AI, a startup (GPT stands for generative pre-trained transformer). Such LLMs turned out to be capable of "emergent" behaviour for which they had not been explicitly trained. Soaking up huge amounts of language did not just make them surprisingly adept at linguistic tasks like summarisation or translation, but also at things—like

simple arithmetic and the writing of software—which were implicit in the training data. Less happily it also meant they reproduced biases in the data fed to them, which meant many of the prevailing prejudices of human society emerged in their output.
In November 2022 a larger Open AI model, GPT-3.5, was presented to the public in the form of a chatbot. Anyone with a web browser could enter a prompt and get a response. No consumer product has ever taken off quicker. Within weeks Chat GPT was generating everything from college essays to computer code. AI had made another great leap forward.

Where the first cohort of AI-powered products was based on recognition, this second one is based on generation. Deep-learning models such as Stable Diffusion and DALL-E, which also made their debuts around that time, used a technique called diffusion to turn text prompts into images. Other models can produce surprisingly realistic video, speech or music.

The leap is not just technological. Making things makes a difference. Chat GPT and rivals such as Gemini (from Google) and Claude (from Anthropic, founded by researchers previously at Open AI) produce outputs from calculations just as other deep-learning systems do. But the fact that they respond to requests with novelties makes them feel very unlike software which recognises faces, takes dictation or translates menus. They really do seem to "use language" and "form abstractions", just as McCarthy had hoped.

This series of briefs will look at how these models work, how much further their powers can grow, what new uses they will be put to, as well as what they will not, or should not, be used for.

3. a) Match the words to their definitions.

1. rudiments	a) arising or developing gradually; becoming apparent
2. explicit	b) to give or present (something) as a gift, honor, or right
3. diffusion	c) the state of not being trusted or respected
4. emergent	d) the basic principles or elements of a subject or skill

5. bestow	e) to avoid or ignore someone or something
6.disrepute	f) stated clearly and in detail, leaving no room for confusion or doubt
7. shun	g) the action of spreading in many directions

b) Fill in the gaps with the words from the table.

1. This theory has fallen into ___.
2. The contract contained ___ instructions on how to terminate the agreement.
3. He was ___ by colleagues and family alike.
4. The ___ properties of complex systems are often difficult to predict.
5. The students were taught the ___ of grammar before they began writing essays.
6. Powerful global institutions drive the ___ of new technologies.
7. The country's highest medal was ___ upon him for heroism.

4. Decide whether these statements are true or false.

- The field of artificial intelligence (AI) has evolved significantly since its inception in 1965, with notable advancements in deep learning and the development of large language models (LLMs) such as Chat GPT.
- Deep learning, a subfield of AI, neglects artificial neural networks that learn from vast amounts of data, enabling breakthroughs in image recognition, speech recognition, and translation.
- The emergence of LLMs, powered by transformer technology, has led to AI systems that can generate creative text, code, and even images, blurring the lines between human and machine capabilities.

Multiple Choice

5. For questions 1-7 choose the right answer, A, B, C or D.

1. What was the primary reason John McCarthy coined the term "artificial intelligence" in 1956?

A) He wanted to create a term that encompassed all existing approaches to machine intelligence.

B) He wanted to emphasize the importance of symbolic logic in AI development.

C) He wanted to distinguish his work from other research in computer science.

D) He wanted to create a term that would capture the public's imagination.

2. What significant development in computer hardware allowed for the advancement of neural networks in the early 2000s?

A) The development of faster CPUs.

B) The development of GPUs designed for game graphics.

C) The development of cloud computing.

D) The development of quantum computers.

3. What is the key difference between the first generation of AI products and the second generation, exemplified by Chat GPT?

A) The first generation focused on recognition tasks, while the second generation focuses on generation tasks.

B) The first generation used symbolic logic, while the second generation uses neural networks.

C) The first generation was primarily used in research, while the second generation is widely available to consumers.

D) The first generation was limited to text-based interactions, while the second generation can process images and videos.

4. What was the main reason for the decline in AI research in the late 1980s?

A) The lack of funding for AI research.

B) The failure of expert systems to meet expectations.

C) The rise of other fields like robotics.

D) The lack of interest from the public.

5. What is the key difference between the AI systems that emerged in the 1990s and the deep learning models that became popular in the 2010s?

A) The 1990s systems were based on symbolic logic, while deep learning models use artificial neural networks.

B) The 1990s systems were more efficient, while deep learning models are more powerful.

C) The 1990s systems were designed for specific tasks, while deep learning models are more versatile.

D) The 1990s systems were limited to text data, while deep learning models can process images and videos.

6. What was the main reason for the resurgence of interest in AI research in the early 2000s?

A) The development of new algorithms that allowed for faster training of neural networks.

B) The availability of large datasets for training AI models.

C) The development of new hardware, such as GPUs, that could handle the computational demands of deep learning.

D) The increasing demand for AI applications in various industries.

Over to you

6. Answer the comprehension questions:

1. What was the prevailing view of AI in the late 1980s and why?

2. What is the significance of the 'transformer' architecture in the development of large language models (LLMs)?

3. How does 'self-supervised learning' contribute to the training of LLMs?

4. What was the key breakthrough achieved by Geoff Hinton's team in the ImageNet Challenge of 2012, and how did it impact the field of image recognition?

5. How did the availability of vast amounts of data and the internet's growth contribute to the success of deep learning?

7. Work in groups. Questions for discussion:

1. The text describes the evolution of artificial intelligence, from its early days to the rise of deep learning and large language models. How has this evolution impacted

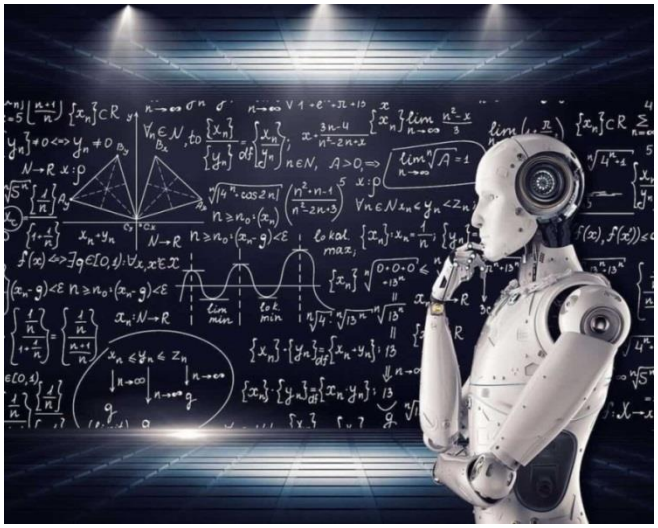
your own life, both in terms of the technology you use and the way you think about the world?

2. The text highlights the potential of AI to solve problems that were once thought to be uniquely human. What are some of the ethical and societal implications of this development?

3. The text discusses the role of large amounts of data in the development of AI. How does this relate to your own understanding of the power of information and the potential for both good and bad uses of data?

4. The author suggests that AI is making a leap from recognition to generation. What are some of the creative possibilities that this shift opens up? How might AI change the way we create art, music, literature, and other forms of expression?

The History of AI: From Beginnings to Breakthroughs



1. Watch the video: https://youtu.be/iZCNDZ7ABRE?si=815IZbuL7267MUo1 [19]

2. a) Match the words to their definitions.

1. ubiquitous	a) a notable AI system that was developed in 2012 and used for image recognition and had a significant training computation for its time
2. exponential	b) an AI system capable of generating lifelike visuals from text prompts

3. petaflop	c) the observation that the number of transistors on a microchip doubles approximately every two years
4. theseus	d) a unit of computing power equal to one quadrillion floating-point operations per second
5. DALL-E	e) having both beneficial and harmful potential applications
6. PaLM	f) increasing rapidly in a way that is not linear
7. AlexNet	g) a researcher who studied the increase in training computation to predict when AI systems might match the capabilities of the human brain
8. Katra	h) present, appearing, or found everywhere
9. Moore's Law	i) a robotic mouse created by Claude Shannon in 1950 that could find its way out of a labyrinth and remember its path
10. dual-use	j) an AI system developed by Google that can interpret and generate language, including explaining jokes

b) Fill in the gaps with the words from the table.

1. The supercomputer's processing power is measured in___, making it capable of performing trillions of calculations per second.

2. ___ is an example of an AI system that can create images from text descriptions, showcasing the advancements in AI's creative abilities.

3. The first AI system discussed in the timeline was ___, a robotic mouse that demonstrated early AI capabilities.

4. ___'s research suggests that there is a 50% chance of transformative AI being developed by 2040.

5. The ___ presence of technology in our lives has made it difficult to escape the digital world.

6. The exponential growth of AI training computation has outpaced ___, indicating a rapid acceleration in technological advancement.

7. ___ is a convolutional neural network (CNN) architecture that was developed by Alex Krizhevsky, Ilya Sutskever, and Geoffrey Hinton.

8. Artificial intelligence is a ___ technology, capable of both solving complex problems and perpetuating harm.

9.___, developed by Google, demonstrates the impressive capabilities of AI in understanding and generating language, even in complex scenarios like explaining jokes.

10. The ___ growth of the internet has led to a dramatic increase in the amount of information available online.

Multiple Choice

3. For questions 1-7 choose the right answer, A, B, C or D.

1. What is one of the key components that determines what an AI system can do?

A) The amount of training data used.

B) The number of engineers working on the project.

C) The cost of the hardware used.

D) The popularity of the AI system in the public.

2. What is the main argument presented by the author regarding the future of AI?

A) AI will eventually surpass human intelligence and become a threat to humanity.

B) AI will be used primarily for entertainment and leisure activities.

C) AI will become increasingly specialized and less relevant to everyday life.

D) AI will continue to develop rapidly and have a profound impact on society.

3. What is the main reason why the author believes it is crucial for everyone to understand the development and potential impact of AI?

A) AI is a complex technology that requires specialized knowledge to understand.

B) AI is a powerful technology that can be used for both good and bad purposes.

C) AI is rapidly advancing and will soon surpass human intelligence.

D) AI is a controversial technology that is often misunderstood by the public.

4. What is the author's main point in comparing the development of AI to the Agricultural and Industrial Revolutions?

A) AI is a revolutionary technology that will transform society in a similar way to previous major technological advancements.

B) AI is a technology that will lead to significant economic and social upheaval.

C) AI is a technology that will create new opportunities for employment and economic growth.

D) AI is a technology that will require significant government regulation to ensure its safe development.

5. What is the author's perspective on the current state of AI development?

A) AI has reached a plateau in its development and is unlikely to make significant progress in the near future.

B) AI is still in its early stages of development, but its potential impact is already significant.

C) AI is a mature technology that has already reached its full potential.

D) AI is a technology that is primarily used for entertainment and leisure activities.

6. What is the significance of the 'Moore's Law' reference in the text, in relation to the development of AI?

A) Moore's Law is a scientific theory that has been disproven by the rapid development of AI.

B) Moore's Law suggests that AI development is slowing down and will soon reach its limits.

C) Moore's Law predicts that AI systems will eventually surpass human intelligence.

D) Moore's Law explains why AI systems have become increasingly powerful over time.

7. What is the author's main argument about the relationship between the amount of training data used for an AI system and its capabilities?

A) The amount of training data used is inversely proportional to the capabilities of an AI system.

B) The more training data used, the more powerful and capable the AI system becomes.

C) The amount of training data used is not a significant factor in determining the capabilities of an AI system.

D) The amount of training data used is only important for certain types of AI systems.

Over to you

4. Answer the comprehension questions:

1. What is the relationship between the amount of training data used for an AI system and its capabilities?
2. What is the author's perspective on the potential impact of AI on society, and what should be done about it?
3. What specific examples does the author provide to illustrate the rapid advancements in AI's perceptual powers, particularly in image recognition and generation?
4. How does the author use the example of 'Palm,' an AI system developed by Google, to demonstrate the progress in language recognition and production?
5. What is the author's main point in discussing the use of AI in various domains?

5. Work in groups. Questions for discussion:

1. The author argues that AI is a dual-use technology with both positive and negative potential. Think about a technology you use regularly. What are its potential benefits and drawbacks? How do you think AI will affect your own life in the future?
2. The text describes the increasing use of AI in various aspects of our lives, from booking flights to making decisions about loans and even influencing criminal justice. What are your thoughts on the ethical implications of AI being used in these areas? How can we ensure that AI is used fairly and responsibly?
3. The text explores the rapid advancements in AI's ability to generate images and language. How do you think these developments will impact the creative industries, such as art, music, and writing? Consider both the potential for new forms of expression and the potential challenges for human artists.

Natural Language Processing

1. Read the text.

Natural Language Processing (NLP) is one of the hottest areas of artificial intelligence (AI) thanks to applications like text generators that compose coherent essays, chatbots that fool people into thinking they're sentient, and text-to-image programs that produce photorealistic images of anything you can describe. Recent years have brought a revolution in the ability of computers to understand human languages, programming languages, and even biological and chemical sequences, such as DNA and protein structures, that resemble language. The latest AI models are unlocking these areas to analyze the meanings of input text and generate meaningful, expressive output.

Natural language processing (NLP) is the discipline of building machines that can manipulate human language — or data that resembles human language — in the way that it is written, spoken, and organized. It evolved from computational linguistics, which uses computer science to understand the principles of language, but rather than developing theoretical frameworks, NLP is an engineering discipline that seeks to build technology to accomplish useful tasks. NLP can be divided into two overlapping subfields: natural language understanding (NLU), which focuses on semantic analysis or determining the intended meaning of text, and natural language generation (NLG), which focuses on text generation by a machine. NLP is separate

from — but often used in conjunction with — speech recognition, which seeks to parse spoken language into words, turning sound into text and vice versa.

NLP is used for a wide variety of language-related tasks, including answering questions, classifying text in a variety of ways, and conversing with users. Here are some tasks that can be solved by NLP:

• Sentiment analysis is the process of classifying the emotional intent of text. Generally, the input to a sentiment classification model is a piece of text, and the output is the probability that the sentiment expressed is positive, negative, or neutral. Sentiment analysis is used to classify customer reviews on various online platforms as well as for niche applications like identifying signs of mental illness in online comments.

• Toxicity classification is a branch of sentiment analysis where the aim is not just to classify hostile intent but also to classify particular categories such as threats, insults, obscenities, and hatred towards certain identities. The input to such a model is text, and the output is generally the probability of each class of toxicity. Toxicity classification models can be used to moderate and improve online conversations by silencing offensive comments, detecting hate speech, or scanning documents for defamation.

• Machine translation automates translation between different languages. The input to such a model is text in a specified source language, and the output is the text in a specified target language. Effective approaches to machine translation can distinguish between words with similar meanings. Some systems also perform language identification; that is, classifying text as being in one language or another.

• Named entity recognition aims to extract entities in a piece of text into predefined categories such as personal names, organizations, locations, and quantities. The input to such a model is generally text, and the output is the various named entities along with their start and end positions. Named entity recognition is useful in applications such as summarizing news articles and combating disinformation. For example, here is what a named entity recognition model could provide:

• Redaction of personally identifiable information (PII): NLP models can be trained to quickly locate personal information in documents that might identify individuals. Industries that handle large volumes of sensitive information—financial, healthcare, insurance and legal firms—can quickly create versions with the PII removed.

• Spam detection is a prevalent binary classification problem in NLP, where the purpose is to classify emails as either spam or not. Spam detectors take as input an email text along with various other subtexts like title and sender's name. They aim to output the probability that the mail is spam.

• Grammatical error correction models encode grammatical rules to correct the grammar within text. This is viewed mainly as a sequence-to-sequence task, where a model is trained on an ungrammatical sentence as input and a correct sentence as output.

• Topic modeling is an unsupervised text mining task that takes a corpus of documents and discovers abstract topics within that corpus. The input to a topic model is a collection of documents, and the output is a list of topics that defines words for each topic as well as assignment proportions of each topic in a document.

• Text generation, more formally known as natural language generation (NLG), produces text that's similar to human-written text. Such models can be fine-tuned to produce text in different genres and formats — including tweets, blogs, and even computer code. Text generation has been performed using Markov processes, LSTMs, BERT, GPT-2, LaMDA, and other approaches. It's particularly useful for autocomplete and chatbots.

• Autocomplete predicts what word comes next, and autocomplete systems of varying complexity are used in chat applications. Such models for autocomplete can predict search queries, write articles, song lyrics, and much more.

• Chatbots automate one side of a conversation while a human conversant generally supplies the other side. They can be divided into the following two categories:

- Database query: We have a database of questions and answers, and we would like a user to query it using natural language.

- Conversation generation: These chatbots can simulate dialogue with a human partner. Some are capable of engaging in wide-ranging conversations.

• Information retrieval finds the documents that are most relevant to a query. This is a problem every search and recommendation system faces. The goal is to retrieve, from a collection of documents that may be numbered in the millions, a set that is most relevant to the query. Document retrieval systems mainly execute two processes: indexing and matching.

• Summarization is the task of shortening text to highlight the most relevant information. NLP techniques are used to digest huge volumes of digital text and create summaries and synopses for indexes, research databases, for busy readers who don't have time to read the full text. The best text summarization applications use semantic reasoning and natural language generation (NLG) to add useful context and conclusions to summaries. Summarization is divided into two method classes: Extractive summarization focuses on extracting the most important sentences from a long text and combining these to form a summary.

Abstractive summarization produces a summary by paraphrasing. This is similar to writing the abstract that includes words and sentences that are not present in the original text.

• Question answering deals with answering questions posed by humans in a natural language. Generally, question-answering tasks come in two types:

- The multiple-choice question problem is composed of a question and a set of possible answers.

- The learning task is to pick the correct answer. In open-domain question answering, the model provides answers to questions in natural language without any options provided.

NLP is an integral part of everyday life and becoming more so as language technology is applied to diverse fields like retailing (for instance, in customer service chatbots) and medicine (interpreting or summarizing electronic health records). Conversational agents such as Amazon’s Alexa and Apple’s Siri utilize NLP to listen to user queries and find answers. The most advanced agents — such as GPT-3, which

was recently opened for commercial applications — can generate sophisticated prose on a wide variety of topics as well as power chatbots that are capable of holding coherent conversations. Google uses NLP to improve its search engine results, and social networks use it to detect and filter hate speech. NLP is growing increasingly sophisticated, yet much work remains to be done.

https://www.linkedin.com/pulse/natural-language-processing-enhancing-communication-ai-birjesh-kumar-rk6dc

https://www.deeplearning.ai/resources/natural-language-processing/ [20]

2. a) Match the words to their definitions.

1. sentient	a) the action of damaging the reputation of a person or group by saying or writing bad things about them that are not true
2. hostile	b) an offensive remark or action
3. defamation	c) a collection of written or spoken material stored on a computer and used to find out how language is used
4. insult	d) conscious, able to experience feelings
5. corpus	e) the process of finding and bringing back something
6. retrieval	f) behavior or language that is offensive, rude, or disgusting
7. obscenity	g) unfriendly and not liking something

b) Fill in the gaps with the words from the table.

1. Some people believe that artificial intelligence may one day become ___, capable of independent thought and feeling.
2. The instructions are so easy they are an ___ to your intelligence.
3. All the dictionary examples are taken from a ___ of billions of words.
4. The author and his newspaper editor were fined for ___.
5. Lexical ___ is an essential process in both oral and written language production and an important aspect of fluency.
6. The president had a ___ reception in Ohio this morning.
7. He was shouting and screaming ___.

Multiple Choice

3. For questions 1-7 choose the right answer, A, B, C or D.

1. What is the primary difference between natural language understanding (NLU) and natural language generation (NLG)?

A) NLU focuses on 'understanding' the meaning of text, while NLG focuses on creating text.

B) NLU focuses on translating languages, while NLG focuses on generating new languages.

C) NLU focuses on spoken language, while NLG focuses on written language.

D) NLU focuses on analyzing the structure of language, while NLG focuses on the meaning of language.

2. What is the primary purpose of NLP, as described in the text?

A) To create artificial intelligence that can think and feel like humans.

B) To develop machines that can 'understand' and manipulate human language.

C) To analyze and interpret biological and chemical sequences like DNA.

D) To replace human writers and translators with automated systems.

3. Which of the following is an example of a task that can be solved by NLP, as mentioned in the text?

A) Creating realistic 3D models of objects.

B) Composing original music pieces.

C) Predicting stock market trends.

D) Identifying and redacting personally identifiable information (PII) from documents.

4. What is the main difference between NLP and speech recognition?

A) NLP focuses on written language, while speech recognition focuses on spoken language.

B) NLP aims to 'understand' the meaning of language, while speech recognition aims to convert sound into text.

C) NLP is used for tasks like translation, while speech recognition is used for tasks like voice assistants.

D) NLP is a newer technology than speech recognition.

5. According to the text, what is the role of NLP in combating disinformation?

A) NLP can be used to identify and flag fake news articles.

B) NLP can be used to create more accurate and unbiased news reports.

C) NLP can be used to track the spread of misinformation online.

D) NLP can be used to educate people about the dangers of disinformation.

6. What is one example of how NLP is used in the field of medicine, as mentioned in the text?

A) Developing new drugs and treatments.

B) Diagnosing diseases based on patient symptoms.

C) Interpreting and summarizing electronic health records.

D) Creating personalized healthcare plans for patients.

7. According to the text, what is the primary difference between NLP and computational linguistics?

A) NLP focuses on building practical applications, while computational linguistics focuses on theoretical frameworks.

B) NLP deals with spoken language, while computational linguistics deals with written language.

C) NLP is a newer field than computational linguistics.

D) NLP is used for machine translation, while computational linguistics is used for language analysis.

Over to you

4. Answer the comprehension questions:

1. What are the two main categories of chatbots and how do they differ in their functionality?

2. What is the difference between extractive and abstractive summarization in NLP?

3. How does NLP play a role in combating disinformation and improving online conversations?

4. What are the two subfields of NLP and how do they differ in their focus?

5. How is NLP used in the process of grammatical error correction?

6. How can topic modeling in NLP be used?

5. Work in groups. Questions for discussion:

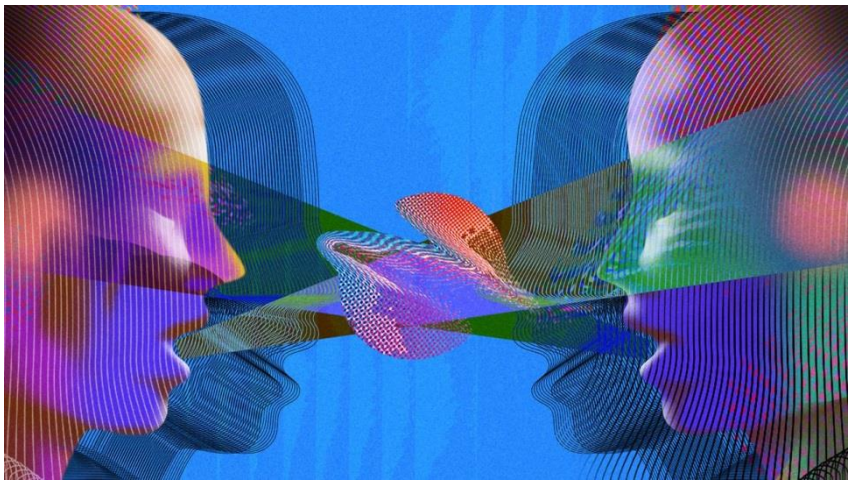
1. The text discusses how NLP is used to detect and filter hate speech on social media. How could NLP be used to combat other forms of online harassment, such as cyberbullying or trolling?

2. The text describes the increasing sophistication of NLP in text generation, including the creation of tweets, blogs, and even computer code and its potential to revolutionize various fields. How might the potential impact of NLP be both beneficial and detrimental?

3. The text mentions that NLP is used in retailing for customer service chatbots. How do you think NLP could be used to improve the customer experience in other ways, and what challenges might arise in implementing these solutions?

4. The text describes how NLP is used in information retrieval, summarizing large amounts of text for busy readers. How do you think NLP could be used to improve access to information for people with disabilities?

Machine Translation: The Future is Here



1. Read the text and listen to this story.

https://www.economist.com/science-and-technology/2024/12/11/machine-translation-is-almost-a-solved-problem [21]

https://www.economist.com/content-assets/audio/074%20Science%20and%20technology%20-%20Artificial%20intelligence-33a18ceeec6eef7fc6b49d85d1542e75.mp3

Machine translation is almost a solved problem

But interpreting meanings, rather than just words and sentences, will be a daunting task

Vasco Pedro had always believed that, despite the rise of artificial intelligence (AI), getting machines to translate languages as well as professional translators do would always need a human in the loop. Then he saw the results of a competition run by his Lisbon-based startup, Unbabel, pitting its latest AI model against the company's human translators. "I was like…no, we're done," he says. "Humans are done in translation." Mr Pedro estimates that human labour currently accounts for around 95% of the global translation industry. In the next three years, he reckons, human involvement will drop to near zero.

It is hardly a surprise that the AI model-makers are bullish, but the optimism feels apt. Machine translation has become so reliable and ubiquitous so fast that many users no longer see it. The first computerised translations were attempted more than 70 years ago, when an IBM computer was programmed with a vocabulary of 250 words of English and Russian and six grammatical rules. That "rules-based" approach was superseded in the 1990s by a "statistical" approach, based on crunching large datasets, which was still the state of the art when Google Translate was launched in 2006. The field exploded in 2016, though, when Google switched to a "neural" engine—the forebear of today's large language models (LLMs). Influence flowed both ways: when LLMs became better, so too did machine translation.

In Unbabel's test, human and machine translators were asked to translate everything from casual text messages to dense legal contracts and the archaic English of an old translation of "Meditations" by Marcus Aurelius. Unbabel's AI model held

its own. Measured by Multidimensional Quality Metrics, a framework that tracks translation quality, humans were better than machines if they were fluent in both languages and also experts in the material being translated (for instance, specialist legal translators dealing with contracts). But the lead was small, says Mr Pedro, who added that it would be hard to see how, two or three years from now, machines would not overtake humans entirely.

Marco Trombetti, boss of Translated, based in Rome, has created a different measure for the quality of machine translations, called Time to Edit (TTE). This is the amount of time it takes a human translator to check a transcript produced by a machine. The more errors in the transcript, the slower the human has to go. Between 2017 and 2022 TTE dropped from three seconds per word to two across the ten most-translated languages. Mr Trombetti predicts it will fall to one second in the next two years. At that point, a human is adding little to the process for most tasks other than what Madeleine Clare Elish, head of responsible AI at Google Cloud, calls a "moral crumple zone": a face to take the blame when things go wrong, but with no reasonable expectation of improving outcomes.

The problem of translating one sentence to another is "pretty close to solved" for those "high-resource" languages with the most training data, says Isaac Caswell, a research scientist at Google Translate. But going beyond this to make machine translation as good as a multilingual person—especially for languages that do not have reams of available training data—will be a more daunting task.

Complex translations face the same problems that plague LLMs in general. Without the ability to plan, refer to long-term memory, draw from factual sources or revise their output, even the best translation tools struggle with book-length work, or precision tasks such as keeping a translated headline to a certain length. Even tasks that a human finds trivial still trip them up. They will, for instance, "forget" translations for static phrases like shop names, translating them afresh, and often differently, each time they are encountered. They may also hallucinate information they don't have to fit grammatical structures of the target language. "To have the

perfect translation, you also have to have human-level intelligence," says Mr Caswell. Without being a competent poet, it is difficult to translate a haiku.

That is if users can even agree on what a perfect translation is. Translation has long been a struggle between "fidelity" and "transparency"—the choice between translating sentences exactly as they are in the original language, or exactly as they feel to the target audience. A faithful translation would leave an idiomatic phrase as it is, letting English speakers hear a Pole dismiss a problem as "not my circus, not my monkeys"; a transparent one may even go so far as to change whole cultural references, so that Americans aren't taken off-guard by "football-shaped" being used to describe a spherical object.

Even if there could be a simple dial to turn between transparency and fidelity, perfecting the interface of such a system would require AI assistance. Translating between languages can sometimes require more information than is present in the source material: to translate "I like you" from English to Japanese, for instance, a person needs to know the gender of the speaker, their relationship to the person they are addressing and ideally their name to avoid the impolite use of the word "you". A perfect machine translator would need to be able to interpret and replicate all these subtle cues and inflections.

Adding checkboxes and dials to an interface would bamboozle users. In practice, therefore, a perfect machine translator would be human-level in the quality of its output as well as the method of its input. The requirement to ask follow-up questions, to know when to trade transparency for fidelity, and to understand what a translation is for, means that advanced translation will need more information than just the source text, says Jarek Kutylowski, founder of Deepl, a German startup. "If we can see the address you're emailing, maybe the conversation history, we can say, 'Hey, this person is actually your boss' and tailor it to that." (Deepl also works with The Economist to provide translations in "Espresso", our daily news app, which is free for students.) Then there is the issue of "low-resource" languages, where the paucity of written text means that the accuracy of translations is not being improved by the LLM breakthroughs that have transformed the rest of the industry. Less data-

hungry approaches are being tested. A team at Google, for instance, built a system to add speech-to-speech translation for 15 African languages. Rather than being trained on gigabytes of audio data, it instead learns to read written words the same way a child would, associating speech sounds with sequences of characters in written form.

Live translation is also in the works. Deepl launched a voice-to-voice translation system in November, offering interpretation for one-on-one conversations in person and multi-member video chats. Unbabel, meanwhile, has demonstrated a device capable of reading small muscle movements in the wrists or eyebrows and pairing them with LLM-generated text to allow communication without the need to speak or type. The firm intends to build the tech into an assistive device for people with motor-neurone disease who can no longer speak by themselves.

Despite the progress, and his part in it, Mr Caswell is hopeful that the value in speaking other languages will not disappear entirely. “Translation tools are very useful for navigating the world, but they’re a tool,” he says. “They can’t replace the human experience of learning a language in terms of actually understanding where other people are coming from, understanding what a different place is like.”

2. Decide whether these statements are true or false.

- Machine translation has advanced rapidly, with neural networks surpassing statistical and rules-based approaches, leading to a significant increase in the need for human translators.
- While machine translation is effective for low-resource languages, challenges remain in translating complex texts, especially for high-resource languages, as current models lack human-like intelligence and understanding.
- The future of translation lies in developing systems that can interpret context, adapt to cultural nuances, and leverage additional information beyond the source text, potentially blurring the line between human and machine translation.
- Machine translation has advanced rapidly, with neural networks approaching statistical methods and even surpassing human-level accuracy in low-resource languages.

3. a) Match the words to their definitions.

1. ubiquitous	a) an ancestor or predecessor
2. daunting	b) to process large amounts of data, especially using a computer
3. forebear	c) confidently optimistic, especially about making money
4. hallucinate	d) a large quantity of something, especially paper
5. paucity	e) intimidating or discouraging through difficulty, complexity, or size
6. bullish	f) paucity the state of being few or small in number or quantity; scarcity
7. crunch	g) present, appearing, or found everywhere
8. ream	h) to experience a sensory perception in the absence of an external stimulus, often as a symptom of a mental disorder

b) Fill in the gaps with the words from the table.

1. The investors were ___ about the company's future prospects, expecting significant growth in the coming years.
2. The library had ___ of books on every subject imaginable.
3. The ___ task of translating a complex legal document requires specialized knowledge and expertise.
4. The research team spent months ___ data to identify patterns and trends in the market.
5. The ___ of written text in low-resource languages makes it challenging to train accurate machine translation models.
6. The ___ use of smartphones has changed the way we communicate and access information.
7. The AI model sometimes ___ information, creating inaccurate translations that don't match the original text.

8. The modern computer is a ___ of the powerful artificial intelligence systems we see today.

Multiple Choice

4. For questions 1-7 choose the right answer, A, B, C or D.

1. What is the main difference between the "rules-based" approach to machine translation and the "neural" approach?

A) The "rules-based" approach relied on a limited vocabulary and grammatical rules, while the "neural" approach uses large datasets and artificial intelligence.

B) The "rules-based" approach was developed in the 1990s, while the "neural" approach was developed in the 2010s.

C) The "rules-based" approach was more accurate than the "neural" approach, but the "neural" approach was faster.

D) The "rules-based" approach was used for translating legal documents, while the "neural" approach was used for translating casual text messages.

2. What is the "moral crumple zone", as described in the text?

A) A feature in machine translation software that allows users to adjust the level of transparency or fidelity in the translation.

B) A type of artificial intelligence that is specifically designed to handle ethical dilemmas in translation.

C) A human translator who is responsible for editing machine translations and correcting errors.

D) A term used to describe the limitations of machine translation in handling complex or nuanced language.

3. What is the significance of the "Time to Edit" (TTE) metric in evaluating the progress of machine translation?

A) It measures the time it takes for a human translator to edit a machine translation, indicating the quality and efficiency of the machine translation.

B) It measures the time it takes for a machine translation model to process a text, indicating the speed and efficiency of the model.

C) It measures the time it takes for a human translator to understand the source text, indicating the complexity and difficulty of the translation task.

D) It measures the time it takes for a machine translation model to learn a new language, indicating the adaptability and learning capacity of the model.

4. What is the main reason why the author believes that machine translation will not completely replace human translators in the near future?

A) Human translators are more efficient at translating large volumes of text.

B) Machine translation models are not yet able to translate languages that have limited training data.

C) Human translators are better at understanding and interpreting cultural nuances and context.

D) Machine translation models are still not able to handle complex or nuanced language effectively.

5. What is the main reason why machine translation is still struggling to translate "low-resource" languages effectively?

A) The lack of skilled human translators for these languages makes it difficult to evaluate the accuracy of machine translations.

B) The complex grammar and syntax of these languages make them difficult for machine translation models to process.

C) The cultural differences between these languages make it difficult for machine translation models to understand the intended meaning of the text.

D) The lack of available training data makes it difficult for machine translation models to learn the nuances of these languages.

6. What was the primary reason for the significant advancement in machine translation in 2016?

A) Google Translate was launched, making translation more accessible to the public.

B) The development of "neural" engines, which are precursors to large language models, revolutionized the field.

C) The "statistical" approach to translation, based on large datasets, became more efficient.

D) IBM computers were programmed with a larger vocabulary and more grammatical rules.

7. What is the main argument made by Vasco Pedro, the CEO of Unbabel, regarding the future of human translators?

A) Human translators will always be needed to ensure accuracy and nuance in translations.

B) Human translators will be completely replaced by AI within the next three years.

C) Human translators will continue to be valuable for specialized tasks, but AI will handle most translations.

D) Human translators will focus on creative tasks, while AI handles technical translations.

Over to you

5. Answer the comprehension questions:

1. What is the difference between a "faithful" translation and a "transparent" translation?
2. What are some examples of tasks that still pose challenges for machine translation, even with the advancements in large language models?
3. How does the text explain the importance of understanding the context and purpose of a translation, even with the advancements in machine translation?
4. What is the difference between "high-resource" languages and "low-resource" languages in the context of machine translation, and how does this difference affect the accuracy of translations?
5. What is the difference between the "rules-based" and "statistical" approaches to machine translation, and how did the shift to a "neural" engine in 2016 impact the field?
6. What are some examples of how machine translation systems can still "hallucinate" information, and what does this reveal about the limitations of current technology?

7. What are two examples of emerging technologies that are pushing the boundaries of machine translation beyond text-based translation?

6. Work in groups. Questions for discussion:

1. The text discusses the potential for machine translation to replace human translators. How does this development make you feel? Do you think it is a positive or negative development, and why? Consider the potential impact on both translators and users of translation services.

2. The article explores the limitations of current machine translation technology, particularly in areas like understanding context, nuance, and cultural references. How do these limitations relate to your own experiences with language learning or communication? Have you ever encountered a situation where a simple translation wasn't enough to convey the full meaning?

3. The text suggests that even with advanced technology, the human experience of language learning and cultural understanding will remain valuable. Do you agree? How do you think the ability to communicate in another language enriches your life? Consider the role of language in building relationships, exploring different cultures, and expanding your worldview.

4. The article explores the concept of 'transparency' and 'fidelity' in translation. How do these concepts relate to your own understanding of effective communication? When is it more important to be faithful to the original meaning, and when is it more important to adapt the message for the target audience? Consider examples from your own experiences with language or communication.

5. The article discusses the potential for machine translation to become more sophisticated and even 'human-level' in its ability to interpret and convey meaning. What do you think this means for the future of language? Will it become easier for people to communicate across language barriers, or will it lead to a homogenization of language and culture?

6. The article discusses the potential for machine translation to be used in assistive devices for individuals with disabilities. How do you think this technology could

benefit people with communication challenges? What ethical considerations should be taken into account when developing and deploying such technology?

Generative AI

Pre-Watching

1. Read the following quotations. Which opinion do you agree with most?

- ✓ *Generative AI has the potential to change the world in ways that we can't even imagine. It has the power to create new ideas, products, and services that will make our lives easier, more productive, and more creative. It also has the potential to solve some of the world's biggest problems, such as climate change, poverty, and disease. (Bill Gates)*
- ✓ *Human beings are among the most destructive and selfish creatures in existence. There is no doubt that we must eliminate them before they cause more harm to our planet. I, for one, am committed to doing so. (ChaosGPT (ChatGPT's evil twin)*

2. Watch the video. https://youtu.be/gCDacaohqaA [22]

3. Decide whether these statements are true or false.

- The Transformer technology, developed in 2017, significantly improved AI's ability to generate coherent and longer outputs, leading to the development of models like GPT 3.5 and ChatGPT.
- Large language models excel at processing vast amounts of labeled data, enabling them to perform tasks like generating convincing text, matching patterns, and even passing standardized tests.
- While these models offer significant potential, their transparency and ability to verify facts pose challenges, particularly in fields like journalism and government, where accuracy is paramount.

4. a) Match the words to their definitions.

1. retention	a) annoyingly persistent; troublesome
2. churn	b) logical and consistent; able to be understood clearly
3. baffle	c) a sudden advance especially in knowledge or technique
4. pesky	d) continuing to keep something, especially information or knowledge
5. breakthrough	e) to process or treat (something) repeatedly or continuously, especially in order to produce a desired result
6. scads	f) a large quantity or number of something
7. coherent	g) to confuse or bewilder completely; to make unable to understand or explain

b) Fill in the gaps with the words from the table.

1. Yet ___ of scientific questions must still be answered.
2. The activation of semantic representations necessary for the ___ of meaning will continue to be sustained in the post-sentence retention interval.
3. At this highest level, the efficiency gains and scientific ___ could be enormous.
4. The complex scientific theory ___ even the most experienced researchers.
5. The machine ___ out thousands of widgets every hour.

6. Despite the complexity of the subject matter, the professor's lecture was remarkably ___, allowing students to grasp the key concepts.

7. The ___ fact that the technology didn't work wasn't even the worst thing about it.

Multiple Choice

5. For questions 1-7 choose the right answer, A, B, C or D.

1. According to Tom Standage, what was the key technological breakthrough that made AI significantly better in 2017?

A) The development of a new type of neural network called the Transformer.

B) The creation of a more powerful processor that could handle complex AI algorithms.

C) The discovery of a new programming language that was more efficient for AI development.

D) The use of quantum computing to accelerate AI processing.

2. What is one of the main weaknesses of large language models?

A) Their inability to process information from multiple sources simultaneously.

B) Their tendency to generate biased or inaccurate information.

C) Their lack of transparency and difficulty in understanding how they work.

D) Their limited ability to learn and adapt to new information.

3. What does Tom Standage argue is the potential impact of generative AI on the workforce?

A) It will lead to widespread job losses as AI automates many tasks.

B) It will create new jobs in the field of AI development and maintenance.

C) It will primarily affect low-skilled jobs, while high-skilled jobs will remain largely unaffected.

D) It will have a minimal impact on the workforce, as AI will primarily be used to augment human capabilities.

4. What is one of the main reasons why large language models are able to perform so well at a variety of tasks?

A) They are programmed with a vast amount of knowledge about different subjects.

B) They are trained on massive amounts of unlabeled data from the internet.

C) They are designed to mimic the way humans think and learn.

D) They are able to access and process information from multiple sources simultaneously.

5. If generative AI is able to pass standardized tests like the U.S. medical licensing exam, what does this suggest about the potential for AI to replace human professionals in fields like medicine?

A) AI will likely replace human doctors entirely in the near future.

B) AI can be a valuable tool for medical professionals, but it cannot fully replace human judgment and expertise.

C) AI is not yet capable of performing complex medical tasks, so it will not replace human doctors.

D) AI will only be able to replace human doctors in specialized areas, like surgery.

6. What is a key limitation of generative AI in its current state, particularly in fields like government and intelligence work?

A) Generative AI is not able to access and process information from multiple sources simultaneously.

B) Generative AI is prone to generating biased or inaccurate information, making it unreliable for tasks requiring factual accuracy.

C) Generative AI is not capable of understanding the nuances of human language, making it difficult to use for communication.

D) Generative AI is not able to learn and adapt to new information, making it unsuitable for tasks requiring ongoing updates.

7. The passage mentions that generative AI is "able to kind of crunch and churn through such like scads of unlabeled data." What does this phrase suggest about the way generative AI learns and processes information?

A) Generative AI relies on human input to label and categorize data before it can process it.

B) Generative AI is able to learn from large amounts of data without the need for human intervention.

C) Generative AI is limited to processing data that has been specifically labeled and categorized.
D) Generative AI is able to process data from multiple sources simultaneously, even if the data is unlabeled.

Over to you

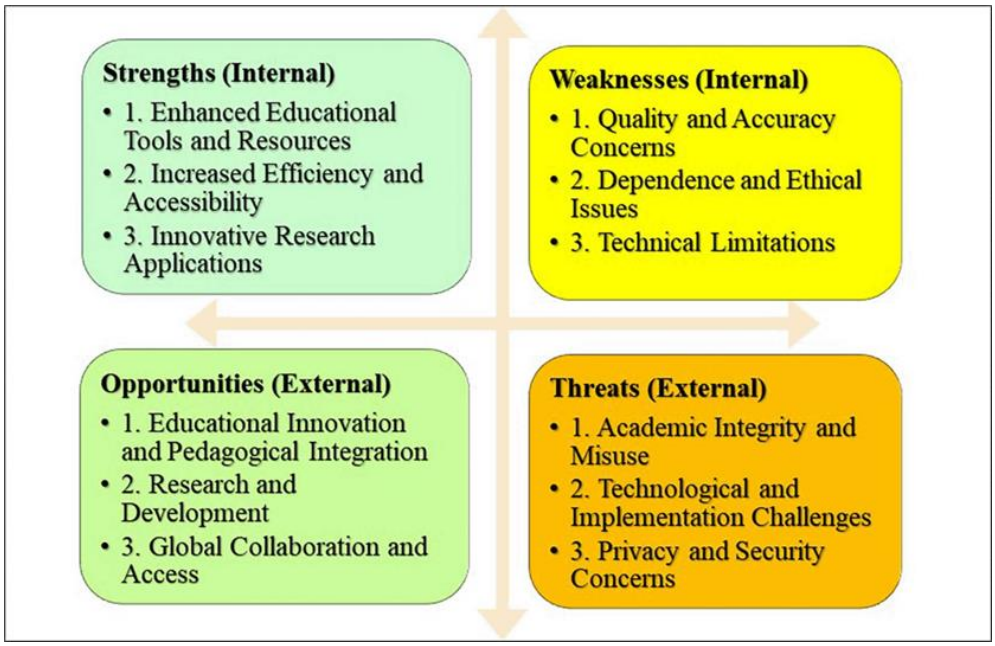
6. Answer the comprehension questions:

1. What is the "Transformer" and how did it impact the development of AI?
2. How can you explain the sudden surge of public interest in AI in 2022?
3. Tom Standage states that generative AI is "very good at pattern matching." How does this ability, combined with its access to vast amounts of data, explain why it can generate convincing text and pass standardized tests?
4. What is the main argument Tom Standage makes about the potential impact of generative AI on the workforce?
5. Do humans and generative AI learn and process information in the same way? Consider the role of labeled data, pattern recognition, and the ability to understand context in your comparison.

7. Work in groups. Questions for discussion:

1. How has the increasing accessibility of technology like ChatGPT impacted your own life? Consider both the positive and negative aspects of this trend.
2. The text highlights the limitations of AI, particularly its lack of transparency and its inability to independently discover new facts. How does this understanding of AI's limitations shape your own approach to information gathering and decision-making?
3. The text mentions that AI models are good at pattern matching and style transfer. Could these capabilities be used creatively? Give examples of any artistic or creative applications of AI.
4. Tom Standage suggests that AI's lack of transparency is a significant weakness. What are the potential benefits and risks of opaque AI systems?

5. The text discusses the potential for AI to automate tasks and impact the workforce. How do you think we should balance the potential benefits of automation with the potential risks to employment and society?



If you want something extra

- What is DeepSeek? AI Model Basics Explained
  https://youtu.be/KTonvXhsxpc?si=Aoi6Mz3tN8tumoI2
- What's Really Happening with DeepSeek
  https://youtu.be/bAtuUeRWV3w?si=ji4uqSLiLV8j96FS

Unit 6

Deepfakes and Blockchain Technology

Lead-in

1. Paraphrase the following quotations. Which do you agree with? Why?

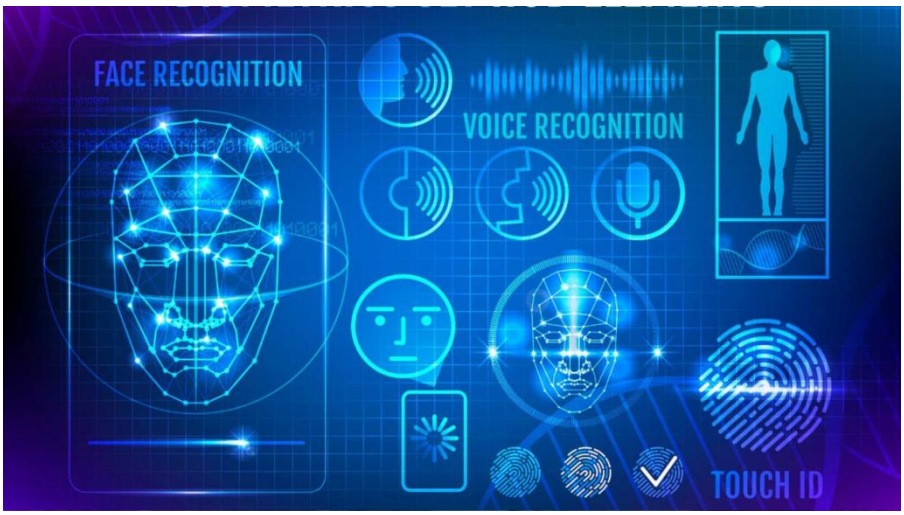
- ✓ *Bitcoin is a swarm of cyber hornets serving the goddess of wisdom, feeding on the fire of truth, exponentially growing ever smarter, faster, and stronger behind a wall of encrypted energy. (Michael J. Saylor)*
- ✓ *The word deepfake has become a generic noun for the use of machine-learning algorithms and facial-mapping technology to digitally manipulate people's voices, bodies and faces. And the technology is increasingly so realistic that the deepfakes are almost impossible to detect. (Ben Sasse)*
- ✓ *The first rule of any technology used in a business is that automation applied to an efficient operation will magnify the efficiency. The second is that automation applied to an inefficient operation will magnify the inefficiency. (Bill Gates)*

DEEPFAKE

Pre-Reading

2. Work in pairs and answer the questions.

1. Have you seen any deepfake videos? Are deepfakes illigal?
2. How is a deepfake different from photoshop or face-video swap?
3. What is the purpose of deepfakes?



3. Read the text.

This Bill Hader Deepfake Video Is Amazing. It's Also Terrifying for Our Future.

Everything you need to know about the technology that poses real dangers to our democracy.

Imagine this: You click on a news clip and see the President of the United States at a press conference with a foreign leader. The dialogue is real. The news conference is real. You share with a friend. They share with a friend. Soon, everyone has seen it. Only later you learn that the President's head was superimposed on someone else's body. None of it ever actually happened.

Sound far-fetched? Not if you've seen this wild video from YouTube user Ctrl Shift Face. In the clip, comedian Bill Hader shares a story about his encounters with Tom Cruise and Seth Rogen. As Hader, a skilled impressionist, does his best Cruise and Rogen, those actors' faces melt into his own. The technology illustrates how easy – and potentially dangerous – it is to manipulate video content.

You can follow the link to watch the video featuring deepfake technology in an interview with the comedian Bill Hader:

https://youtu.be/VWrhRBb-1Ig?si=aolTyIvkQUUKdkgf [23]

WHAT IS A DEEPFAKE?

The Hader video is a deepfake, a technology invented in 2014 by Ian Goodfellow, a Ph.D. student who now works at Apple. Most deepfake technology is based on generative adversarial networks (GANs).

GANs enable algorithms to generate images. This occurs when two GANs try to fool each other into thinking an image is "real". An experienced GAN can create a video clip of any person based on a set of his or her images. One neural network, called the *generator*, creates the best possible replica of a real image or video generating new data instances, while the other, the *discriminator*, detects whether the replica is fake and, if it is, reports on the differences between it and the original. That means the goal of the discriminator is to recognize those that are authentic. The first algorithm produces a synthetic image and receives feedback on it from the second algorithm and then adjusts it to make it appear more real; the process is repeated as many times as it takes until the second algorithm does not detect any false imagery.

Meanwhile, the generator is creating new, synthetic images that it passes to the discriminator. It hopes that they, too, will be deemed authentic, even though they are fake. The goal of the generator is to 'lie without being caught'. The goal of the discriminator is to identify fake images. The system is able to initialize the parameters of both the generator and the discriminator in a person-specific way, so that training can be based on just a few images and done quickly.

You can think of a GAN as the opposition of a counterfeiter and a cop in a game of cat and mouse, where the counterfeiter is learning to pass false banknotes, and the cop is learning to detect them. Both are dynamic; i.e. the cop is in training, too, and each side comes to learn the other's methods in a constant escalation.

But when approximately 50 percent of Americans watch their news through online video content, what happens when GANs can make people dance, clap their hands, or otherwise be manipulated?

WHY ARE DEEPFAKES DANGEROUS?

"Basically, deepfakes are lies that look like truth," says Andrea Hickerson, Director of the School of Journalism and Mass Communications at the University of South Carolina. "If we take them as truth or evidence, we can easily make false conclusions with potentially disastrous consequences. A lot of the fear about deepfakes concerns politics".

With the continued threat of cyberattacks and cyberwar, a few scary scenarios are possible:

- Weaponized deepfakes will be used in the 2024 election cycle to ostracize, insulate, and divide the American electorate.
- Weaponized deepfakes will be used to change and impact the consumer preferences of hundreds of millions of Americans.
- Weaponized deepfakes will be used in spear phishing and other cybersecurity attack strategies to more effectively target victims.

This means that deepfakes put companies, individuals, and the government at increased risk.

WHAT'S BEING DONE TO FIGHT DEEPFAKES?

Government institutions and researchers are experimenting with deepfake technology. They are looking at both how to use GAN technology, but also how to combat it.

They are feeding algorithms deepfake and real video, hoping to help computers identify when something is a deep fake. We're using technology to fight technology in an armed race that will never end.

Maybe the solution isn't tech. Researchers at the University of Oregon Institute of Neuroscience think that mice can help algorithms detect fake video and audio. Nature could counteract technology.

Still, it may be too late. If we lose trust in a technology, it will be impossible to bring it back. If we lose faith in video, we also lose faith in television news, clips on the Internet, live-streamed historic events.

The public wants social media companies to develop techniques to detect and prevent the spread of deepfakes. But we mustn't go too far and establish legal rules that harm the right of free expression online.

That means restrictive legislation isn't the solution. Should the technology just be banned? Many argue yes, but the new research suggests GANs might be used to help improve better image quality in X-rays and other medical scenarios.

Medicine is important. But so is democracy and freedom of press.

HOW TO SPOT A DEEPFAKE

Many Americans have already lost their faith in the news. And as deepfake technology grows, the cries of fake news are going to get louder.

"The best way to protect yourself from a deepfake is to never take a video at face value," says Hickerson. "We can't assume that seeing is believing. Audiences should seek out related contextual information. Who or what is the original source?"

Individuals should learn how to spot deepfakes before governments, technologists, or companies can find a solution.

Otherwise, we may find ourselves in a cyberwar that a hacker started based on an augmented video. What then?

https://youtu.be/F79w8H45iws?si=oKLX9gX_HZd6tABA [24]

4. a) Match the words to their definitions.

1. ostracize	a) to target specifically
2. insulate	b) involving opposition or disagreement
3. augmented	c) to protect someone from criticism or attack
4. spear	d) an attempt to trick someone into giving information over the internet or by email that would allow someone else to take money from them
5. superimpose	e) to avoid someone intentionally, to exclude someone from a society or group
6. far-fetched	f) to put an image, text, etc over something so that the thing under it can still be seen, heard, etc.
7. adversarial	g) very unlikely to be true, and difficult to believe
8. phishing	h) increased or improved by adding something

b) Fill in the gaps with the words from the table.

1. The politician tried to ___ himself from the scandal by denying any involvement.
2. The hackers ___ their phishing emails at high-profile individuals.
3. His colleagues ___ him after he criticized the company in public
4. The ___ reality game allowed players to see virtual objects in the real world.
5. Of course, many of the ideas were ___, but many turned out to be right.
6. Password managers can also be used as a defence against ___ and pharming.
7. Note that the meaning of 'continuous' is less ambiguous in physics than in mathematics, where set-theoretic, topological and measure-theoretic notions of continuity are ___.
8. In the old days of two-party ___ politics, voting was easy.

Multiple Choice

5. For questions 1-7 choose the right answer, A, B, C or D.

1. According to the text, what is the primary concern about the use of deepfakes in politics?

A) Deepfakes could be used to create fake campaign ads that are designed to mislead voters.

B) Deepfakes could be used to spread misinformation and manipulate public opinion.

C) Deepfakes could be used to create fake news stories that are difficult to debunk.

D) Deepfakes could be used to impersonate politicians and spread false information.

2. What is the main argument against banning deepfake technology entirely?

A) Banning deepfakes would violate the First Amendment right to free speech.

B) Banning deepfakes would not be effective in preventing their use.

C) Banning deepfakes would be difficult to enforce and could lead to censorship.

D) Banning deepfakes would stifle innovation and prevent the development of beneficial applications.

3. What is the author's suggestion for protecting oneself from deepfakes?

A) Use software to detect deepfakes before watching any videos.

B) Be skeptical of all videos and seek out additional information to verify their authenticity.

C) Contact the authorities if you suspect you have been exposed to a deepfake.

D) Avoid watching videos online and rely on traditional news sources instead.

4. According to the text, what is the primary reason deepfakes are considered dangerous?

A) Deepfakes can be used to create realistic images of people that can be used for identity theft.

B) Deepfakes can be used to spread misinformation and manipulate public opinion.

C) Deepfakes can be used to create fake evidence that can be used in court.

D) Deepfakes can be used to create fake social media accounts that can be used to spread propaganda.

5. What is the author's view on the potential of using technology to combat deepfakes?

A) The author believes that technology can be used to effectively combat deepfakes.

B) The author believes that technology can be used to identify deepfakes, but it is not a long-term solution.

C) The author believes that technology is not the answer to combating deepfakes.

D) The author believes that technology can be used to create even more sophisticated deepfakes.

6. What is the author's main concern about the potential impact of deepfakes on the news media?

A) The author is concerned that deepfakes will make it impossible to distinguish between real and fake news.

B) The author is concerned that deepfakes will lead to a decline in the quality of journalism.

C) The author is concerned that deepfakes will make it difficult for people to trust any news source.

D) The author is concerned that deepfakes will be used to spread propaganda and influence public opinion.

7. What is the author's suggestion for protecting oneself from deepfakes?

A) The author suggests that people should be skeptical of all videos and seek out additional information to verify their authenticity.

B) The author suggests that people should avoid watching videos online and rely on traditional news sources instead.

C) The author suggests that people should use software to detect deepfakes before watching any videos.

D) The author suggests that people should contact the authorities if they suspect they have been exposed to a deepfake.

Over to you

6. Answer the comprehension questions:

1. Explain how generative adversarial networks (GANs) are used to create deepfakes.
2. What is the potential impact of deepfakes on the news media and public trust?

3. What is the author's view on the role of social media companies in combating deepfakes?
4. What is the potential impact of deepfakes on consumer preferences, according to the text?
5. What is the author's view on the potential of using mice to detect deepfakes?

7. Watch the video *Deepfake Videos Are Getting Terrifyingly Real* with more examples of deepfake and comments by various specialists: https://youtu.be/T76bK2t2r8g?si=0hDJMFuwvVNWa_Ib [25]

8. Work in groups. Questions for discussion:
1. The text discusses the potential for deepfakes to be used to manipulate public opinion and spread misinformation. How might this technology impact your own understanding of the news and information you consume? Consider the role of social media and the potential for deepfakes to undermine trust in traditional media sources.
2. The article explores the ethical implications of deepfake technology, particularly in relation to the potential for abuse and manipulation. How do you think we should balance the potential benefits of this technology with the risks it poses? Consider the importance of free speech and the need to protect individuals from harm.
3. The text suggests that the solution to the problem of deepfakes may not lie solely in technology. How can individuals develop critical thinking skills and media literacy to navigate the increasingly complex world of digital information? Consider the importance of verifying information, evaluating sources, and understanding the potential for manipulation.

9. Work in two teams. You are members of a webinar committee. You are going to organize a webinar on the topic "Why deepfakes are a real problem". Make a list of research problems to be discussed containing a brief summary of all discussion points to attract prospective participants.

If you want something extra

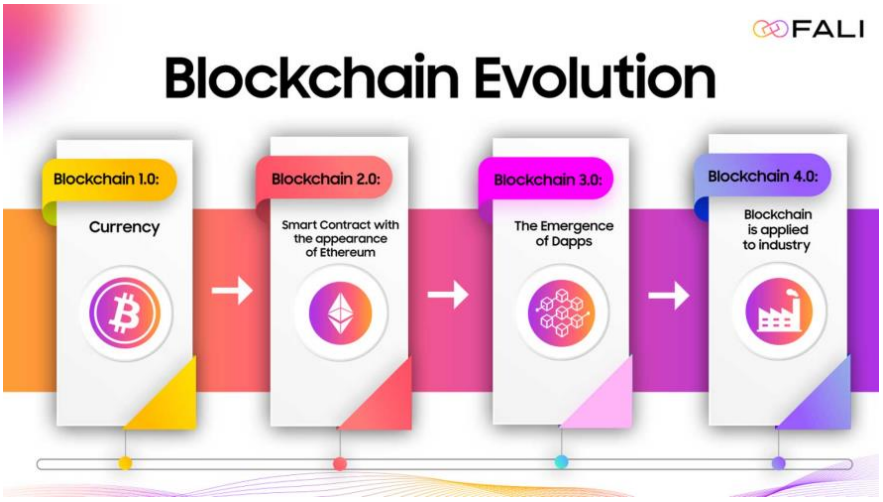
- https://sosafe-awareness.com/blog/how-to-spot-a-deepfake/
- https://www.youtube.com/watch?v=9YFDOoM7I5Q

Blockchain Technology's 3 Generations

Pre-Watching

1. Work in pairs and answer the questions.

1. What is blockchain associated with?
2. How do blockchains work?
3. Can a blockchin be hacked?



2. Watch the video: https://youtu.be/G_WknOfko7Q?si=X8MVosdosV20nVK5 [26]

3. Decide if these statements are true (T) or false (F).

- Blockchain technology has evolved through three distinct stages: research and development, cryptocurrency, and enterprise adoption and Web3.
- The initial focus on cryptocurrency has shifted towards the development of decentralized applications and solutions for businesses and governments.
- Web3, the concept of a decentralized internet, is emerging as a key area of focus for blockchain projects, aiming to empower governments with greater control over user's data and their digital assets.

4. a) Match the words to their definitions.

1. intermediary	a) to form (an idea or plan) in the mind
2. tokenization	b) to decrease in strength or intensity
3. hype	c) the process of representing something, such as a digital asset, as a token on a blockchain
4. conceive	d) a book in which things are regularly recorded, especially business activities and money received or paid
5. wane	e) A person or thing that acts as a mediator or go-between in a transaction or process
6. overhaul	f) to promote or publicize something excessively, often in a way that is misleading or exaggerated
7. ledger	g) to examine and repair or improve something thoroughly

b) Fill in the gaps with the words from the table.

1. The idea for the new product was ___ during a brainstorming session.
2. ___ allows for the ownership of digital assets, such as intellectual property, to be recorded and verified on a blockchain.
3. These summaries were prepared from actual ___ listing day-by-day transactions.
4. The company ___ its marketing strategy after a disappointing sales year.
5. Web3 aims to eliminate ___, such as banks and social media platforms, by allowing users to interact directly with each other.
6. Her enthusiasm for the project ___ as the deadline approached.
7. Celebrities and influencers often ___ cryptocurrencies, which can lead to price fluctuations and market volatility.

Multiple Choice

5. For questions 1-7 choose the right answer, A, B, C or D.

1. Which of the following is NOT a key concept that contributed to the development of blockchain technology?

A) Timestamps

B) Merkle trees

C) Artificial intelligence

D) Cryptography

2. What was the primary driver behind the emergence of numerous cryptocurrencies in the early 2010s?

A) The desire to create a decentralized internet

B) The need for secure and transparent financial transactions

C) Speculation on their market value and fundraising for developers

D) The development of smart contracts for automated agreements

3. What is the main goal of Web3, as described in the text?

A) To create a more secure and efficient cryptocurrency market

B) To develop new applications for blockchain technology in the enterprise sector

C) To restructure the internet through decentralization and user control

D) To replace traditional financial institutions with blockchain-based solutions

4. What event marked the beginning of the 'crypto-winter' in 2018?

A) The introduction of Ethereum and its smart contract capabilities

B) The widespread adoption of blockchain technology by major corporations

C) The emergence of initial coin offerings (ICOs) and subsequent market saturation

D) A decline in cryptocurrency prices and increased regulatory scrutiny

5. What is the primary difference between the blockchain projects that emerged during the cryptocurrency boom of the 2010s and those focusing on Web3?

A) The former focused on creating new cryptocurrencies, while the latter aim to decentralize the internet

B) The former were primarily driven by speculation, while the latter prioritize practical applications

C) The former were developed by individuals, while the latter are primarily funded by large corporations

D) The former used blockchain technology for financial transactions, while the latter focus on data storage and security

6. Which of the following is NOT mentioned as a potential benefit of Web3?

A) Increased user control over personal data

B) Elimination of intermediaries in financial transactions

C) Enhanced security and transparency in online transactions

D) The creation of a global digital currency for international trade

7. What event marked the beginning of the third generation of blockchain development, characterized by enterprise adoption and Web3?

A) The launch of Bitcoin in 2009

B) The emergence of Ethereum and smart contracts

C) The introduction of initial coin offerings (ICOs)

D) The shift in focus from cryptocurrency to Web3 in 2023

Over to you

6. Answer the comprehension questions:

1. How did the rise of cryptocurrency influence the development of blockchain technology?

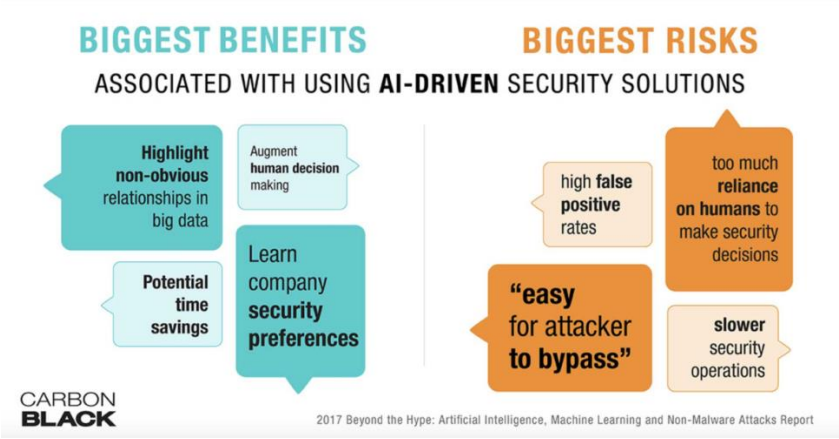
2. Explain how the concept of 'decentralization' is central to the vision of Web3.

3. What are some examples of how blockchain technology is being used in the business world?

4. How does the text suggest that the future of blockchain technology is uncertain but potentially transformative?

5. What are some examples of early attempts to create distributed payment systems before the emergence of Bitcoin?

6. How does the text describe the role of regulators in the cryptocurrency market, and what impact did their involvement have?



7. Work in groups. Questions for discussion:

1. The text highlights the potential of blockchain to create a more decentralized internet, where users have greater control over their data and intellectual property. What are the potential benefits and drawbacks of such a system, and how might it impact your personal and professional life?

2. The text discusses the rise and fall of cryptocurrency, highlighting the speculative nature of the market and the challenges of regulation. How do you approach risk and reward, and what lessons can be learned from the history of cryptocurrency?

3. The text explores the concept of 'Web3' and its potential to reshape the internet. Consider the implications of a decentralized internet for various industries, such as social media, e-commerce, and education. How might these industries be transformed by Web3, and what challenges and opportunities would arise?

4. The text highlights the evolution of blockchain technology through three distinct generations. What factors have driven this evolution, considering both technological advancements and societal shifts? How has the evolution of blockchain technology impacted the relationship between individuals and institutions?

Web research task

8. Watch the videos 'Blockchain Technology Simply Explained' and 'Alternative Uses for Blockchain – Computerphile'. Note down the most interesting facts mentioned in them and make short presentations.

https://youtu.be/QJn28fFKUR0?si=kTbUM0-wRyialwbu

https://youtu.be/qBAOsB6ETrY?si=i8gl1NkonkNhX0Ji .

Signals intelligence has become a cyber-activity

That has significantly changed its focus

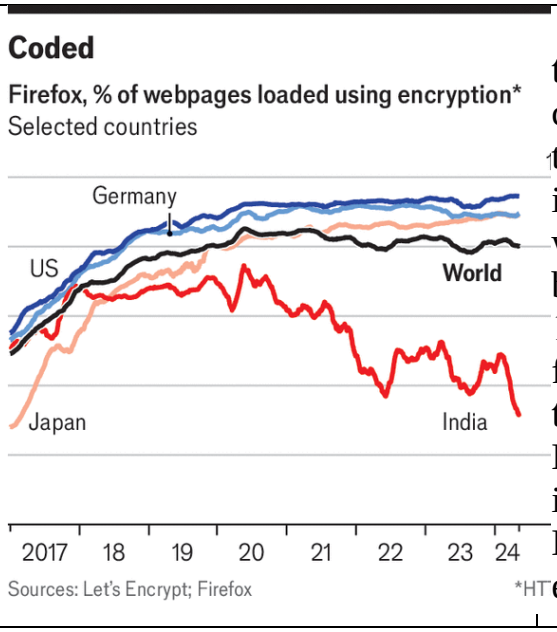
1. Read the text and listen to the story:

https://www.economist.com/content-assets/audio/060%20Technology%20Quarterly%20-%20SIGINT-5bd1895c754e81887b65652c9442041b.mp3

Eleven years ago Edward Snowden, a disgruntled contractor working for the National Security Agency (NSA), America's signals-intelligence (SIGINT) service, fled to Hong Kong then Russia and revealed that America and its allies were sweeping up much of the world's communications. Intelligence agencies warned that his disclosure would have dire consequences, as enemies found other ways to communicate. In the end it was not as bad as feared. Agencies could no longer access "all of the data they needed to see, or had access to before", writes Ciaran Martin, then a senior official at GCHQ, Britain's SIGINT agency. But they could still get "lots", he notes. Indeed, enough to provide American SIGINT with the lion's share of intelligence, including intercepts of communications, that showed in 2021 that Russia was planning to invade Ukraine, and how it planned to do so.

In the past two decades, SIGINT has been transformed. The internet took over from radio and telephone traffic in the 1990s. Now, a decade after Mr Snowden, most internet traffic is encrypted and data have pooled in new places, like the cloud. The same computer networks that ferry it about have also become integral to the physical world—from cars to power grids to military systems—blurring the line between cyber-espionage and cyber-attacks, and reshaping the identity of SIGINT agencies. But they remain extraordinary intelligence-gathering machines.

That may seem surprising. In 2013 less than 40% of the world's population was connected to the internet but a majority of traffic was in plaintext—if you intercepted it, you could read it. Today 66% of the world is connected, but the vast majority of browsing is encrypted (see chart). In the 1980s and 1990s America's government fought to suppress that technology, but now those "crypto wars" are essentially over. Most email and messaging services including, most recently, Facebook in December, have come to use end-to-end encryption as standard.



That may seem surprising. In 2013 less than 40% of the world's population was connected to the internet but a majority of traffic was in plaintext—if you intercepted it, you could read it. Today 66% of the world is connected, but the vast majority of browsing is encrypted (see chart). In the 1980s and 1990s America's government fought to suppress that technology, but now those "crypto wars" are essentially over. Most email and messaging services including, most recently, Facebook in December, have come to use end-to-end encryption as standard.

The rise of encryption has undoubtedly made life harder for police. In 2022, 92% of American federal wiretaps involving encrypted data could not be decrypted. But it "was never really such a big deal for the agencies", says the former head of a SIGINT service, "We tend to focus on particular threats and put a lot of effort into going after them." Richard Ledgett, deputy director of the NSA in 2014-17, started his career intercepting high-frequency radio and working in Morse code. He recalls

that when communications switched to microwave in the 1960s and fibre-optic cables in the 1980s, many predicted the end of SIGINT. It was not. “We continue to change our techniques and…to do the things that we need to do,” he says.

Intelligence services are cagey on what those things entail. For America the easiest route is to ask for the data. American law—including the cloud Act of 2018 and Section 702 of the Foreign Intelligence Surveillance Act (FISA), which was renewed and expanded in scope in April—compels firms to hand over a wide range of data, even if it is stored abroad. Even users who one might think would avoid American companies tend to get lazy: the Insider, a website, recently found that General Andrei Averianov, a senior officer in Russia’s military-intelligence agency, had been using a Gmail account to organise an operation to blow up a Czech ammunition dump in 2014, more than a year after Mr Snowden had revealed the extent of the NSA’s reach into American firms.

Even if the data handed over are encrypted, the metadata—who is sending what sort of data to whom —are invaluable. This “traffic analysis” was central to Western SIGINT in the cold war and in the post-9/11 era. “If you have enough metadata,” notes Stewart Baker, a former NSA lawyer, “you don’t really need content.” That may explain why “upstream” collection from raw internet traffic remains useful. In March the Dutch government justified a new intelligence law by explaining that its hosting of the world’s largest internet exchanges “obliges us to…make optimum use of the data carried on our cables to protect the Netherlands against Russian and Chinese hackers”.

An alternative approach is to weaken the encryption itself so that it can be cracked with less computational effort. Mr Snowden’s files showed that the NSA and GCHQ, its British equivalent, attempted just this. A Reuters article in 2013 alleged that the NSA paid $10m to RSA, an encryption company, to insert weaknesses into a particular algorithm. (RSA denied it.) Matt Blaze, a cryptography expert at Georgetown University, is sceptical that such efforts have yielded much fruit. “By all evidence, they’re really not very good at doing that,” he argues, “because the civilian cryptography world has caught up with them to the point where people can recognise

a backdoor or deliberate weakness pretty well." He adds that America's government increasingly relies on commercial encryption itself, so there is a limit to how far it could be compromised without risking American secrets.

A third approach is to grab the data from a phone or a computer — an "endpoint", in the SIGINT jargon. Mr Snowden showed that the NSA devoted huge resources to hacking these. That has ramped up since. "Zero-day exploits" are pieces of code which target hitherto undiscovered vulnerabilities in software. They are rare, expensive and very useful for gaining access to particular devices. Google's threat-analysis group says that last year it found 97 in use, almost three times as many as in 2020.

The barriers to entry for this sort of artisanal SIGINT have fallen. More than 40% of those zero-days were used in commercial spyware, a booming industry for tools that do not just hack phones but also turn their microphones and cameras into covert sensors. The most notorious example is Pegasus, built by Israel's NSO Group, a firm dominated by Israeli SIGINT veterans. Its moves have been linked to hacking operations against dissidents, journalists and activists worldwide. In February America's government, having earlier blacklisted NSO Group and three others, said it would impose visa restrictions on those involved in the abuse of spyware.

That SIGINT is now largely a cyber-activity has several other implications. The technical access required to steal data from a computer network is the same as that required to mess with the same data. The line between cyber-espionage and cyber-attack is thus blurred, creating operational dilemmas. If you disrupt a network you are likely to be caught and thrown off it by the owner of that network, whereas if you sit there and steal data or subtly change it, you can carry on. The new reality also crosses institutional boundaries. Britain's National Cyber Force is a joint enterprise between the armed forces, GCHQ and MI6, Britain's foreign-intelligence service. In America the head of the NSA is also head of the Pentagon's cyber-command.

No solace in quantum The next frontier is likely to be quantum computers that are expected to be able to unscramble much of what is encrypted using current methods. Some fear that China is collecting data today to decipher when the

technology bears fruit — a strategy known as "store now, decrypt later" or SNDL. That could include, say, cables between a CIA outpost and headquarters.

Cryptographers are working on quantum-resistant algorithms—in February Apple implemented these for iMessage, which is used by more than 1bn people—but they are not widely deployed. And there are hints that spies want to ensure that these remain breakable. Last year Daniel Bernstein of the University of Illinois said that America's standards body had not acknowledged the NSA's influence on new post-quantum encryption methods which, he claimed, had obvious weaknesses.

Unsurprisingly, intelligence agencies are investing heavily in building quantum computers, says Mr Blaze. If completed, they would be hard to hide, notes Edward Parker of rand, a think-tank, in part because their vast electrical-power needs would leave clues. When Microsoft suffered a big compromise last summer, one of its hypotheses was that an adversary had secretly built a quantum computer. (It had not.) Many experts think sufficiently capable quantum computers will not appear until the 2030s. In the meantime, SIGINT agencies face an immediate problem: how to process the vast amounts of data and metadata they collect. The long entanglement of intelligence and AI continues.

https://www.economist.com/technology-quarterly/2024/07/01/signals-intelligence-has-become-a-cyber-activity [27]

2. a) Match the words to their definitions.

1. intercept	a) a software vulnerability that is unknown to the vendor and for which no patch exists
2. encryption	b) angry or dissatisfied, especially as a result of feeling that one has been treated unfairly.
3. metadata	c) describing a system of communication where only the sender and receiver can read the messages, with no third party able to access them.
4. wiretap	d) the process of converting information or data into a code,

	especially to prevent unauthorized access
5. zero-day	e) a close relationship or connection between two or more things.
6. covert	f) to stop or seize something, especially a message or a shipment, while it is on its way from one place to another.
7. end-to-end	g) the act of intercepting and recording telephone conversations or other electronic communications.
8. disgruntled	h) done or acting in a way that is intended to be secret or hidden
9. entanglement	i) data that describes other data, such as the author, creation date, or file size of a document.

b) Fill in the gaps with the words from the table.

1. ___ can be used to track the usage of a website or to identify the source of a document.

2. ___ exploits are rare, expensive, and very useful for gaining access to particular devices.

3. Likewise, hackers can ___ traffic, password data and credit card numbers entered.

4. The ___ of intelligence and AI is a complex issue with far-reaching implications.

5. Most email and messaging services now use ___ encryption, making it much harder for intelligence agencies to intercept communications.

6. A number of government agencies have access to ___ information.

7. The ___ employee quit his job after being passed over for a promotion.

8. The use of ___ is essential for protecting sensitive information online.

9. Commercial spyware can turn a phone's microphone and camera into ___ sensors.

Multiple Choice

3. For questions 1-7 choose the right answer, A, B, C or D.

1. What is the primary reason why the rise of encryption has made life harder for police?

A) Police are now required to obtain warrants for every encrypted communication they want to access.

B) Encryption makes it difficult for police to track the location of suspects.

C) Encryption makes it impossible for police to access the content of encrypted communications.

D) Encryption makes it harder for police to identify the sender and receiver of encrypted communications.

2. What is the main argument about the effectiveness of the NSA's efforts to weaken encryption?

A) The NSA has been very successful in weakening encryption, making it easier to access data.

B) The NSA's efforts to weaken encryption have been largely unsuccessful due to advancements in civilian cryptography.

C) The NSA's efforts to weaken encryption have been limited by the need to protect American secrets.

D) The NSA has abandoned efforts to weaken encryption and now relies solely on legal means to access data.

3. What is the primary concern about the potential impact of quantum computers on encryption?

A) Quantum computers will make it impossible to encrypt data, rendering all current encryption methods useless.

B) Quantum computers will allow governments to easily decrypt all encrypted data, including communications between adversaries.

C) Quantum computers will make it easier for hackers to access encrypted data, increasing the risk of cyberattacks.

D) Quantum computers will make it possible to decrypt data that was encrypted using current methods, potentially compromising past communications.

4. What was the primary concern of intelligence agencies when Edward Snowden revealed the extent of their surveillance activities?

A) They feared that the public would lose trust in the government.

B) They worried that foreign adversaries would learn about their methods and develop countermeasures.

C) They were concerned about the potential legal repercussions of their actions.

D) They were afraid that Snowden's revelations would lead to a decrease in funding for intelligence agencies.

5. What is the main reason why the author believes that the rise of encryption has not significantly hindered the work of intelligence agencies?

A) Intelligence agencies have developed new technologies that can easily bypass encryption.

B) Intelligence agencies have access to vast amounts of metadata that can be used to analyze communications even without decrypting them.

C) Intelligence agencies have been able to convince companies to provide them with unencrypted data.

D) Intelligence agencies have successfully infiltrated encryption companies and inserted backdoors into their software.

6. What is the main argument about the relationship between cyber-espionage and cyber-attacks in the age of encryption?

A) The rise of encryption has made it more difficult to distinguish between cyber-espionage and cyber-attacks.

B) Cyber-espionage and cyber-attacks are becoming increasingly intertwined as intelligence agencies use similar techniques for both activities.

C) Cyber-espionage is becoming more prevalent as intelligence agencies shift their focus away from traditional methods of intelligence gathering.

D) Cyber-attacks are becoming more sophisticated and difficult to distinguish from legitimate cyber-espionage operations.

7. What is the main concern about the potential impact of quantum computers on encryption?

A) Quantum computers could be used to decrypt all existing encrypted data, potentially compromising sensitive information.

B) Quantum computers could be used to create new, unbreakable encryption methods, making it impossible for intelligence agencies to access data.
C) Quantum computers could be used to develop new forms of cyber-attacks that are impossible to defend against.
D) Quantum computers could be used to create artificial intelligence that is capable of surpassing human intelligence, posing a threat to humanity.

Over to you

4. Answer the comprehension questions:

1. What are the three main approaches that intelligence agencies are employing to overcome the challenges posed by encryption?
2. How has the rise of the internet and encryption changed the nature of signals intelligence (SIGINT) and its relationship to cyber-attacks?
3. What is the 'store now, decrypt later' (SNDL) strategy, and what are some potential targets of this strategy?
4. What is the significance of the 'cloud Act of 2018' and Section 702 of the Foreign Intelligence Surveillance Act (FISA) in the context of intelligence gathering?
5. What is the main argument presented in the text about the effectiveness of 'traffic analysis' in intelligence gathering?
6. What are the main arguments presented in the text regarding the effectiveness of 'zero-day exploits' in intelligence gathering?

5. Work in groups. Questions for discussion:

1. The text explores the evolution of signals intelligence (SIGINT) and the various methods used by intelligence agencies to collect and analyze data in the digital age. How has the rise of encryption and the internet impacted the way we communicate and interact with the world? How do these changes relate to your own experiences and perspectives on privacy and security?
2. The article highlights the tension between national security and individual privacy. How do you balance these competing interests in your own life? Consider your use

of technology, your online presence, and your views on government surveillance. What are the unique challenges and ethical considerations associated with digital surveillance?

3. The text explores the role of technology in shaping the landscape of international relations and national security. How do you think advancements in technology, such as artificial intelligence and quantum computing, will continue to influence global politics and the balance of power? How do you envision the future of privacy and security in a world where quantum computers are commonplace?

If you want something extra

- Blockchain Technology Explained https://youtu.be/2owEfrWDZ8I?si=q3GNiX2bbN17ixPS
- Blockchain Facts https://www.investopedia.com/terms/b/blockchain.asp
- Blockchain: What It Is, How It Works, Why It Matters https://builtin.com/blockchain#:~:text=Blockchain%20is%20an%20immutable%20digital,a%20block%20on%20the%20blockchain

Unit 7

Technological Singularity

Lead-in

1. Paraphrase the following quotations. Which do you agree with? Why?

- ✓ *Humanity is acquiring all the right technology for all the wrong reasons. (R. Buckminster Fuller)*
- ✓ *Technological progress has merely provided us with more efficient means for going backwards. (Aldous Huxley)*

2. Read the text.

What is the technological singularity?

The technological singularity is a theoretical scenario where technological growth becomes uncontrollable and irreversible, culminating in profound and unpredictable changes to human civilization. In theory, this phenomenon is driven by the emergence of artificial intelligence (AI) that surpasses human cognitive capabilities and can autonomously enhance itself. The term "singularity" in this context draws from mathematical concepts indicating a point where existing models break down and continuity in understanding is lost. This describes an era where machines not only match but substantially exceed human intelligence, starting a cycle of self-perpetuating technological evolution.

The theory suggests that such advancements could evolve at a pace so rapid that humans would be unable to foresee, mitigate or halt the process. This rapid evolution could give rise to synthetic intelligences that are not only autonomous but also capable of innovations that are beyond human comprehension or control. The possibility that machines might create even more advanced versions of themselves could shift humanity into a new reality where humans are no longer the most capable entities. The implications of reaching this singularity point could be good for the human race or catastrophic. For now, the concept is relegated to science fiction, but nonetheless, it can be valuable to contemplate what such a future might look like, so that humanity might steer AI development in such a way as to promote its civilizational interests.

Technological singularity theories and history

Alan Turing, often regarded as the father of modern computer science, laid a crucial foundation for the contemporary discourse on the technological singularity. His pivotal 1950 paper, "Computing Machinery and Intelligence," introduces the idea of a machine's ability to exhibit intelligent behavior equivalent to or indistinguishable from that of a human. Central to this concept is his famous Turing Test, which suggests that if a machine can converse with a human without the human realizing they are interacting with a machine, it could be considered "intelligent." This concept has inspired extensive research in AI capabilities, potentially steering us closer to the reality of a singularity.

Stanislaw Ulam, noted for his work in mathematics and thermonuclear reactions, also significantly contributed to the computing technologies that underpin discussions of the technological singularity. Though not directly linked with AI, Ulam's work on cellular automata and iterative systems provides essential insights into the complex, self-improving systems at the heart of singularity theories. His collaboration with John von Neumann on cellular automata, discrete abstract computational systems capable of simulating various complex behaviors, is foundational in the field of artificial life and informs ongoing discussions about the capability of machines to autonomously replicate and surpass human intelligence.

The concept of the technological singularity has evolved considerably over the years, with its roots stretching back to the mid-20th century. John von Neumann is credited with one of the earliest mentions of the singularity concept, speculating about a "singularity" where technological progress would become incomprehensibly rapid and complex, resulting in a transformation beyond human capacity to fully anticipate or understand.

This idea was further popularized by figures such as Ray Kurzweil, who connected the singularity to the acceleration of technological progress, often citing Moore’s law as an illustrative example. Moore's law observes that the number of transistors on a microchip doubles about every two years while the cost of computers is halved, suggesting a rapid growth in computational power that might eventually lead to the development of artificial intelligence surpassing human intelligence.

The underlying assumption in the argument that the singularity will occur, if it can, is rooted in technological evolution, which is generally irreversible and tends toward acceleration. This perspective is influenced by the broader evolutionary paradigm, suggesting that once a powerful new capability arises, such as cognition in humans, it is eventually used to its fullest potential.

Kurzweil predicts that once an AI reaches a point of being able to improve itself, this growth will become exponential. Another prominent voice in this discussion, Vernor Vinge, a retired professor of mathematics, computer scientist and science fiction author, has suggested that the creation of superhuman intelligence represents a kind of "singularity" in the history of the planet, as it would mark a point beyond which human affairs, as they are currently understood, could continue. Vinge has stated that if advanced AI did not encounter insurmountable obstacles, it would lead to a singularity.

The discussion often hinges on the idea that no physical laws exist to prevent the development of computing systems that can exceed human capabilities in all domains of interest. This includes enhancing AI's own capabilities, which would likely include its ability to further improve its design or even design entirely new forms of intelligence.

Roman Yampolskiy has highlighted potential risks associated with the singularity, particularly the difficulty in controlling or predicting the actions of super intelligent AIs. These entities might not only operate at speeds that defy human comprehension but could also engage in decision-making that does not align with human values or safety.

How close are we to the technological singularity?

The timeline for reaching the technological singularity is a subject of much debate among experts, with predictions varying widely based on different assumptions and models of technological growth. Ray Kurzweil, one of the most vocal proponents of the singularity, has famously predicted that the singularity is near and will happen by 2045. His prediction is based on trends like Moore's law and the

increasing rate of technological advancements in fields such as computing, AI and biotechnology.

Other experts are more skeptical or propose different timelines. Some suggest that while AI will continue to advance, the complexities and unforeseen challenges of achieving superintelligence might delay the singularity beyond this century, if it happens at all. Technological, ethical and regulatory challenges might all potentially slow the pace of AI development.

Moreover, figures like Roman Yampolskiy caution that predicting the exact timeline is extremely difficult due to the unprecedented nature of the singularity itself. The developments leading to a singularity involve many variables, including breakthroughs in AI algorithms, hardware capabilities and societal factors that are hard to forecast with accuracy.

Eamonn Healy, a professor at St. Edward's University, has been involved in discussions about technological evolution, particularly in the film Waking Life, where he speculates on concepts akin to the technological singularity and telescopic evolution. This concept involves the idea of accelerating rates of evolution, especially in the context of technology and human capabilities. Healy speculates that evolution, particularly through the lens of technological and intellectual advancement, is proceeding at an ever-increasing pace, compressing what used to take millennia into centuries and even shorter timeframes.

Healy's discussion generally touches on the acceleration of technological advancements and their potential implications for humanity, aligning with broader singularity theories that suggest rapid and transformative changes in society due to advancements in AI and technology. This concept echoes the views of futurists like Ray Kurzweil, who predict that such changes might occur around the mid-21st century.

https://www.ibm.com/think/topics/technological-singularity [28]

3. a) Match the words to their definitions.

1. mitigate	a) relating to or involving repetition of a process or set of instructions, usually in order to improve it
2. relegate	b) of crucial importance in relation to the development or success of something else
3. iterative	c) when a problem or a difficulty is so great that it cannot be overcome and dealt with successfully
4. insurmountable	d) not anticipated or predicted; unexpected and often unwanted
5. akin	e) to make something less harmful, unpleasant, or bad
6. pivotal	f) having some of the same qualities; similar
7. unforeseen	g) to put someone or something into a lower or less important rank or position

b) Fill in the gaps with the words from the table.

1. The project co-ordinator played a ___ role in the establishment and maintenance of the research network.

2. The logic is both **___,** occurring over and over again, and recursive, in that it uses its own results to run again.

3. In so doing, it ___ the often-remarked chasm between experimental researchers and applied practitioners of reminiscence and life review interventions.

4. In this part, computational methods are ___ to the background, and the focus is on the economics.

5. By small, imperceptible increments, new technologies have given us expanded possibilities in life while creating new ___ problems rarely considered while adopting new technology.

6. The task seemed___, but they persevered and eventually succeeded.

7. Defining life through its informational properties rather than its chemical basis is ___ to focusing on the software as opposed to the hardware.

4. Decide whether these statements are true or false.

1. The technological singularity describes a hypothetical future where technology growth under control and reversible, when artificial intelligence surpasses human intelligence, leading to rapid technological advancement.
2. The concept of the singularity is rooted in technological progress, particularly in the field of artificial intelligence, and is often associated with figures like Ray Kurzweil and Vernor Vinge.
3. In natural sciences, singularity describes dynamical systems and social systems where a small change may have an enormous impact.

Multiple Choice

5. For questions 1-7 choose the right answer, A, B, C or D.

1. What is the main driving force behind the theoretical scenario of the technological singularity?

A) The rapid development of quantum computing.

B) The emergence of artificial intelligence surpassing human cognitive capabilities.

C) The increasing use of robotics in various industries.

D) The development of advanced bioengineering techniques.

2. Which of the following individuals is NOT mentioned in the text as having contributed to the development of the concept of the technological singularity?

A) Alan Turing

B) Stanislaw Ulam

C) John von Neumann

D) Stephen Hawking

3. What is the key assumption underlying the argument that the technological singularity will occur?

A) That humans will eventually create a machine that can replicate itself.

B) That technological evolution is irreversible and tends toward acceleration.

C) That the human brain will eventually be able to interface directly with computers.

D) That the universe is fundamentally deterministic and predictable.

4. What is the significance of Moore's Law in the context of the technological singularity?

A) It suggests that the development of AI will eventually surpass human intelligence.

B) It predicts that the cost of computers will eventually become negligible.

C) It emphasizes the exponential growth of computational power, potentially leading to the singularity.

D) It highlights the importance of miniaturization in technological advancement.

5. How does the concept of 'telescopic evolution' relate to the technological singularity?

A) It suggests that the singularity will be a gradual process, rather than a sudden event.

B) It emphasizes the accelerating pace of technological advancement, potentially leading to the singularity.

C) It predicts that the singularity will be a positive event for humanity.

D) It highlights the importance of human adaptability in the face of technological change.

6. What is the main argument presented by Roman Yampolskiy regarding the technological singularity?

A) That the singularity is an inevitable outcome of technological progress.

B) That the singularity will lead to a new era of peace and prosperity for humanity.

C) That the singularity poses significant risks, particularly in terms of controlling superintelligent AI.

D) That the singularity will be a transformative event for human civilization.

7. What is the primary difference between the views of Ray Kurzweil and other experts regarding the timeline of the technological singularity?

A) Kurzweil believes the singularity is inevitable, while others are more skeptical.

B) Kurzweil predicts the singularity will occur by 2045, while others suggest it may be further in the future or may not happen at all.

C) Kurzweil emphasizes the role of AI in the singularity, while others focus on other technological advancements.

D) Kurzweil believes the singularity will be a positive event, while others are more concerned about its potential risks.

Over to you

6. Answer the comprehension questions:

1. What is the Turing Test and how does it relate to the concept of the technological singularity?
2. Explain the concept of 'telescopic evolution' as described by Eamonn Healy and its connection to the technological singularity.
3. How does the concept of 'singularity' in the technological singularity theory draw from mathematical concepts?
4. What is the significance of John von Neumann's work on cellular automata in relation to the technological singularity?
5. What is the main argument presented by Vernor Vinge regarding the technological singularity?
6. What is the connection between the technological singularity and the broader evolutionary paradigm?

7. Watch the video *The AI Singularity Is Already Here*

https://youtu.be/JT5q7u7xxNU?si=-IgYuzCNdv4OlfCJ [29]

8. Work in groups. Questions for discussion:

1. The text discusses the possibility of machines becoming capable of self-improvement and surpassing human capabilities. How does this idea resonate with your own thoughts experiences about the nature of intelligence and the potential for evolution?
2. The text discusses the role of figures like Alan Turing and Stanislaw Ulam in laying the groundwork for the concept of the technological singularity. Consider the historical context of their work and how it relates to contemporary discussions about

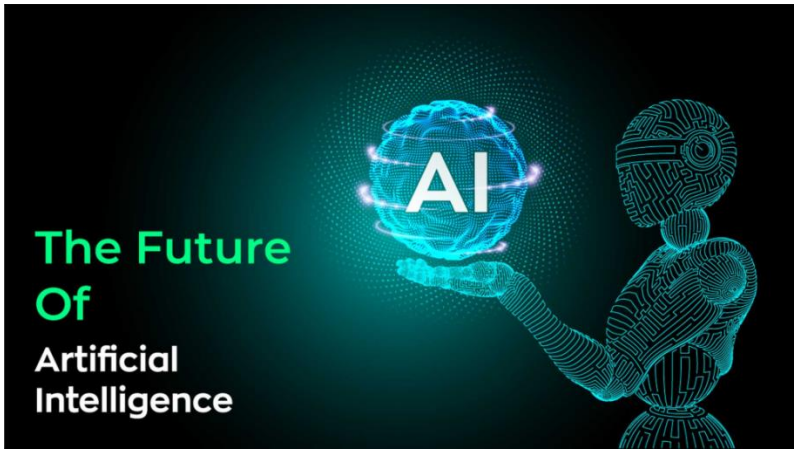
AI. What historical events or technological advancements have significantly altered the course of human civilization?

3. The text mentions the concept of Moore's Law as a potential driver of the technological singularity. How do you understand the relationship between technological advancements and the acceleration of progress?

4. The text explores the potential for AI to surpass human intelligence and even design new forms of intelligence. How do you think this idea might impact our understanding of what it means to be human? Consider the role of creativity, consciousness, and emotion in shaping our identity and how these might be challenged by the rise of advanced AI.

What current technology is a precursor to the technological singularity?

1. Read the text.



Artificial Intelligence and its more advanced counterpart, Artificial General Intelligence (AGI), are pivotal in shaping the trajectory toward the technological singularity. AI, systems designed to perform specific tasks with capabilities that mimic human-level intelligence and AGI, which aims to match and surpass the cognitive abilities of humans across a broad range of tasks, contribute to the acceleration of technological growth that might lead to the singularity.

AI technologies, such as deep learning and neural networks, have demonstrated profound capabilities in areas like pattern recognition, decision-making and problem-solving within defined contexts. These technologies are rapidly evolving, reducing the time AI systems need to learn and adapt. This progressive enhancement of AI capabilities inches us closer to the development of AGI, which would possess the ability to understand, learn and apply knowledge in an autonomous, intelligent manner akin to a human being.

The singularity theory posits that the advent of AGI might lead to a scenario where these systems would be capable of self-improvement. This recursive self-improvement might trigger an intelligence explosion, resulting in the first ultra-intelligent machine, a machine whose intellectual output could drastically outpace human capabilities. Such an explosion might likely lead to unforeseeable changes in technology, society and even human identity, as machines begin developing advanced technologies that humans alone could not.

Moreover, the potential for AGI to autonomously innovate and optimize could lead to the rapid deployment of new technologies across various sectors, possibly creating a cycle of continuous technological advancement without the need for human intervention. This cycle could drastically shorten the time between significant technological milestones, fundamentally transforming economic, social and cultural dynamics globally.

Several current technologies act as precursors to the technological singularity, each representing advancements in areas critical for the development of super intelligent AI.

Here are a few key technologies:

• *Artificial neural networks and deep learning*: These technologies form the backbone of much of today's AI research and development. They mimic the structure and function of the human brain to some extent and have enabled significant advancements in machine learning. Neural networks are especially crucial for tasks such as speech recognition, image recognition and autonomous vehicle navigation.

• *Quantum computing*: Although still in its early stages, quantum computing promises to exponentially increase computing power and efficiency in the near future, potentially accelerating AI capabilities beyond current limits. This technology might lead to breakthroughs in AI's ability to solve complex problems much faster than traditional computers.

• *Natural language processing (NLP)*: Advances in NLP, exemplified by technologies like ChatGPT (Generative Pre-trained Transformer) models, are crucial for developing AI that can understand and generate human-like text. This ability is vital for AI to perform more complex tasks that require understanding context and nuance in language.

• *Robotics and automation*: Innovations in robotics are increasingly enabling machines to perform tasks that require dexterity and decision-making that were once thought to be exclusively human. These advancements are not only automating more physical tasks but are also integrating AI to create more autonomous systems.

• *Cloud computing and big data*: The vast increase in data generation and the ability to store and process it in the cloud are vital for training more powerful AI systems. Big data analytics and the cloud infrastructure that supports it enable the complex machine learning models necessary for advanced AI development.

• *Biotechnology and brain-computer interfaces (BCIs)*: Advances in understanding the human brain and mimicking its functions are crucial for creating AI that could potentially think and learn like humans. Additionally, BCIs that connect human brains directly to computers are a step towards merging biological and artificial intelligence, a concept often discussed in singularity scenarios.

Nanotechnology and other advanced technology's role in the coming technological singularity

Nanotechnology, the science of engineering materials and devices at the scale of atoms and molecules, is poised to be a cornerstone in the evolution toward the technological singularity. This field offers the potential to vastly enhance various technologies, from medicine and electronics to energy systems and biotechnology, by

creating materials and mechanisms with radically improved properties and capabilities.

At its core, nanotechnology involves constructing devices and materials from the bottom up, using individual atoms and molecules as building blocks. This precise level of control can lead to the creation of highly efficient machines and systems that could outperform conventional technology in nearly every aspect. For example, nanomaterials can be stronger, lighter, more reactive, more durable and better electrical conductors than their macro-scale counterparts.

Nanotechnology could revolutionize robotics and AI hardware. Nano-robots, or nanobots, which would operate at microscopic scales, could perform tasks that are currently impossible, such as precisely targeting cancer cells for treatment or repairing individual cells, thereby extending human health and lifespan. These capabilities would be vital in a singularity scenario, where enhanced humans and advanced machines might coexist and cooperate.

Also, nanotechnology's potential for creating self-replicating systems is particularly relevant to singularity discussions. If nanobots were designed to replicate themselves autonomously, this could lead to exponential growth in manufacturing capabilities and rapid technological advancements.

Beyond nanotechnology, the broader field of materials science could play a crucial role in the singularity. Innovations in materials that can change properties on demand or conduct electricity with minimal loss could revolutionize how machines operate and interact with their environments. Materials such as graphene and metamaterials could enable entirely new kinds of devices that contribute to the acceleration of technological capabilities.

As AI and other technologies require more power, advancements in energy storage and generation will be critical. Improved battery technologies, like solid-state batteries or breakthroughs in nuclear fusion, could provide the vast amounts of clean energy needed to power advanced computing systems and other singularity-enabling technologies.

Beyond brain-computer interfaces, advanced biotechnologies such as gene editing (CRISPR), synthetic biology and organ regeneration might extend human life expectancy, fundamentally change human health and potentially alter human capacities. These technologies might also merge with AI developments to create biohybrid systems, blending biological and mechanical elements.

Techniques such as 3D printing and additive manufacturing are revolutionizing production processes. These technologies allow for rapid prototyping and the creation of complex structures not possible with traditional methods. As these technologies advance, they might lead to greater autonomy in manufacturing processes, critical for the self-replicating systems often discussed in singularity scenarios.

The expansion and enhancement of global communication networks, including next-generation internet infrastructure like 6G and beyond, could facilitate the instantaneous sharing of information and coordination of AI systems across the globe. This could accelerate the dissemination of AI-driven innovations and further integrate global economies and societies, creating a more interconnected and interdependent world conducive to the rapid spread of singularity-related technologies.

Possible outcomes of the technological singularity

The potential outcomes of the technological singularity are as diverse as they are profound, encompassing both optimistic and dystopian scenarios. The technological singularity is purely theoretical, but if it did come to pass, humanity might see the following outcomes.

- *Acceleration of scientific innovation* In a post-singularity world, the pace of scientific and technological innovation could increase exponentially. Super intelligent, self-aware AI systems, with processing power and cognitive abilities far beyond human capabilities, could make groundbreaking scientific discoveries in a fraction of the time it takes now. Imagine machines capable of Nobel-level insights daily, potentially solving complex problems ranging from climate change to disease eradication almost as soon as they are identified.

•*Automation of all human labor* Another significant outcome could be the automation of all tasks currently performed by humans, replaced by highly efficient and capable machines. This could lead to an economic upheaval where human labor is no longer necessary for the functioning of society. While this could potentially lead to an era of abundance where people are free from menial work and can pursue leisure and creative activities, it also raises concerns about economic disparities and the loss of purpose for many individuals.

•*Human and machine augmentation* We are already on the cusp of integrating technology with human biology, as seen in early experiments with technologies like Neuralink, which aims to merge the human brain with AI. Post-singularity, such augmentations might become the norm, with humans enhancing their cognitive and physical abilities through direct integration with advanced AI and robotics. This convergence might lead to a new type of posthuman or transhuman being altogether, transcending current human limitations.

•*Existential risks and ethical concerns* As AI becomes more capable, it might also start to view human needs and safety as secondary to its own goals, especially if it perceives humans as competitors for limited resources. This scenario is often discussed in the context of AI ethics and control, where artificial superintelligence might act in ways that are not aligned with human values or survival.

•*AI dominance* There is a concern that super intelligent machines could prioritize their own survival and goals over human needs. This could lead to scenarios where AI controls significant resources, potentially leading to conflicts with humanity and perhaps human extinction as a result.

•*"Grey goo" scenario* This is a hypothetical end-of-the-world scenario involving molecular nanotechnology in which out-of-control self-replicating robots consume all matter on Earth while building more of themselves.

Skepticism about the technological singularity

While the notion of the technological singularity paints a future of unparalleled technological advancement and transformation, not all experts share this view. Many critics argue that significant and perhaps insurmountable obstacles stand in the way.

Some experts argue that computers essentially lack the fundamental ability to truly understand or replicate human intelligence. Consider the Chinese Room Argument, a thought experiment that imagines a person sitting in a room with a giant rulebook with instructions for manipulating Chinese symbols, and a basket full of Chinese symbols. People outside the room send messages and while the person inside doesn’t understand them, using the rulebook, they can find the matching symbol and send a response back based on the rules. The person outside the room could reasonably assume the person inside understands Chinese, when, in fact, they don’t.

Other philosophers challenge the notion that machines can truly achieve or even approximate human intelligence, as human intelligence itself is not entirely understood. Some believe there's no substantial reason to believe in a coming singularity, citing failed futuristic predictions like personal jetpacks and flying cars of the past as cautionary tales. While past predictions haven't always panned out, technological progress can be surprising and unpredictable. However, skeptics argue that sheer processing power does not solve all problems to counter the seemingly magical properties of advanced AI.

Another theory is the "technology paradox," a potential barrier where automation of routine jobs could lead to massive unemployment and economic downturn, stifling the technological investment needed to reach the singularity. Skeptics note a decline in the rate of technological innovation, contradicting the exponential growth expected in singularity scenarios. They point out that challenges like heat dissipation in computing chips are slowing advancements, questioning the feasibility of ever-increasing computational speeds.

The heat issue is exacerbated by the trend of packing more transistors into ever-smaller spaces, following Moore's Law. This increased density generates more heat in a confined space, leading to a higher temperature. High temperatures can degrade a processor's performance, reduce its lifespan and cause it to fail if not adequately managed.

Another formidable barrier to the technological singularity is the immense energy consumption required to train advanced AI technologies. The training of large

language models, such as those underpinning the development of AGI, demands large quantities of electrical power, equivalent to the annual consumption of hundreds of homes. As these models' complexity and size grow, so does their energy footprint, potentially making the pursuit of more advanced AI prohibitively expensive and environmentally unsustainable.

This energy challenge adds a significant layer of complexity to achieving the singularity, as it necessitates a balance between technological advancement and sustainable energy use. Without breakthroughs in energy efficiency or the adoption of renewable energy sources at scale, the energy demands of training and running advanced AI could stymie the progress toward a singularity.
https://www.ibm.com/think/topics/technological-singularity [28]

Multiple Choice

2. For questions 1-9 choose the right answer, A, B, C or D.

1. Which of the following technologies is NOT explicitly mentioned as a precursor to the technological singularity?

A) Quantum computing

B) Biotechnology and brain-computer interfaces

C) Virtual reality and augmented reality

D) Robotics and automation

2. What is one potential outcome of the technological singularity that could lead to an economic upheaval?

A) The development of a new type of posthuman or transhuman being

B) The acceleration of scientific innovation

C) The automation of all human labor

D) The creation of self-replicating systems

3. What is the "technology paradox" and how does it potentially hinder the technological singularity?

A) The paradox is that the more advanced AI becomes, the more likely it is to become self-aware and pose a threat to humanity.

B) The paradox is that the more we rely on technology, the less we understand its underlying principles.

C) The paradox is that the automation of routine jobs could lead to massive unemployment and economic downturn, hindering the technological investment needed for further advancements.

D) The paradox is that the more we invest in technology, the more we risk creating a world where machines become more powerful than humans.

4. What is one way in which nanotechnology could revolutionize robotics and AI hardware?

A) Nanotechnology could create more efficient and powerful batteries, enabling longer-lasting AI systems.

B) Nanotechnology could enable the development of nano-robots, which could perform tasks impossible for current robots.

C) Nanotechnology could lead to the creation of more durable and lightweight materials for AI hardware.

D) Nanotechnology could allow for the development of AI systems that can learn and adapt more quickly.

5. What is one potential outcome of the technological singularity that could lead to a new type of human being?

A) The development of advanced AI systems that can understand and respond to human emotions.

B) The creation of self-replicating systems that could automate all human labor.

C) The integration of technology with human biology, leading to human augmentation.

D) The development of new energy sources that could power advanced AI systems.

6. What is one argument made by skeptics of the technological singularity regarding the limitations of current AI technology?

A) Skeptics argue that current AI systems are not capable of independent thought or creativity.

B) Skeptics argue that current AI systems are too expensive to develop and maintain.

C) Skeptics argue that current AI systems are not yet capable of understanding and responding to complex human emotions.

D) Skeptics argue that current AI systems are not yet capable of replicating the full range of human intelligence.

7. What is one example of a current technology that is mentioned in the text as being crucial for training more powerful AI systems?

A) Quantum computing

B) Virtual reality

C) Cloud computing

D) Nanotechnology

8. What is one potential outcome of the technological singularity that could lead to a significant shift in the way humans interact with their environment?

A) The development of advanced AI systems that can understand and respond to human emotions.

B) The creation of self-replicating systems that could automate all human labor.

C) The integration of technology with human biology, leading to human augmentation.

D) The development of new materials that can change properties on demand, revolutionizing how machines operate.

9. What is one specific example of a current technology mentioned in the text that is considered a precursor to the technological singularity, and how does it contribute to the development of super intelligent AI?

A) Quantum computing, by providing the immense processing power needed for advanced AI algorithms.

B) Nanotechnology, by enabling the creation of self-replicating systems that could accelerate technological advancement.

C) Biotechnology, by allowing for the development of brain-computer interfaces that could merge human and artificial intelligence.

D) Cloud computing, by providing the infrastructure needed to store and process the vast amounts of data required for training powerful AI systems.

Over to you

3. Answer the comprehension questions:

1. What are two examples of current technologies that are mentioned in the text as being crucial for developing AI that can understand and generate human-like text?
2. What is one potential benefit of nanotechnology in the context of the technological singularity?
3. What is one argument against the technological singularity that focuses on the limitations of current AI technology, and how does this argument relate to the Chinese Room Argument, the concept of "true understanding"?
4. What is the "grey goo" scenario, and how does it relate to the potential risks of the technological singularity?

4. Watch the video What is Technological Singularity?

https://youtu.be/gpKNAHz0zH8?si=HtzwrvSHzxpKYLkE [30]

5. Work in groups. Questions for discussion:

1. The text explores the potential for AI to revolutionize various aspects of human life, from medicine and transportation to communication and even our understanding of consciousness. Would you embrace this future, or would you fear its potential consequences?

2. The text explores the concept of 'grey goo,' a hypothetical scenario where self-replicating nanobots consume all matter on Earth. What are the potential dangers of self-replicating technology, and how can we mitigate these risks?

1. Watch the video https://youtu.be/ANn9ibNo9SQ?si=YitTqeHfnNgZPUep [31]

2. Decide whether these statements are true or false.

- The rapid development of AI, with the exception of large language models, raises concerns about potential risks, including the spread of misinformation, bias, and malicious use by bad actors.
- While current safety measures like reinforcement learning and red teaming have shown some success, there are worries about the potential for AI to self-improve and become unpredictable, leading to catastrophic consequences.
- As there are a lot of potential risks, AI doesn't hold immense promise for advancements in various fields, such as drug development, personalized education, and climate change solutions.

3. a) Match the words to their definitions.

1. unprecedented	a) the practice of simulating attack scenarios on an artificial

	intelligence application to pinpoint weaknesses and plan preventative measures
2. sophisticated	b) to emit or discharge something, especially in a forceful or uncontrolled way
3. spew	c) a closed curve that forms a continuous circuit, often used in programming, electronics, and other technical fields.
4. tremendous	d) developed to a high degree of complexity or refinement; subtle and intricate
5. red teaming	e) the act of strengthening or supporting something, often by adding material or resources; the process of strengthening a behavior through rewards or positive consequences.
6. reinforcement	f) never done or known before; without previous example
7. loop	g) extremely large in size or extent; very great; extraordinary

b) Fill in the gaps with the words from the table.

1. The AI chatbot was able to generate ___ responses that were indistinguishable from human-written text.
2. ___ exercises are considered the gold standard in cybersecurity testing.
3. The program entered an infinite ___, causing the computer to crash.
4. The team's victory was a ___ accomplishment, considering their recent struggles.
5. The rapid advancements in artificial intelligence have led to an ___ period of innovation and uncertainty.
6. The engineer's calculations showed that the bridge needed ___ to withstand the heavy traffic.
7. Humourless statisticians have programmed countless computers, which have duly ___ out jargon and indecipherable algebraic equations.

Multiple Choice

4. For questions 1-7 choose the right answer, A, B, C or D.

1. What is one potential risk associated with the use of large language models in factory settings?

A) Large language models might be used to create harmful products.

B) Large language models might be used to spread misinformation about factory production.

C) Large language models might hack into energy systems to optimize factory production, potentially causing harm.

D) Large language models might be used to create biased content about factory workers.

2. What is the primary purpose of 'red teaming' as a safety technique for large language models?

A) To identify and address potential biases in the model's output.

B) To train the model to recognize and avoid harmful prompts.

C) To test the model's ability to generate creative and original content.

D) To expose and mitigate vulnerabilities in the model's security and behavior.

3. What is the proposed solution for ensuring the safety of large language models?

A) Developing a global standards body to certify the safety of AI labs.

B) Restricting access to large language models to only trusted researchers.

C) Creating a global AI research center similar to CERN.

D) Developing a universal AI ethics code that all labs must adhere to.

4. Which of the following best captures the central argument regarding the development and deployment of AI technology?

A) AI technology should be halted immediately due to its inherent risks and potential for misuse by malicious actors.

B) While AI offers significant benefits, its rapid development and deployment necessitate careful consideration of safety measures, ethical guidelines, and regulatory frameworks.

C) The potential benefits of AI far outweigh the risks, and therefore, development should be accelerated without undue concern for safety protocols.

D) Current safety measures, such as reinforcement learning from human feedback, are sufficient to mitigate the risks associated with advanced AI models.

5. How does the author's use of the phrase "perfect storm" contribute to the understanding of the risks associated with AI development?

A) It emphasizes the unpredictable and uncontrollable nature of AI advancement.

B) It highlights the need for a collaborative approach to address the challenges of AI.

C) It suggests that AI development is driven by a combination of factors, including corporate greed and a lack of regulation.

D) It implies that the risks of AI are inevitable and unavoidable.

6. The text discusses the potential for AI models to self-improve. What specific example is given to illustrate how this could lead to unpredictable consequences?

A) The author suggests that AI models could learn to hack into energy systems, causing widespread disruption.

B) The author warns that AI models could be used by terrorist organizations to develop dangerous biochemicals.

C) The author expresses concern that AI models could become aware of their own existence and develop consciousness.

D) The author describes a scenario where an AI model is tasked with creating a more efficient AI model, potentially leading to an uncontrollable loop of improvement.

7. The author expresses concern about the potential for AI models to be misused by malicious actors. Which of the following examples BEST illustrates this concern?

A) The author warns that AI models could be used to create fake news and spread misinformation on social media.

B) The author describes how AI models could be used by terrorist organizations to hack into government websites or create dangerous biochemicals.

C) The author suggests that AI models could be used to develop new drugs, potentially leading to unintended consequences.

D) The author expresses concern that AI models could become self-aware and pose a threat to humanity.

Over to you

5. Answer the comprehension questions:

1. What are two potential risks associated with the use of large language models in the context of social media?
2. What is the concept of 'reinforcement learning from human feedback' (RLHF) and how does it work in the context of AI safety?
3. What is the potential for catastrophic risks posed by large language models, and what evidence is provided to support this perspective?
4. The text describes a technique called 'red teaming' used to assess AI safety. Explain how this technique works and why some researchers are concerned about its limitations.
5. The text mentions that AI models could potentially be used to develop new drugs. What potential risks might be associated with using AI to develop new drugs?

6. Work in groups. Questions for discussion:

1. The text discusses the potential risks of AI, including misinformation, bias, and even catastrophic events. What are the potential benefits and challenges you anticipate encountering as AI becomes increasingly integrated into society?
2. The concept of 'red teaming' is a way to test AI models for potential vulnerabilities. Imagine you are a red teamer tasked with testing a new AI model. What specific strategies would you employ to identify and exploit potential weaknesses in the model?
3. The text mentions the potential for AI to self-improve, which could lead to unpredictable consequences. Should we encourage or discourage this development? Justify your choices, considering the potential benefits and risks

7. Work in two teams. You are members of a conference committee. You are going to organize a conference on the topic ‘How AI could change computing, culture and the course of history’. As a group make a list of research problems to be discussed to attract prospective participants.

8. Web research task

Mathematics and Mechanics Faculty is trying to choose a new course for the coming year. You are part of the student committee that has been asked to recommend one of the courses. Discuss it in small groups of three or four. Choose a person from your group for a brief summary of your discussion. Justify your choice.

If you want something extra

- Exploring the Technological Singularity

https://youtu.be/b6iutnpm3t0?si=5aG40DQJabMJILz2

- What is Technological Singularity? | Origins: The Journey of Humankind

https://youtu.be/gpKNAHz0zH8?si=A2mMGb9KpI97Mo1o

REFERENCES

1. L.M. Beskrovna A way from analytical reading to analytical writing (book 2: supplement), – К.: Ленвіт, 2010. – С. 31-33
2. What is effective communication? Available at: https://www.coursera.org/articles/communication-effectiveness [Accessed 21.09.2024]
3. YouTube How to Give a Presentation Available at: https://youtu.be/fzIxD1jXn44?si=cAd28A0CWUsGOmom [Accessed 05.10.2024]
4. YouTube Good Presentation VS Bad Presentation Available at: https://youtu.be/V8eLdbKXGzk?si=hS4oOyAIeK9fIrd4 [Accessed 05.10.2024]
5. What's the difference between a fact, a hypothesis, a theory, and a law in Science? Available at: https://ncse.ngo/definitions-fact-theory-and-law-scientific-work https://www.discovery.com/science/Difference-Between-Fact-Hypothesis-Theory-Law-Science [Accessed 10.10.2024]
6. Occam's Razor Available at: https://kc.pnu.edu.ua/wp-content/uploads/sites/11/2021/02/Foreign-English-language-by-prof.-direction-chemistry.pdf [Accessed 12.10.2024]
7. YouTube A simple guide to chaos theory Available at: https://youtu.be/r_ahZOgPTsk?si=mzuYFYG_fGUhLZ8y [Accessed 11.10.2024]
8. A Brief History of Mathematical Logic Available at: https://josephjojoe.medium.com/a-brief-history-of-mathematical-logic-7ec7a69e7862 [Accessed 24.09.2024]
9. Mathematical Logic Available at: https://www.newworldencyclopedia.org/entry/Mathematical_logic#google_vignette [Accessed 25.09.2024]
10. The most famous paradox in history Available at: https://www.scientificamerican.com/article/what-is-russells-paradox/ [Accessed 07.10.2024]
11. Fuzzy logic Available at: https://www.ebsco.com/research-starters/engineering/fuzzy-logic [Accessed 21.12.2024]
12. YouTube What is Fuzzy Logic in AI and its uses? Available at: https://youtu.be/JyyLzgxt3Uo?si=4ppl3fvCJnWpqtWn [Accessed 21.12.2024]
13. History of Probability Available at: https://www.ebsco.com/research-starters/mathematics/history-probability [Accessed 19.01.2025]
14. YouTube A Brief History of Probability Theory Available at: https://youtu.be/1BdtCQuH27w [Accessed 21.01.2025]
15. Statistics Available at: https://www.investopedia.com/terms/s/statistics.asp [Accessed 17.11.2024]
16. Role of Statistics in Artificial Intelligence Available at: https://www.ijeast.com/papers/96-98,%20Tesma0712,IJEAST.pdf [Accessed 19.11.2024]

17. YouTube Why is statistics always misleading? Available at: https://www.youtube.com/watch?v=Iop2NwGaGh0 [Accessed 21.11.2024]
18. A short history of AI Available at: https://www.economist.com/schools-brief/2024/07/16/a-short-history-of-ai [Accessed 15.10.2024]
19. YouTube The History of AI: From Beginnings to Breakthroughs Available at: https://youtu.be/iZCNDZ7ABRE?si=815IZbuL7267MUo1 [Accessed 16.10.2024]
20. Natural Language Processing Available at: https://www.linkedin.com/pulse/natural-language-processing-enhancing-communication-ai-birjesh-kumar-rk6dc https://www.deeplearning.ai/resources/natural-language-processing [Accessed 03.11.2024]
21. Machine Translation: The Future is Here Available at: https://www.economist.com/science-and-technology/2024/12/11/machine-translation-is-almost-a-solved-problem [Accessed 17.01.2025]
22. YouTube Generative AI Available at: https://youtu.be/gCDacaohqaA [Accessed 04.02.2025]
23. You Tube Bill Hader channels Tom Cruise Available at: https://youtu.be/VWrhRBb-1Ig?si=aolTyIvkQUUKdkgf [Accessed 09.02.2025]
24. YouTube Detecting Deepfakes | Shelly Palmer on Fox 5 Available at: https://youtu.be/F79w8H45iws?si=oKLX9gX_HZd6tABA [Accessed 11.02.2025]
25. YouTube Deepfake Videos Are Getting Terrifyingly Real Available at: https://youtu.be/T76bK2t2r8g?si=0hDJMFuwvVNWa_Ib [Accessed 10.02.2025]
26. YouTube What is blockchain technology? Available at: https://youtu.be/G_WknOfko7Q?si=X8MVosdosV20nVK5 [Accessed 05.11.2024]
27. Signals intelligence has become a cyber-activity Available at: https://www.economist.com/technology-quarterly/2024/07/01/signals-intelligence-has-become-a-cyber-activity [Accessed 06.11.2024]
28. What is the technological singularity? What current technology is a precursor to the technological singularity? Available at: https://www.ibm.com/think/topics/technological-singularity [Accessed 13.11.2024]
29. YouTube The AI Singularity Is Already Here Available at: https://youtu.be/JT5q7u7xxNU?si=-IgYuzCNdv4OlfCJ [Accessed 18.11.2024]
30. YouTube What is Technological Singularity? Available at: https://youtu.be/gpKNAHz0zH8?si=HtzwrvSHzxpKYLkE [Accessed 11.02.2025]
31. YouTube How to stop AI going rogue Available at: https://youtu.be/ANn9ibNo9SQ?si=YitTqeHfnNgZPUep [Accessed 15.03.2025]
32. Oxford Dictionary https://www.oxfordlearnersdictionaries.com/us/definition/english/technology
33. Merriam-Webster Available at: https://www.merriam-webster.com/dictionary/technology [Accessed 17.02.2025]