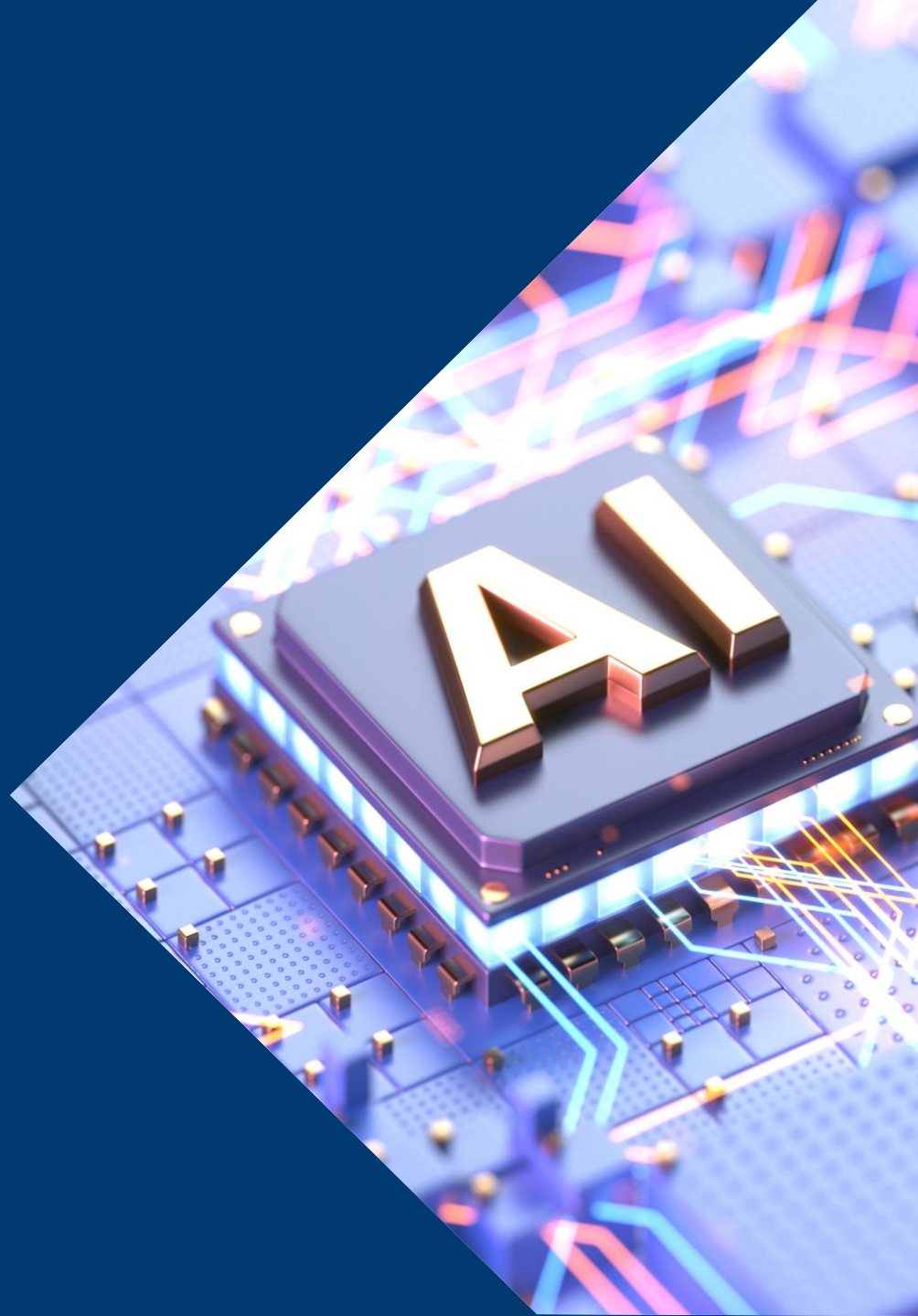
ECT
Engineering College of Technology.

AI & Electrical Engineering & Industrial Automation

A Practical Toolbox of Skills for the Next Decade

Watch Webinar Recording Here

Steve Mackay PhD



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Introduction – Presenter

Steve Mackay

ECT & EIT Chief Engineering Officer

Steve

FIE(Aust) CPEng GCC BSc (ElecEng), BSc (Hons), MBA, MMR, PhD

How entrepreneurship and resilience define me.

- My passion for engineering and education has led me into many entrepreneurial ventures.
- My curiosity drives me to study and learn every day – AI is a key tool.
- This love for education means that I truly admire high quality teaching and dedicated teachers who put students at the centre of all they do.
- Through my career I have overcome a huge number of failures and set backs and I believe my resilience has assisted me through these times; it has enabled me to look ahead with optimism.
- As we face unprecedented weather extremes our communal resilience is being tested. I believe tackling population growth, weak economies, pollution, exploitation and climate change will present our greatest engineering challenges and opportunities.

About ECT

We are dedicated to ensuring that you receive a world-class education and gain skills that you can immediately apply in the workforce.

Engineering Specialists

ECT - affiliated to the well-established Engineering Institute of Technology (EIT) - is an engineering education specialist. ECT delivers bachelor's and master's degrees.

Industry-Driven Programs

Our programs are designed by industry experts, ensuring you graduate with cutting-edge skills that are valued by employers. Our program content remains current with rapidly changing technology and industry developments.

UK Recognised Education

ECT is OfS registered and accredited, meeting the Office for Students' requirements for course quality, academic standards, student support and student protection.

Lecturers and Instructors

Our teachers are subject specialists with industry experience and the requisite academic qualifications. The online platform allows ECT to source them from a large, global pool of expertise.

Unique Delivery Model

We deliver our programmes via a unique delivery methodology that makes use of live and interactive tutorials, an international pool of expert lecturers, dedicated learning support officers, hands-on workshops and state-of-the-art remote labs connected to real equipment, and simulation software.

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We are going to interact vigorously with you

- We DO NOT have the time to go through every slide – these are a resource for you and worth critiquing at your convenience.

- We love your feedback – good and bad – we all learn together.

Agenda

1	Today’s objective
2	Why AI Matters for Engineers
3	Fundamentals of AI, Machine Learning and LLMs
4	Applications and Case Studies
5	AI Design Pitfalls to Manage
9	Wrap Up

1. Today's Objective

Explore how Artificial Intelligence (AI) - and Machine Learning (ML) are both being harnessed by industry and how these technologies can empower you to drive change in a sustainable ways in engineering in electrical engineering and industrial automation.

What you will gain:

- Clear understanding of AI and ML applied to electrical and industrial automation engineering
- Strategies for integrating AI into your work

Q1 - What is your current job title? (enter into the text box)

2. Why AI Matters for Engineers

- AI adoption is accelerating across every major industrial sector
  - ML for load forecasting and protection tuning
  - Oil & gas - AI for predictive maintenance and drilling optimization
  - Mining - AI to reduce downtime and improve plant throughput
- Engineers work with data-driven systems
  - SCADA/PLC systems produce millions of datapoints per day
  - Identify anomalies, inefficiencies and early-stage faults
- AI boosts engineering productivity (20–40% ?)
  - Faster design iterations
  - Automated documentation and report generation
  - More accurate troubleshooting using AI-assisted diagnostics
- AI reduces risk and improves safety
  - Early detection of arc-flash conditions, vibration anomalies, thermal hotspots
  - Intelligent alarm reduction cuts human error by up to 70%
- AI is becoming a core engineering competency—not optional
  - Industry expects engineers who can integrate AI with OT systems
  - Those who don’t adapt will be left

Capabilities to Build

1. Data & Analytics Literacy
   - Extract, clean, and interpret sensor, PLC and historian data
   - Understand time-series analysis and anomaly detection
2. AI-Assisted Engineering Design
   - Use AI to draft ladder logic, P&IDs, protection settings, control strategies
   - Apply AI to optimise power system and process control models
3. AI + OT Integration
   - Deploy AI at the edge
   - Connect ML models to PLC/SCADA via OPC UA or MQTT
4. Verification & Engineering Judgement
   - Validate AI outputs using standards (IEC/AS), physics, and calculations
   - Recognise hallucinations, incorrect assumptions, and unsafe logic
5. Automation of Routine Engineering Tasks
   - AI-based report generation
   - Fault code explanation
   - Alarm grouping
   - Data summarisation
6. Ethics & Cybersecurity
   - Handle data safely
   - Ensure AI does not compromise critical infrastructure
   - Understand IP, data sovereignty, and auditability

AI Limitations

- Lacks deep physics
- Not always accurate
- Cannot replace safety
- Needs verification

Engineer’s Reality in 2025

- Explosion in sensor data
- Rising complexity: smart grids & Industry 4.0
- Labour shortages
- AI boosts productivity but needs critical view

AI Risks

- Over-reliance
- Faulty recommendations
- Cybersecurity
- IP leakage

Safe Use Framework

- Validate with calcs
- Check standards
- Simulate
- Pilot first
- Document

What AI Means in Engineering

- Machine learning
- Deep learning
- LLMs
- Computer vision
- Optimisation algorithms
- Digital twins

Career Boost

- Faster workflows
- Better troubleshooting
- Predictive maintenance
- Competitive advantage

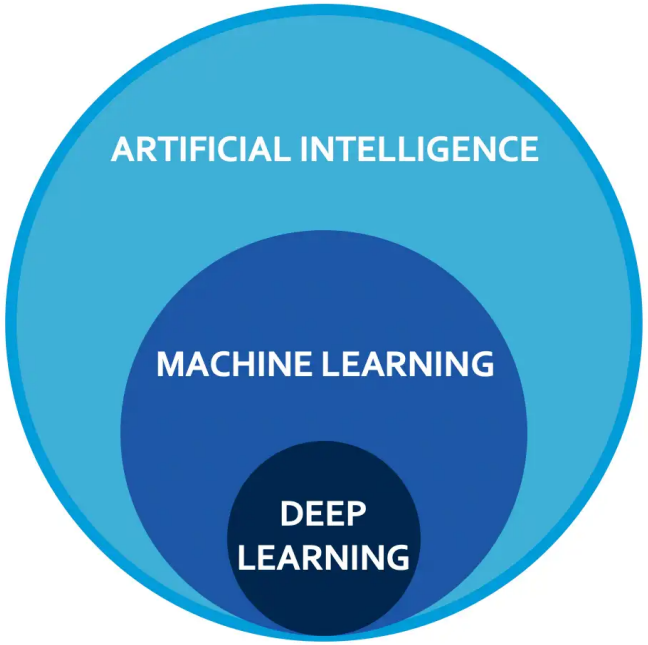
AI Strengths for Engineers

- Pattern detection
- Predictive modelling
- Code generation
- Fault classification
- Control optimisation
- Documentation

Future of AI in Automation

- Autonomous control rooms
- Generative PLC systems
- Self-tuning grids
- Full digital twins

3. Fundamentals of AI, Machine Learning & LLMs



Artificial Intelligence
The science of making machines smarter, which in turn augments human knowledge and capabilities.

Machine Learning
Application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience.

Deep Learning
The next generation of machine learning that employs multiple layers of learning from massive data-sets.

Chatbots and Conversational AI
AI Natural language processing and deep learning helps give users factoids based on their queries

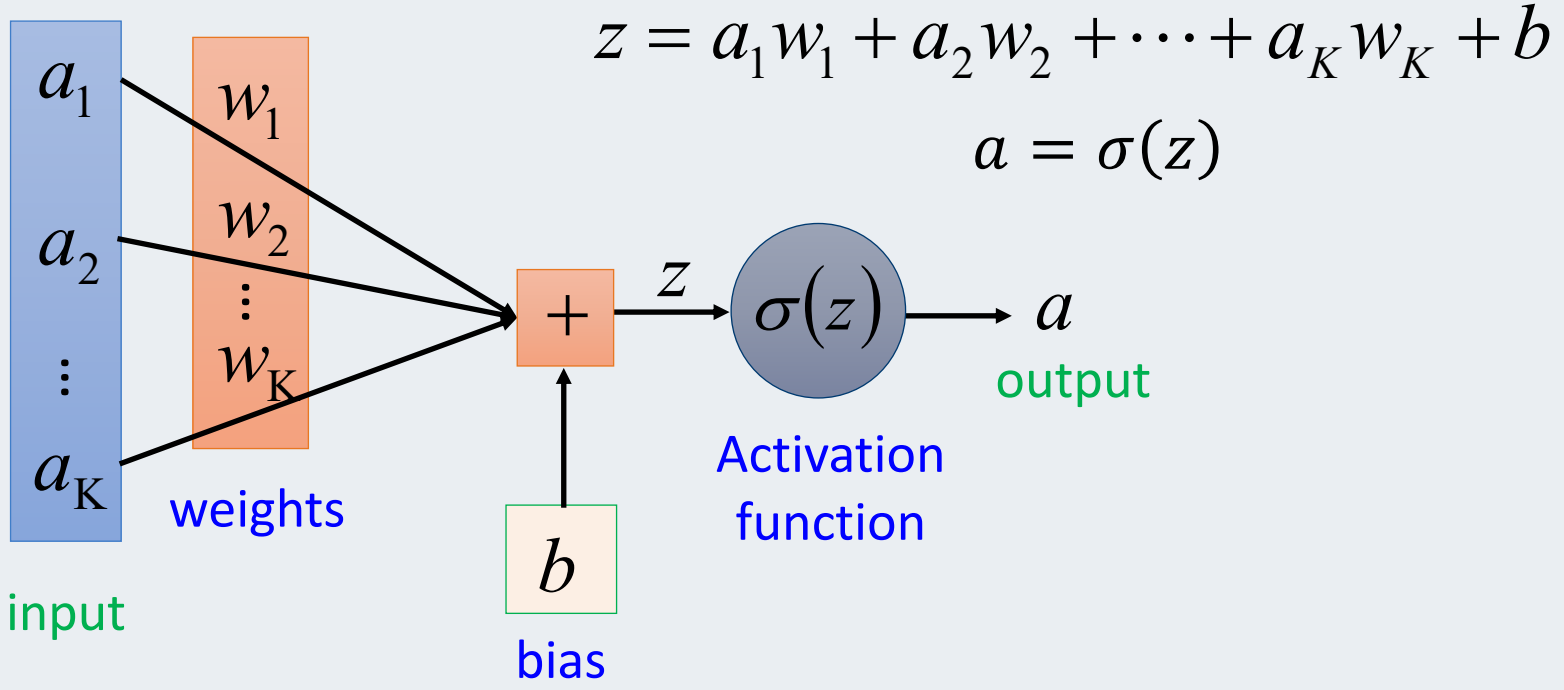
*Chatbots such as **ChatGPT** produce text like output*
The next generation of Conversational AI may include voice

BRIGHTEDGE

Elements of Neural Networks

NNs consist of hidden layers with neurons (i.e., computational units)

A single **neuron** maps a set of inputs into an output number, or $f: R^K \rightarrow R$



Acknowledgement to University of Idaho: CS404/504 - **Slide credit: Hung-yi Lee – Deep Learning Tutorial**

Essentials of Large Language Models (LLMs)

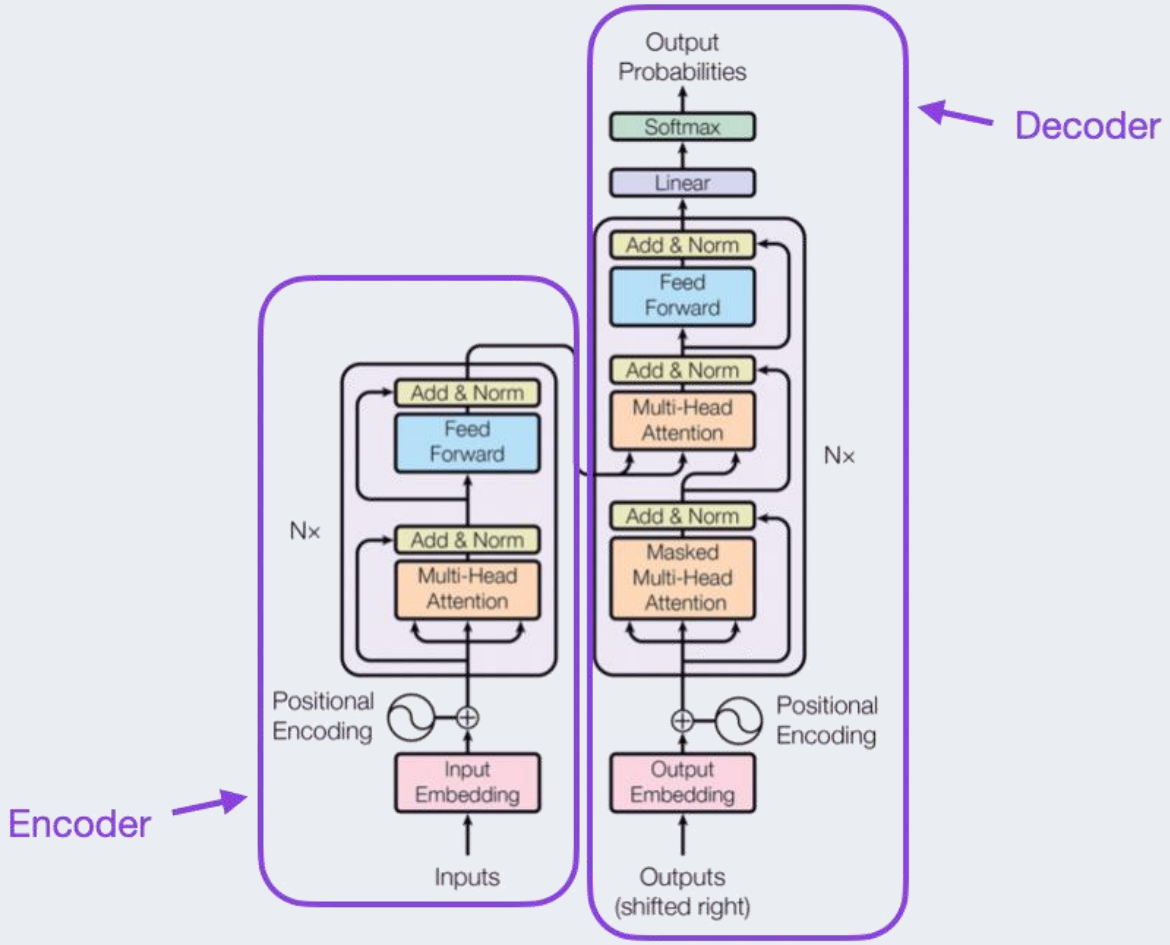


Figure 1: The Transformer - model architecture.

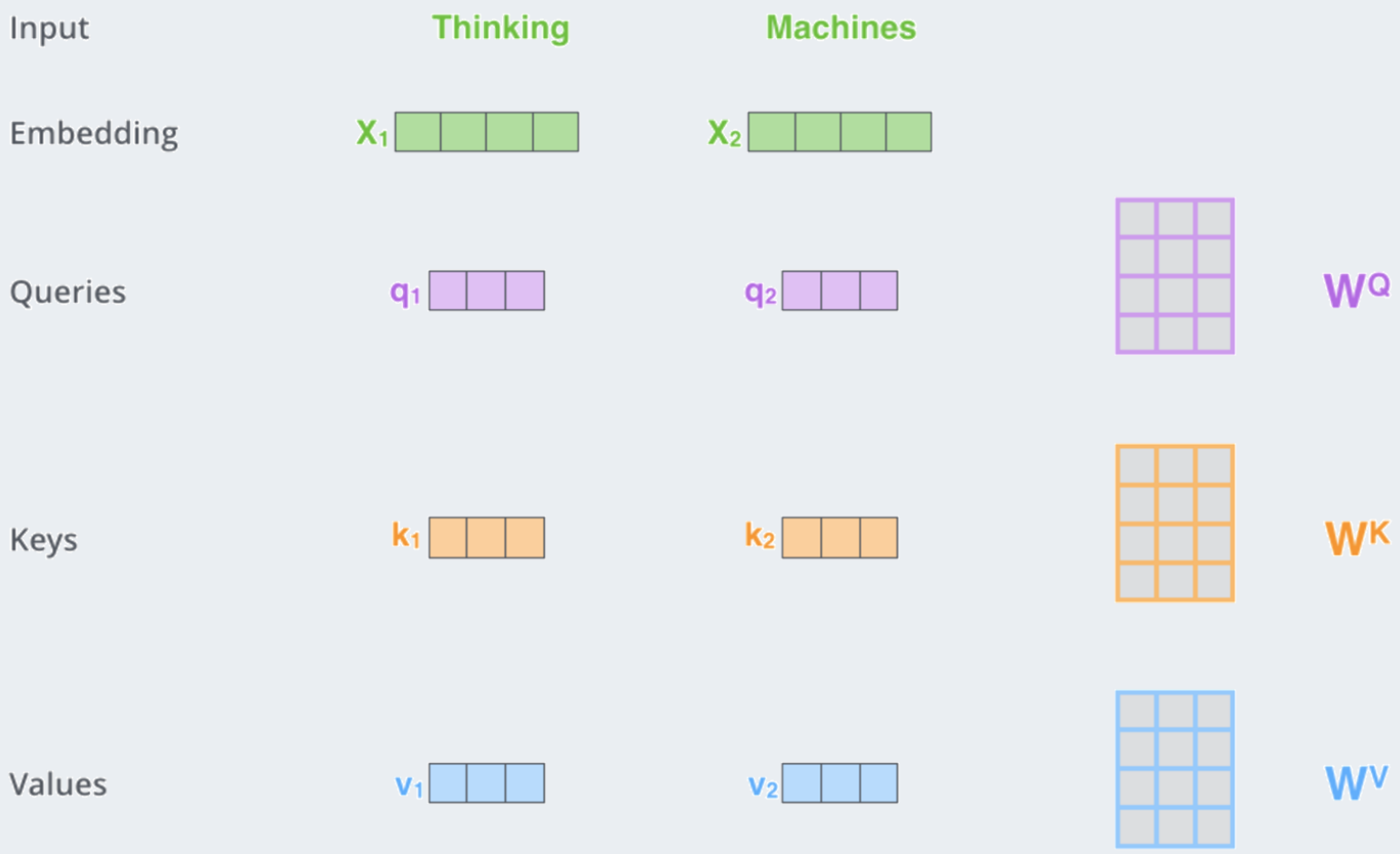
Self-Attention

While processing **each word** it allows to look at other positions in the input sequence for clues to build a better encoding for **this word**.

Step1: create three vectors from each of the encoder's input vectors:

Query, a Key, Value (typically smaller dimension).

by multiplying the embedding by three matrices that we **trained** during the training process.

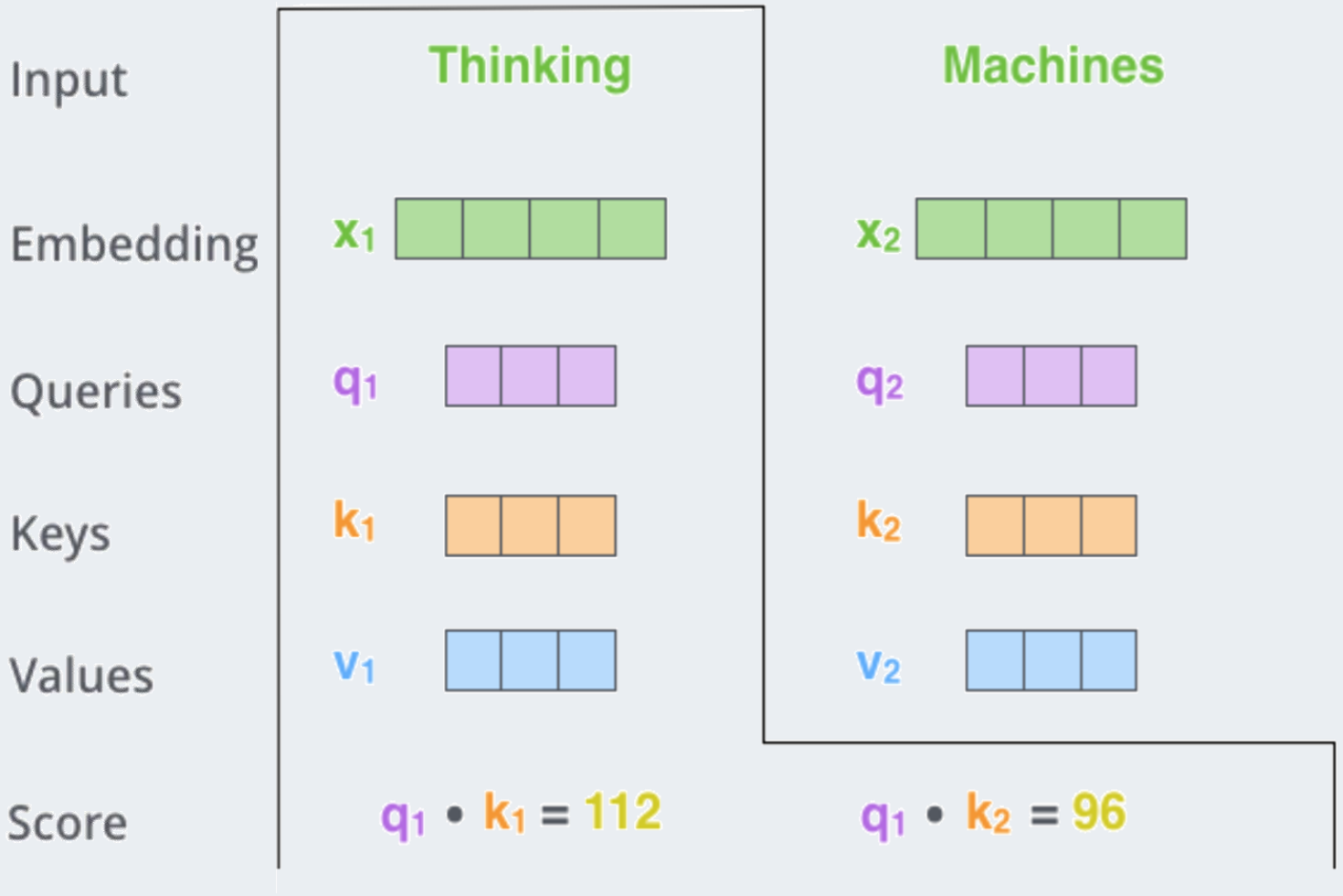


Self-Attention

Step 2: calculate a score (like we have seen for regular attention!) how much focus to place on other parts of the input sentence as we encode a word at a certain position.

Take dot product of the query vector with the key vector of the respective word we're scoring.

E.g., Processing the self-attention for word "Thinking" in position #1, the first score would be the dot product of q1 and k1. The second score would be the dot product of q1 and k2.

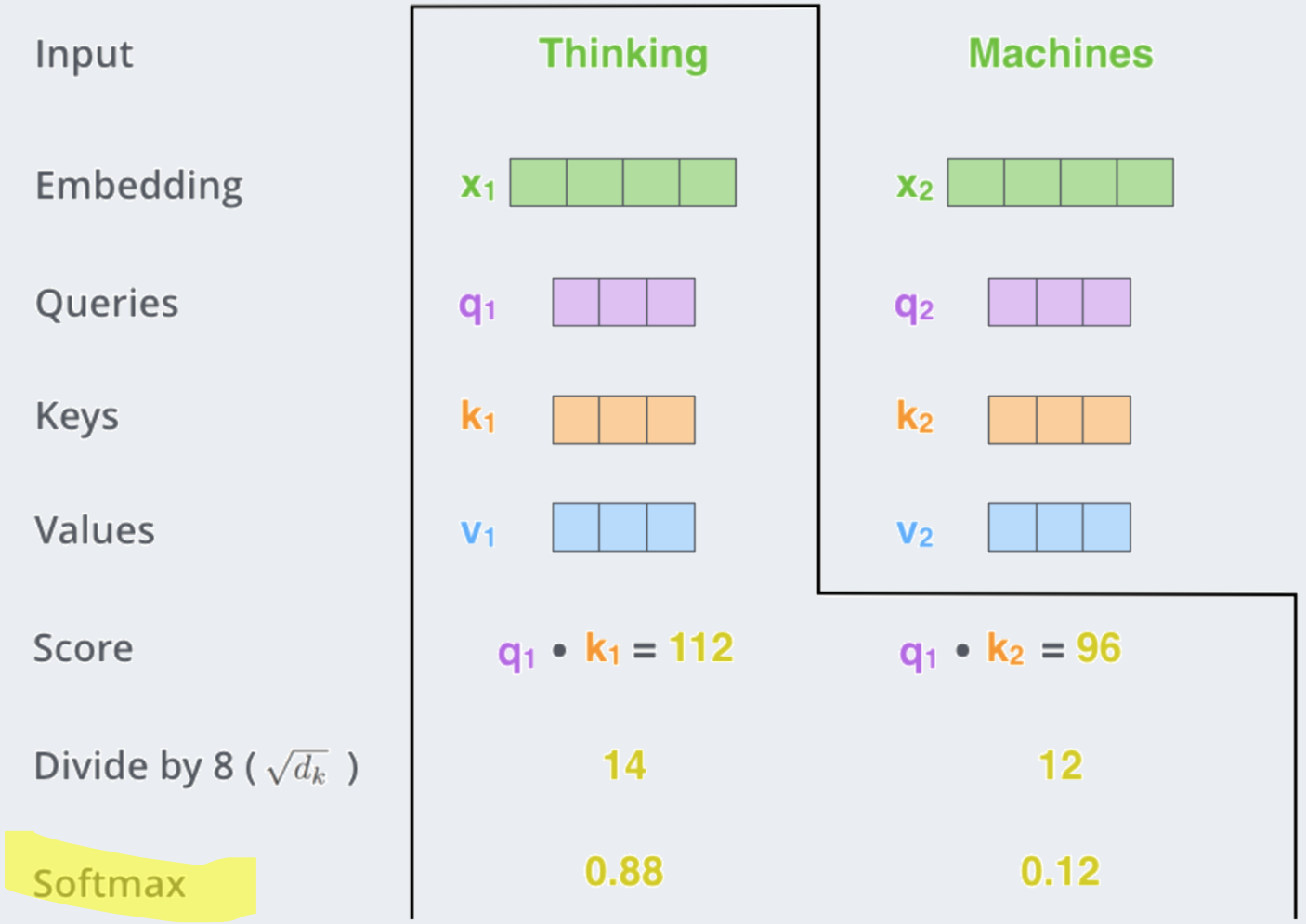


Self-Attention

Step 3 divide scores by the square root of the dimension of the key vectors (more stable gradients).

Step 4 pass result through a softmax operation. (all positive and add up to 1)

Intuition: softmax score determines how much each word will be expressed at this position.



Self-Attention

Step6 : sum up the weighted value vectors. This produces the output of the self-attention layer at this position

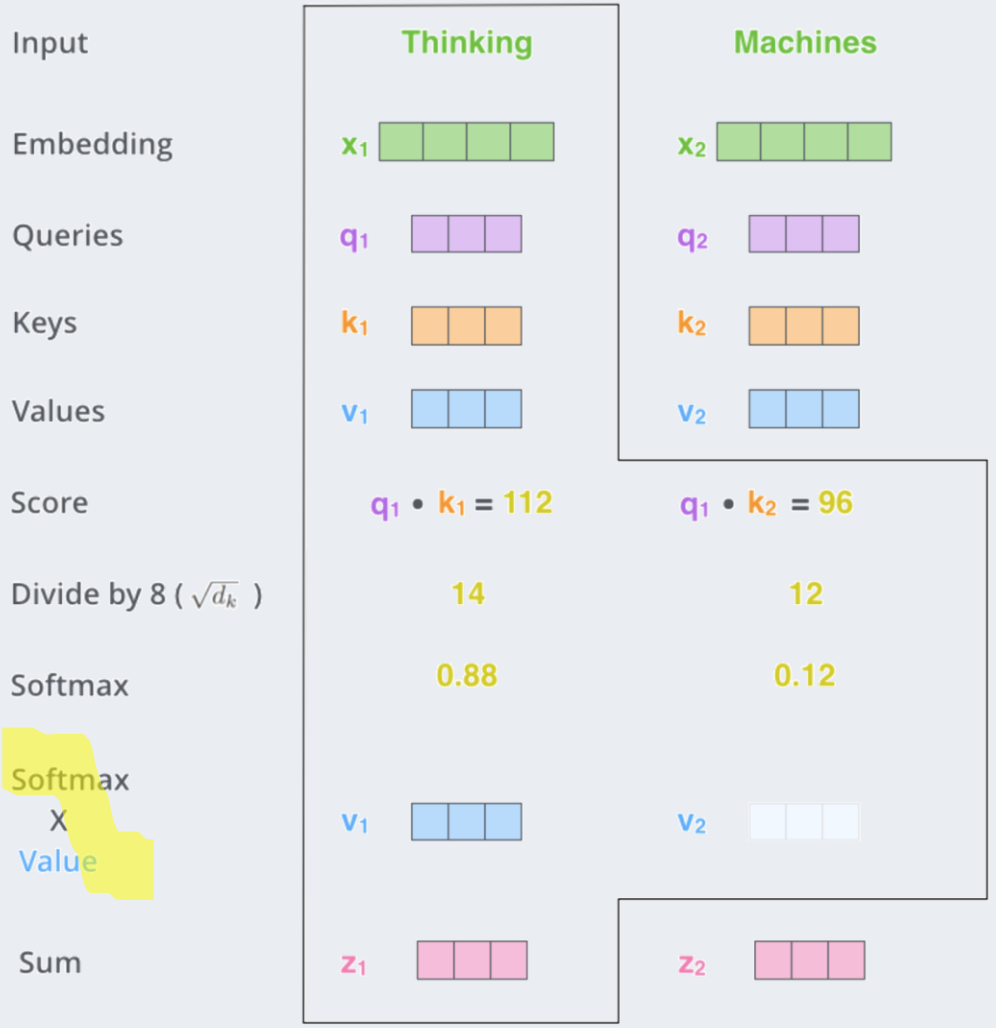
More details:

What we have seen for a word is done **for all words** (using matrices)

Need to **encode position** of words

And improved using a mechanism called "**multi-headed**" attention

see https://jalammar.github.io/illustrated-transformer/



LLMs in 2025; GPT-5, Gemini, Claude, Llama

- ChatGPT has taken the world by storm – Gemini ‘top of the wozza’ today (Nov’25).
- Use Prompt Engineering with it - a key technique.
- Use a human to check the results.
- Do not use it to do something we can’t do ourselves.
- If you can’t verify the accuracy or quality of the result; don’t use ChatGPT.
- Avoid using sensitive or private data.
- Use data with the best interest of the individual and society.
- Legal ownership will play out in due course.

Q2. What AI tool do you use?
Eg, ChatGPT, Gemini, Copilot, etc
(enter into the text box)

Q3 Do you find AI Useful or not Useful? (enter into the text box)

Q4 What applications do you have for AI? Eg, researching, summarising, design, etc (enter into the text box)

Q5 What challenges do you experience using AI? (enter into the text box)

ChatGPT is useful

- It is great for summarizing text.
- It can remember previous discussions in a specific session.
- It saves time and money.
- Multimodal input/output and on-device privacy mode.

However:

- It is trained on data (books, articles and web sites).
- There is the potential bias in data.
- It can only cope with conversations pertaining to one topic.
- Hallucinations can occur.

Language is primarily for communications

- Language is not for thought
- Language is optimized for communications
- Does not appear to be a prerequisite for complex thought

4. Applications & Case Studies

"Education is what remains after one has forgotten what one has learned in school"

- Albert Einstein

Power Systems Applications

- Load forecasting
- Transformer monitoring
- Fault prediction
- Relay optimisation
- Stability analysis

Renewables & Smart Grids

- PV/Wind forecasting
- Battery optimisation
- Grid integration
- Harmonic detection
- Inverter tuning

Machines & Drives

- Motor fault detection
- Vibration/thermal analysis
- Predictive maintenance
- VFD tuning
- Energy optimisation

Industrial Safety

- Vision PPE detection
- Arc flash mapping
- Hazard prediction
- Substation intrusion detection

PLC Programming with AI

- Ladder logic generation
- Natural language → PLC blocks
- Debugging help
- Documentation
- Refactoring

SCADA & IIoT

- Alarm rationalisation
- Anomaly detection
- Predictive control
- Reporting automation
- Cybersecurity detection

Process Control

- AI PID tuning
- Reinforcement learning
- Soft sensors
- Oscillation prediction

Robotics & Automation

- Path planning
- Vision QC
- Cobots
- Object recognition

AI-Ready Engineer Skillset

- Data skills
- ML basics
- AI tool proficiency
- Domain knowledge

Key Tools

- Python
- MATLAB/Simulink
- Edge AI tools
- SCADA
- PLCs such as Siemens/Rockwell/Schneider AI modules

Field Engineering Tools

Thermal imaging + AI

Drones

Vibration ML

Commissioning dashboards

Useful Resources for Exercises

- ChatGPT4
- Outlook and Bing on your browser
- Easiest resource to use to help you in the following tasks: https://talkai.info/
- Go to bottom of your screen – you don't need to install the app

OR

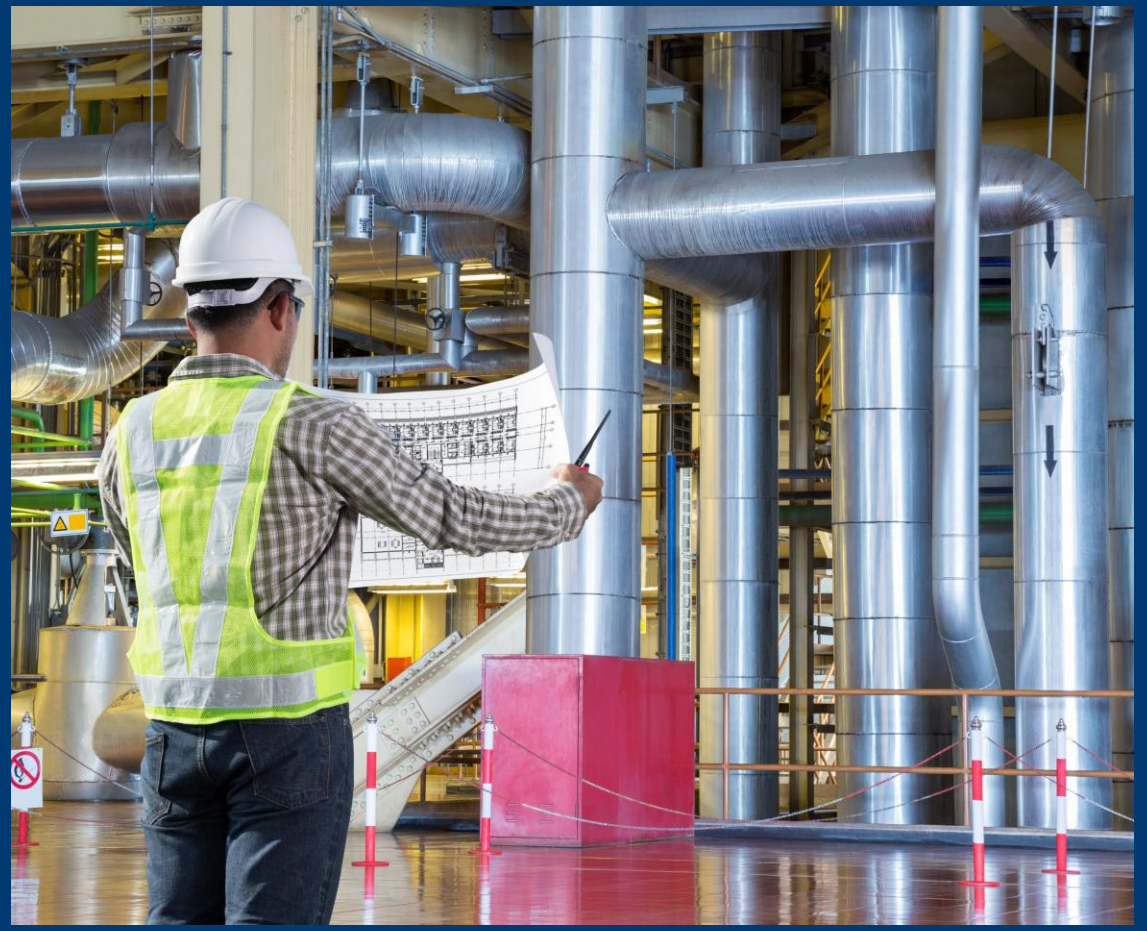
OpenAI's website (https://openai.com/chatgpt), straight from the source, but it does indeed require signing up (although you can quickly sign in with your Google/Microsoft/Apple account).

Exercise 1. Control and Instrumentation Design

You are an expert control and instrumentation engineer - ask ChatGPT to help you with the following design problem:

A pump station to pump sea water at the rate of 400 cubic meters per hour into a mineral processing plant off the coast of the Cornwall, England or the Sperrgebiet region of Namibia. Detail the control and instrumentation strategy that will be required to control this pump station.

- Consider the specifics and the constraints of the project when formulating the design.
- Critically assess the response from ChatGPT.
- Make some suggestions for the design of the picture of the works that you have created.



Exercise 2 – AI-Assisted Fault Diagnosis

Task:

Paste SCADA alarm logs into ChatGPT and ask:

“Group these alarms, identify the likely root cause,

and propose a troubleshooting sequence.”

Purpose:

Shows how AI clusters alarms, detects patterns,

and infers causal chains in control/SCADA systems.

Alarm Sequence (Random Order)

10:04:55 – LT-901-CAL-DUE – Level Transmitter Calibration Due

10:01:05 – P-101-STAT-TRIP – Pump P-101 Tripped

09:15:20 – AHU-07-FLTR-DIRTY – AHU Filter Dirty

10:01:12 – F-301-FLOW-L – Process Flow Low

10:06:31 – FIRE-ZONE3-FLT – Fire System Fault (Zone 3)

10:01:02 – P-101-PRES-L – Pump P-101 Discharge Pressure Low

09:55:00 – BDY-102-DR-OPEN – Boundary Door Open

10:01:09 – TK-201-LVL-L – Tank 201 Level Low

10:03:02 – MCC-2A-SPARE-FUSE-BLOWN – Spare Fuse Blown

09:45:11 – GEN-1-VIB-H – Generator Vibration High

10:01:18 – P-101-MOTOR-OL – Pump Motor Overload

11:11:11 – CHLR-2-TRIP – Chiller Trip

Solution: Alarm Grouping & Diagnosis

Grouped Alarms (single diagnosable fault chain):

- P-101-PRES-L – Pump discharge pressure low
- P-101-STAT-TRIP – Pump P-101 tripped
- TK-201-LVL-L – Tank 201 level low
- F-301-FLOW-L – Process flow low
- P-101-MOTOR-OL – Motor overload

Diagnosis:

These five alarms form one sequence: Loss of pressure → Pump trip → Drop in tank level → Low flow → Motor overload indication.

All remaining alarms are unrelated and should not be grouped.

Exercise 3 – AI-Based PID Tuning

Task:

Ask ChatGPT:

“Given overshoot, settling time and steady-state error specs, propose improved PID gains and justify each change.”

Purpose:

Demonstrates AI-supported optimisation while reinforcing engineering validation and control loop judgment.

Exercise 4 – Ladder Logic Generation

Task:

Ask ChatGPT:

“Generate a 4-rung DOL motor starter ladder logic program with Start/Stop, seal-in, and overload trip.”

Purpose:

Illustrates how AI drafts PLC logic that engineers can review, validate, and refine.

Solutions with Explanations

Solution 2 – Fault Diagnosis:
AI clusters alarms (e.g., Low Pressure → Pump Trip → Tank Level Drop), identifies the primary initiating event, and proposes checks.
Reason: AI recognises patterns across time-ordered alarms.

Solution 3 – PID Tuning:
AI typically increases Kp for responsiveness, adjusts Ki to reduce steady-state error, and reduces Kd to limit overshoot.
Reason: Reflects standard tuning logic; must be verified in real systems.

Solution 4 – Ladder Logic:
Rung 1: STOP (NC) + START (NO) → M coil
Rung 2: Seal-in: M contact (NO) → M coil
Rung 3: Overload (NC) → M coil
Rung 4: Contactor output → driven by M coil
Reason: Classic DOL starter pattern; AI often produces correct logic but may miss site-specific interlocks or safety rules.

5. AI design pitfalls to manage

- Hallucinated specs & loads
- Missing local codes / permits
- Poor site-data → bad outputs
- Climate & ESG mis-alignment
- Global-North material bias
- Liability still sits with the engineer
- Unclear IP on AI drawings/designs/code
- GDPR / POPIA data-sharing risks
- Deskilling of junior staff
- Skill & GPU gaps for upkeep
- Diagrams are still problematic

Take-away: AI is a powerful drafting partner, **not an autonomous designer**; always pair with rigorous data, local standards and human engineering judgment.

6. Wrap Up

Wrap-Up

- AI will not replace engineers, but engineers who use AI will outpace those who don’t.
- Stay curious, critical, and focused on practical engineering impact.
- Your engineering judgement remains the non-negotiable foundation.
- Build three capabilities: data + Python basics, verifying AI outputs, and weekly AI experimentation.
- Treat AI like a junior engineer—use it for drafts, but you verify everything.
- Start small with pilot AI projects (predictive maintenance, SCADA alarm clean-up, PLC generation).

Q&A

Thank You!

Upcoming Programmes

Engineering College of Technology (ECT) *UK-Recognised Qualifications*	Start Date
Bachelor of Engineering (Honours) in Industrial Automation	September 2026, February 2027
Bachelor of Engineering (Honours) in Electrical Engineering	September 2026, February 2027
Master of Science (Power System Analysis and Renewable Integration)	October 2026, February 2027
Master of Science (Industrial Automation and Instrumentation Control)	October 2026, February 2027

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Head Office
Whittle Way, Stevenage SG1 2FS,
United Kingdom

Phone
Inside UK: 0203 582 1389
Outside UK: +44 203 582 1389

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