Getting Started with AI: A Guide for Engineering Educators

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## Introduction

This guide provides a practical introduction to generative AI tools for engineering faculty who are new to AI integration. Whether you’re curious about AI capabilities or planning to incorporate these tools into your courses, this resource will help you navigate the first steps of your AI journey.

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 ## 1. Understanding AI in the Engineering Education Context

### What is Generative AI?

Generative AI refers to artificial intelligence systems that can create new content—text, images, code, and more—based on patterns learned from vast datasets. For engineering education, these tools can:

* Generate explanations of complex engineering concepts
* Create example problems and solutions
* Assist with code development and debugging
* Produce visualizations of abstract principles
* Help design engineering systems and components
* Analyze and provide feedback on student work

### Why Consider AI in Engineering Courses?

Engineering education faces specific challenges that AI tools can help address:

* **Technical Complexity**: AI can provide alternative explanations for difficult concepts
* **Visualization Needs**: AI can generate visual representations of abstract or microscopic phenomena
* **Repetitive Calculations**: AI can handle routine calculations, freeing time for deeper analysis
* **Diverse Application Contexts**: AI can connect theoretical concepts to varied real-world applications
* **Need for Personalized Feedback**: AI can provide individualized guidance at scale

### Current Limitations to Keep in Mind

* **Technical Accuracy**: AI can make errors in calculations or provide outdated information
* **Discipline-Specific Knowledge**: AI may lack depth in highly specialized engineering topics
* **Visualizing Complex Systems**: Some engineering visualizations require specialized tools beyond general AI capabilities
* **Verification Needs**: AI outputs require human verification, especially for safety-critical applications

### Discipline-Specific Considerations

| Engineering Discipline | Key AI Opportunities | Special Considerations |
| --- | --- | --- |
| **Civil Engineering** | Structural analysis explanations, code compliance checking | Safety-critical applications require thorough verification |
| **Mechanical Engineering** | Thermodynamics visualizations, CAD assistance | Physical behavior simulation may require specialized tools |
| **Electrical Engineering** | Circuit analysis, signal processing explanations | Component details may be outdated or simplified |
| **Chemical Engineering** | Reaction pathway visualization, process optimization | Safety and environmental considerations need human oversight |
| **Computer Science** | Code generation, algorithm explanation | Code quality and efficiency need human evaluation |
| **Biomedical Engineering** | Complex system visualizations, literature synthesis | Medical applications require careful validation |

 ## 2. The Six Dimensions of AI Integration

The AI Integration Taxonomy provides a framework for thinking about how to incorporate AI into your courses. Here’s a simplified introduction to each dimension:

### Pedagogical Purpose

Ask yourself: What specific learning challenges am I trying to address? - Explaining difficult concepts - Developing technical skills - Enhancing engineering workflows - Creating educational materials - Visualizing complex systems

### Integration Depth

Ask yourself: How central will AI be to course activities? - As an optional supplementary resource - For specific guided activities - Embedded throughout course practices - Transforming how the course is structured

### Student Agency

Ask yourself: How much control will students have over AI use? - Following your specific instructions - Gradually increasing responsibility - Exploring within defined boundaries - Making independent decisions

### Assessment Alignment

Ask yourself: How will I evaluate learning in an AI context? - Documenting AI workflow processes - Comparing AI-generated and traditional approaches - Critically evaluating AI outputs - Reflecting on learning with AI support

### Technical Implementation

Ask yourself: What practical aspects need consideration? - Which tools best match my course needs - How students will access these tools - How to craft effective engineering prompts - How to handle AI limitations and errors

### Ethical & Professional Development

Ask yourself: How will I address responsible AI use? - Attribution practices for AI contributions - Alignment with engineering industry practices - Building critical understanding of AI capabilities - Ensuring equitable benefits for all students

 ## 3. Selecting Your First AI Tools

### General-Purpose AI Tools

| Tool | Best For | Access Model | Engineering Strengths | Limitations |
| --- | --- | --- | --- | --- |
| **ChatGPT** (OpenAI) | Text generation, code assistance, explanations | Free tier available; subscription for advanced features | Widely used, good for code, versatile | May hallucinate technical details |
| **Claude** (Anthropic) | Detailed explanations, reasoning, document analysis | Free tier available; subscription for advanced features | Excellent for complex engineering concepts, can process longer context | Sometimes overly cautious with technical information |
| **Gemini** (Google) | Visual information processing, research information | Free tier available; subscription for advanced features | Strong math capabilities, connected to recent research | Occasionally weaker at code generation |
| **Copilot** (GitHub) | Code generation, programming assistance | Subscription; educational access available | Excellent for engineering programming tasks | Limited to coding contexts |

### Setting Up Your First Tool

#### ChatGPT Quick Start

1. Go to [chat.openai.com](https://chat.openai.com) and create an account
2. Use your institutional email if your institution has an educational agreement
3. Start with the free tier (GPT-4o) for initial exploration
4. For more advanced features (like longer responses), consider o3 in the Plus subscription

#### Claude Quick Start

1. Go to [claude.ai](https://claude.ai) and create an account
2. Claude offers a generous free tier that handles complex engineering discussions well
3. Use Claude 3.5-Haiku for standard interactions or Claude 3.7-Sonnet for more advanced needs

### Choosing Your First Tool

For most engineering educators, we recommend starting with **ChatGPT** or **Claude** due to their: - Versatility across multiple engineering uses - Accessibility without specialized setup - Strong user communities for support - Free access tiers sufficient for exploration

 ## 4. Practical First Steps with AI Tools

### Before You Begin

1. **Create an account** with your institutional email where possible (this may provide educational benefits)
2. **Set aside 30-60 minutes** for uninterrupted exploration
3. **Have engineering materials handy** (a concept you teach, a problem you assign, etc.)
4. **Start with low stakes exploration** rather than production-ready content

### Initial Exploration Activities

#### Activity 1: Concept Explanation

Ask the AI to explain an engineering concept you teach, in multiple ways:

Explain the concept of control system stability in three different ways:
1. To a first-year engineering student
2. Using a real-world analogy
3. With connections to related engineering principles like feedback and system response

Include any limitations in your explanation that engineers should be aware of.

#### Activity 2: Problem Generation

Ask the AI to create practice problems similar to ones you use:

Generate three practice problems on fluid mechanics at the junior undergraduate level in mechanical engineering.

For each problem:
1. State the problem clearly
2. Provide the solution with step-by-step work [NOTE: this is experimental and may not work as expected at this time]
3. Highlight common student misconceptions related to this type of problem

#### Activity 3: Visual Explanation Request

Ask the AI to describe how to visualize a concept:

Describe how to visualize stress distribution in a loaded beam in a way that would help students understand the underlying principles. This may be particularly feasible with newer image-generation tools, though this is also still more experimental than not.

Be specific about what elements should be included in this visualization and how they relate to the mathematical or physical principles involved.

#### Activity 4: Analyze Your Own Prompt

After receiving responses, analyze what worked and what didn’t:

Please analyze the effectiveness of my previous prompt. What elements of my prompt led to useful responses? What could I improve to get better information for engineering education purposes?

 ## 5. Engineering-Specific Prompting Strategies

Effective prompts for engineering contexts often require specific elements:

### Specify Technical Parameters

I need an explanation of fluid flow in a pipe with:
- 2-inch diameter
- Reynolds number of approximately 2500
- Water at 20°C as the fluid

### Define Educational Context

I'm teaching this to junior mechanical engineering students who have completed:
- Fluid Mechanics I
- Thermodynamics
- Differential Equations

### Request Multiple Perspectives

Please explain this concept from:
- A mathematical perspective
- A physical/intuitive perspective
- An applications perspective

### Ask for Limitations

What are the limitations or edge cases where this explanation breaks down? What simplifying assumptions are being made?

### Prompt Structure Template

I need help with [specific engineering task].

Context:
- [Course level and discipline]
- [Relevant prerequisites]
- [Specific applications or focus]

Requirements:
- [Technical parameters]
- [Desired format]
- [Level of detail]

Additional considerations:
- [Limitations to address]
- [Connections to make]
- [Common misconceptions]

### Discipline-Specific Prompt Examples

#### Civil Engineering

I need an explanation of moment distribution in statically indeterminate structures.

Context:
- This is for a junior-level structural analysis course
- Students have completed statics and mechanics of materials
- Focus on building frames and continuous beams

Requirements:
- Include both the mathematical process and physical interpretation
- Show a step-by-step example with a two-span continuous beam
- Highlight the connection between moment diagrams and deflected shapes

Additional considerations:
- Address the limitation of hand calculations vs. computer analysis
- Connect to practical applications in building design
- Address common sign convention confusion

#### Electrical Engineering

I need an explanation of operational amplifier circuits.

Context:
- Sophomore-level circuit analysis course
- Students have completed DC/AC circuit analysis
- Focus on practical applications in signal processing

Requirements:
- Explain ideal op-amp assumptions
- Include examples of inverting and non-inverting configurations
- Use both mathematical equations and intuitive explanations

Additional considerations:
- Address real-world limitations of ideal assumptions
- Include frequency response considerations
- Connect to common applications in sensor interfaces

#### Computer Science

I need help explaining recursion in algorithm design.

Context:
- Data structures and algorithms course for second-year students
- Students have completed an introductory programming course
- Using Python as the primary language

Requirements:
- Explain the concept with a simple example first
- Provide a more complex example showing tree traversal
- Include both code and visual representations

Additional considerations:
- Compare with iterative approaches
- Address stack overflow limitations
- Connect to real-world applications in search algorithms

 ## 6. Addressing Common Concerns

### “Will students still learn fundamental skills?”

**Strategy**: Use a layered approach where fundamental skills are taught and assessed first, then AI tools are introduced to build on these foundations.

**Example Implementation**: In a circuits course, have students manually solve basic circuit analysis problems first. Once proficient, introduce AI to help analyze more complex circuits, with students verifying key results manually.

**Assessment Connection**: Create assessment that explicitly measures both foundational skills and AI-enhanced capabilities separately.

### “How do I ensure academic integrity?”

**Strategy**: Shift from “preventing AI use” to “requiring appropriate AI use” with clear documentation.

**Example Implementation**: Create an “AI Consultation Form” where students document: - The prompt they used - The raw AI response - Their evaluation of the response accuracy - How they modified or incorporated the AI input

**Assessment Connection**: Make the documentation of AI use part of the assessment criteria, evaluating students’ critical thinking about AI outputs.

### “What if the AI provides incorrect information?”

**Strategy**: Use this as a teaching opportunity for critical evaluation and verification.

**Example Implementation**: Provide an intentionally challenging problem where the AI is likely to make simplifying assumptions. Guide students to identify these limitations and develop more rigorous solutions.

**Assessment Connection**: Include the ability to identify and correct AI errors as an explicit learning outcome, with corresponding assessment criteria.

### “Will students become dependent on AI?”

**Strategy**: Focus on teaching AI as a tool that requires engineering judgment rather than a replacement for expertise.

**Example Implementation**: Have students compare how different AI tools approach the same engineering problem, then analyze the differences and determine which approach is most valid.

**Assessment Connection**: Develop meta-cognitive assessments that measure students’ understanding of when AI is appropriate vs. when other approaches are needed.

 ## 7. Planning Your First AI-Enhanced Activity

### Step 1: Start Small

Choose a single, bounded activity where AI might add value: - Concept explanation for a difficult topic - Initial brainstorming for a design project - Feedback on draft lab reports - Generation of practice problems

### Step 2: Define Specific Learning Objectives

Example objectives that leverage AI capabilities: - Students will be able to critically evaluate explanations of fluid dynamics principles - Students will be able to generate and test multiple design alternatives efficiently - Students will be able to identify and correct errors in technical communication

### Step 3: Create Clear Student Instructions

Essential elements to include: - Specific AI tool to use (or options) - Clear prompting guidance - Verification expectations - Documentation requirements - Connection to learning objectives

### Sample Activity: AI-Enhanced Problem Analysis

AI-Enhanced Problem Analysis Activity

Preparation:
1. Choose one of the provided AI tools (ChatGPT, Claude, or Gemini)
2. Have your completed solution to Problem 3.5 available for reference

Instructions:
1. Submit Problem 3.5 to your chosen AI tool with the prompt: "Please solve this engineering problem step by step, explaining your reasoning at each stage."
2. Compare the AI solution to your own solution, noting:
 - Any differences in approach
 - Steps where the AI excelled or struggled
 - Assumptions made by the AI
 - Errors or limitations in the AI solution
3. Submit a 1-page analysis addressing:
 - Which solution method is more appropriate and why
 - What the AI missed or simplified
 - How you would improve the AI's approach
 - How this tool might be useful in your future engineering work

### Sample Activity: Discipline-Specific Examples

#### Mechanical Engineering: Concept Visualization

Thermal Gradient Visualization Activity

Learning Objectives:
- Visualize abstract thermal concepts spatially
- Connect mathematical expressions to physical phenomena
- Identify limitations in simplified thermal models

Instructions:
1. Choose a thermal system we've studied (heat exchanger, engine, HVAC component)
2. Use Claude to generate descriptions of how temperature gradients develop in your system
3. Use DALL-E to create visualizations based on these descriptions
4. Analyze the visualizations for accuracy and limitations
5. Prepare a brief presentation explaining:
 - Key thermal principles illustrated
 - How the visualization helps understanding
 - Technical limitations of the AI-generated visualization
 - How you would improve the visualization

#### Civil Engineering: Code Compliance Check

Building Code Analysis Activity

Learning Objectives:
- Apply building code requirements to design decisions
- Evaluate AI-assisted code compliance checking
- Develop critical evaluation skills for regulatory information

Instructions:
1. Select one aspect of your building design project
2. Use ChatGPT to analyze compliance with relevant building codes
3. Prompt: "Analyze the following [structural/accessibility/fire safety] design for compliance with the International Building Code 2021, Chapter [X]. Identify any compliance issues and suggest revisions."
4. Verify the AI's analysis using the actual code documents
5. Submit a report documenting:
 - The AI's compliance analysis
 - Your verification process
 - Instances where the AI was correct/incorrect
 - Recommendations for using AI in code compliance workflows

 ## 8. Implementation Checklist

Use this checklist to ensure you’ve considered key aspects before implementing an AI-enhanced activity:

**Preparation** - [ ] Tested the activity yourself with the AI tool(s) - [ ] Identified potential AI limitations or errors - [ ] Created verification strategies for important calculations/concepts - [ ] Developed clear student instructions - [ ] Aligned with institutional AI policies

**Learning Design** - [ ] Defined specific learning objectives - [ ] Connected AI use to engineering disciplinary practices - [ ] Determined appropriate level of student guidance - [ ] Created documentation requirements - [ ] Designed appropriate assessment approach

**Technical Considerations** - [ ] Ensured required AI tools are accessible to all students - [ ] Provided alternatives for technical failures - [ ] Considered data privacy aspects - [ ] Created support mechanism for student questions

**Assessment** - [ ] Determined how AI use affects assessment criteria - [ ] Created clear rubric addressing AI components - [ ] Planned for collecting feedback on the activity - [ ] Considered academic integrity aspects

**Assessment Integration** - [ ] Identified which aspects of AI use will be assessed - [ ] Developed rubric elements specifically for AI-related skills - [ ] Created differentiated assessment for AI-allowed vs. AI-restricted components - [ ] Planned for meta-cognitive reflection on AI use

 ## 9. Sample Syllabus Language

### Basic AI Policy Statement

Artificial Intelligence Tools in This Course

This course recognizes the increasing role of AI tools in engineering practice. Students are permitted to use AI tools (such as ChatGPT, Claude, or similar) with the following guidelines:

1. Transparency: All use of AI tools must be documented according to the course AI Documentation Guidelines.

2. Verification: Students are responsible for verifying all AI-generated content for accuracy and appropriateness.

3. Learning Primacy: AI tools should support, not replace, your learning. Some assignments or portions of assignments will be designated as "AI-restricted" to ensure development of fundamental skills.

4. Academic Integrity: Undocumented use of AI tools will be considered an academic integrity violation. When in doubt, document your use.

The course will include instruction on effective and appropriate use of AI tools in engineering contexts.

### Comprehensive AI Integration Statement

AI Integration Approach

This course takes a developmental approach to AI tools in engineering education, with the goal of preparing you for their professional use while ensuring you develop necessary fundamental skills.

• Phase 1 (Weeks 1-4): Foundations
 - AI tools are restricted to specific, marked activities
 - Focus on developing baseline engineering skills
 - Introduction to AI capabilities and limitations

• Phase 2 (Weeks 5-10): Guided Integration
 - AI tools permitted for designated parts of assignments
 - Documentation of AI use required
 - Development of AI prompt engineering skills
 - Critical evaluation of AI outputs emphasized

• Phase 3 (Weeks 11-15): Professional Practice
 - AI tools integrated as professional tools
 - Emphasis on engineering judgment
 - Focus on enhancing and verifying AI outputs
 - Reflection on ethical implications

Assignments will clearly indicate which components are:
- AI-Restricted: No AI tools permitted
- AI-Allowed: AI tools permitted with documentation
- AI-Enhanced: AI tools required with critical evaluation

Assessment will evaluate both your foundational engineering knowledge and your ability to effectively leverage AI tools. The AI Use Documentation Form must be submitted with any assignment where AI tools are used.

### AI Documentation Template Reference

For assignments where AI use is permitted, students must complete the AI Use Documentation Form that includes:

1. What task(s) you used AI to accomplish
2. The specific AI tool(s) used
3. The exact prompts provided
4. How you evaluated the AI's response
5. What modifications you made to the AI output
6. What you learned from the interaction

This documentation will be considered part of the assignment submission and factored into grading. The goal is not to discourage AI use, but to develop critical thinking about AI tools.

 ## 10. Resources for Further Learning

### Case Studies from Engineering Disciplines

* [Using ChatGPT for Concept Mastery in Thermodynamics](/resources/teaching/materials/case-studies/thermodynamics-chatgpt)
* [Integrating ChatGPT in a Mechanical Engineering Design Course](/resources/teaching/materials/case-studies/mechanical-design-chatgpt)
* [GitHub Copilot in Programming Courses](/resources/teaching/materials/case-studies/programming-course-github-copilot)
* [Using Claude in a Materials Science Course](/resources/teaching/materials/case-studies/materials-science-claude)
* [Claude in an Electrical Engineering Circuit Analysis Course](/resources/teaching/materials/case-studies/electrical-engineering-claude)

### Implementation Planning Templates

* [Course-Level AI Implementation Plan](/resources/teaching/materials/templates/course-level-implementation-plan)
* [AI Assignment Design Template](/resources/teaching/materials/templates/ai-assignment-rubrics)
* [Case Study Analysis Worksheet](/resources/teaching/materials/templates/case-study-analysis-worksheet)

### Prompting Resources

* [Engineering-Specific Prompts](/resources/teaching/materials/prompting/engineering-prompts)
* [AI Prompt Engineering Guide](/resources/teaching/materials/prompting/ai-prompt-engineering-guide)

### Workshop Materials

* [Prompt Engineering Challenge](/resources/teaching/workshops/prompt-engineering-challenge)
* [Designing Effective AI Assignments](/resources/teaching/workshops/effective-ai-assignments)

### Assessment Resources

* [AI Literacy Rubric Framework](/resources/teaching/materials/assessment/ai-literacy-rubric)
* [Assessment Design in the Age of AI](/resources/teaching/materials/assessment/assessment-design)
* [Documenting AI Use in Engineering Courses](/resources/teaching/materials/assessment/documenting-ai-use)

*This guide was developed as part of the IDEEAS Lab materials for integrating generative AI into engineering education. For questions or additional resources, please contact [workshops@ideeaslab.org].*