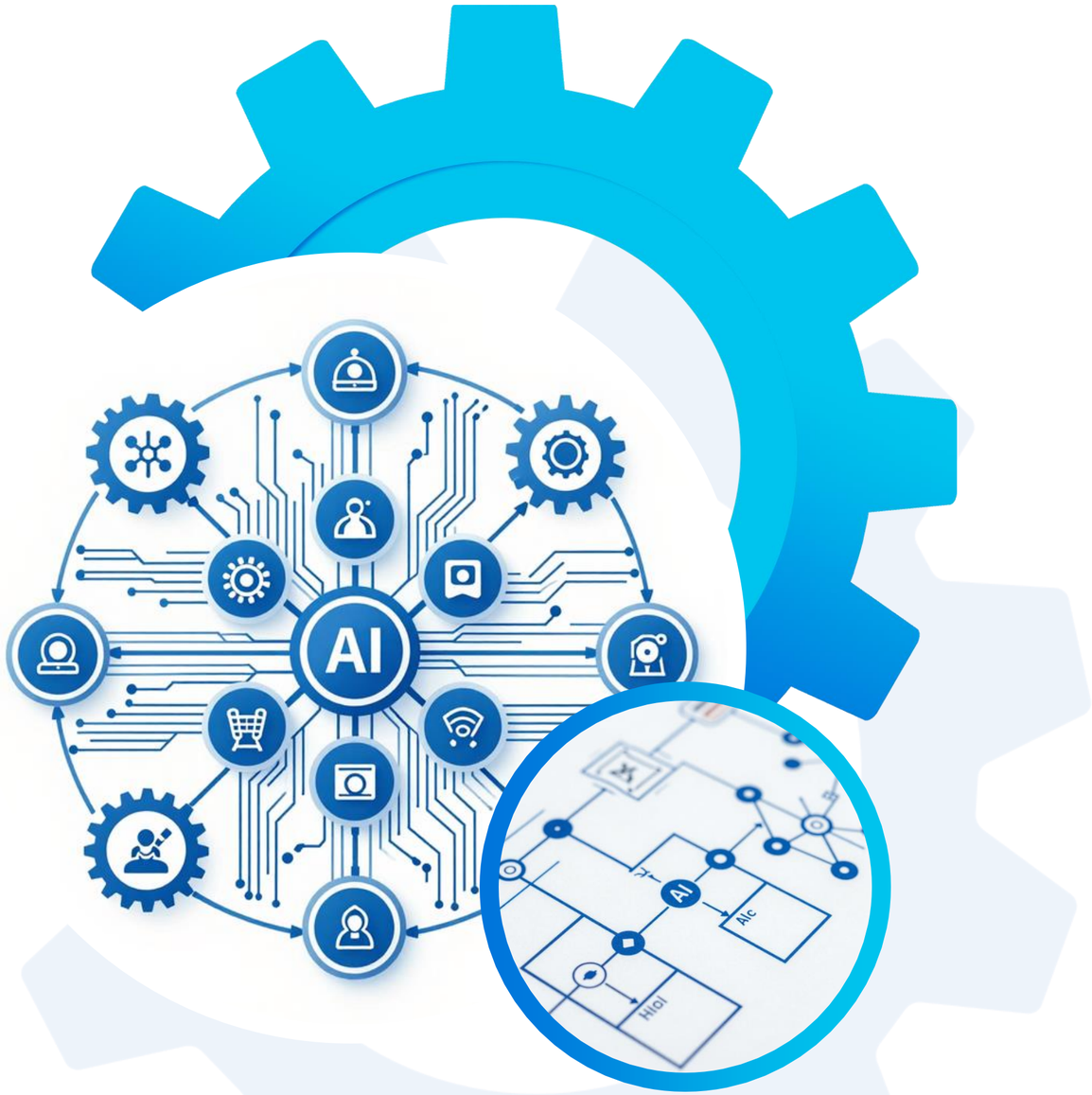
TEACHING ENGINEERING STUDENTS TO THINK WITH AI, NOT THROUGH AI

Best practices for responsible AI use in technical problem solving

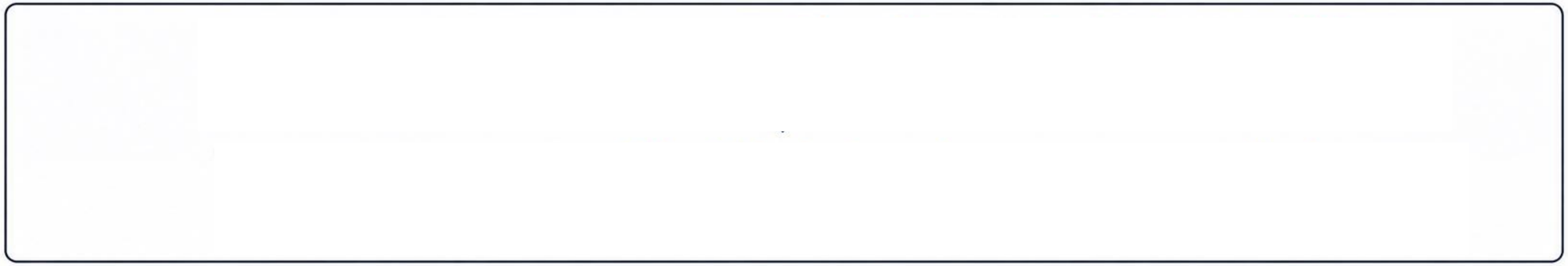


Presenter :
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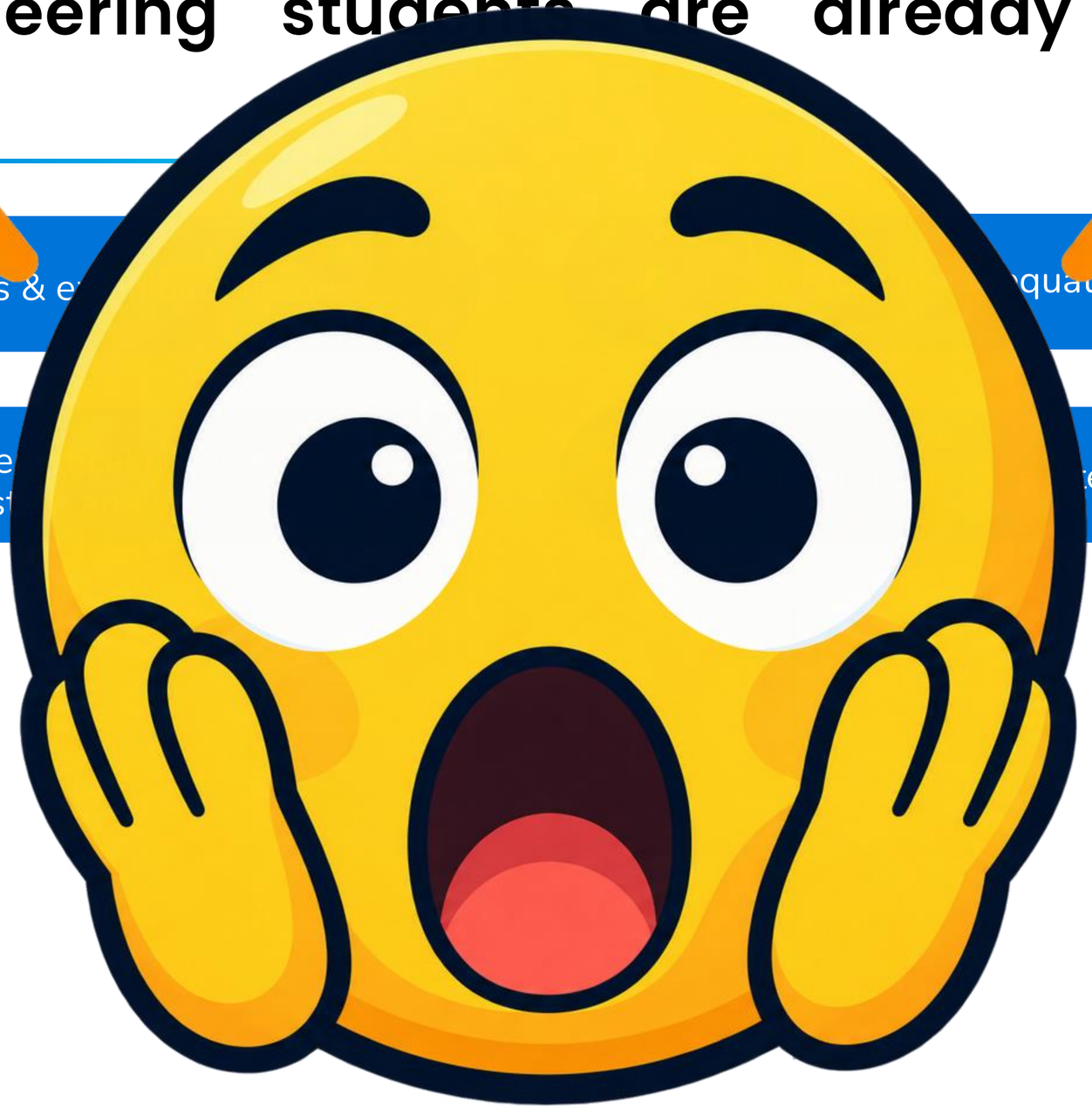
Tshwane University of Technology (TUT)

Our (engineering) education problem



Our engineering students are already using AI

- Writing reports & e… …quations
- Deriving mathe… conducting syst… …tems



How to teach responsible AI use TO STUDENTS

How do we use AI as a teaching and learning collaborator rather than a “thought substitute”?

A five-step framework for responsible AI use in engineering problem solving

1

THINK
before you PROMPT

Formulate the engineering problem first.

Define variables, constraints, and expected behavior before touching AI.

2

PREDICT
before you ASK

Develop an expectation of the answer.

Estimate order-of-magnitude, sign, and units so you can judge AI output.

3

INTERROGATE
rather than ACCEPT

Challenge assumptions and reasoning.

Ask: What method was used? What was neglected? Is this physically plausible?

4

VERIFY
independently

Use simulation, hand calculation, and dimensional analysis.

Never accept unvalidated results.

5

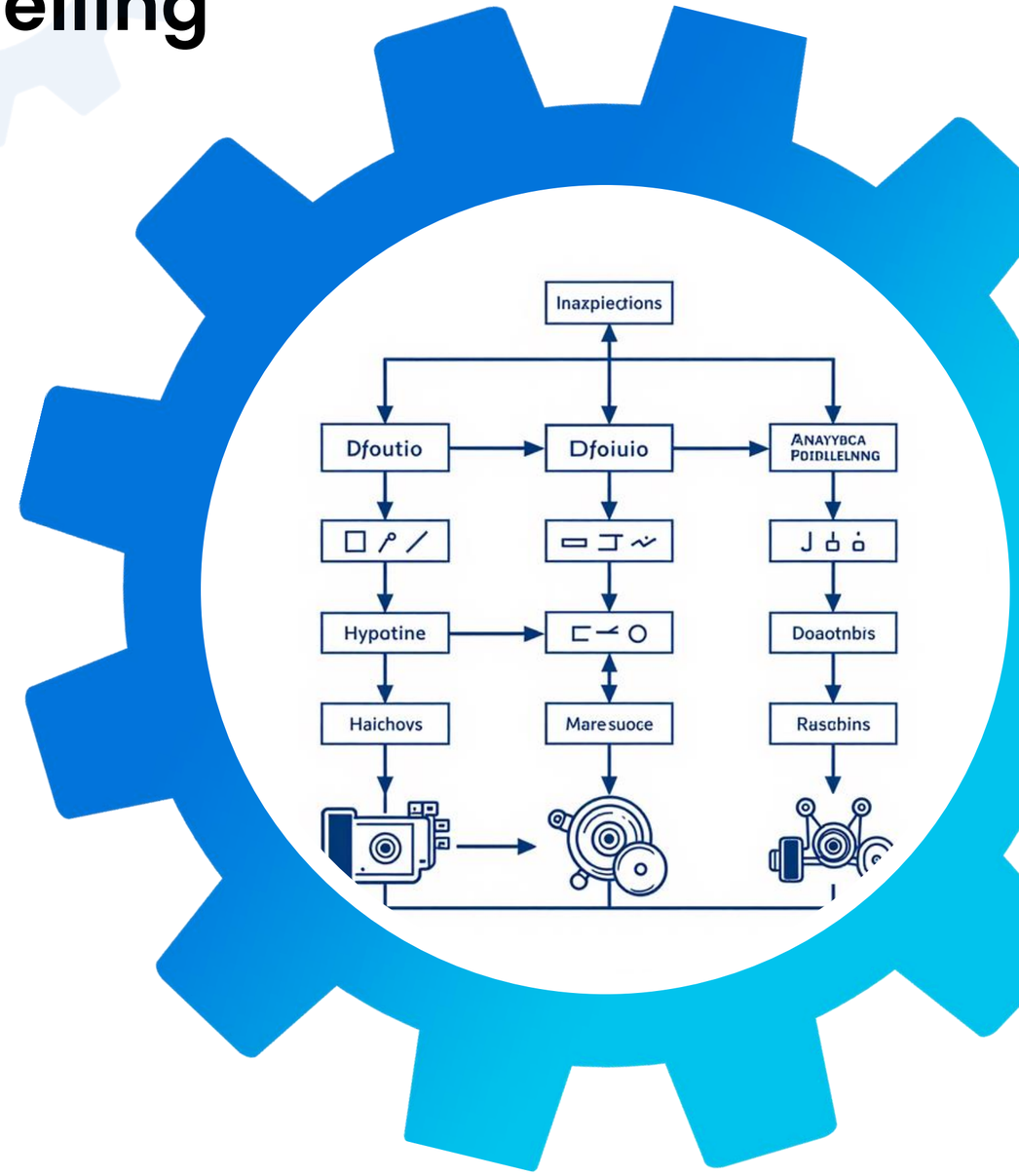
REFLECT
after using AI

Identify what AI contributed, what you contributed, and where

AI could be wrong, and often is!

AI should improve student learning experience, not remove engineering thought processes.

Case Study 1: Linear Systems modelling



Th

Case

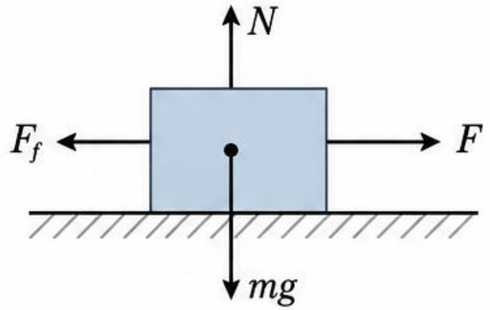
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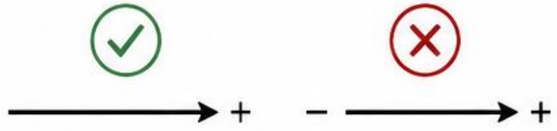
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Bypassed/lost engineering knowledge:

✗ Free-body diagram



✗ Sign conventions



Consistent signs give correct results.

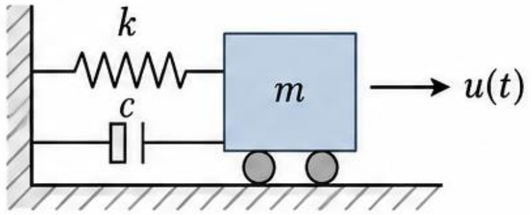
Inconsistent signs lead to errors.

✗ Newton's second law

$$\sum F = m\,a$$

Sum of forces — Mass — Acceleration

✗ Selection of state variables



Choose x, $\dot{x}$ (not F, a, etc.) as state variables.

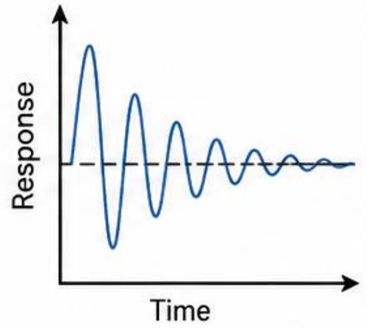
✗ Matrix dimensions

$$A\,x = b$$

$n\times n$ $\quad$ $n\times 1$ $\quad$ $n\times 1$

Dimension mismatch → wrong equations

✗ Physical interpretation



Numbers without meaning can hide wrong models.

Always make sense of results.

b

The AI inclusive way

Case Study 1: Linear Systems modelling

What has been achieved?

Student is forced to demonstrate applied first principle knowledge In controlled environment.

PHASE 1: STUDENT FIRST (without AI):

Draw free-body diagram · Define coordinate system · Identify inputs/outputs · Derive governing equation · Predict system order

❖ In class test environment (~ 40%)

What has been achieved?

Student is able to explore the AI assistive tools at home or in groups, they learn from each other and “discover” during the AI sound boarding.

PHASE 2: AI to be used:

Use AI tool to independently derive the model from the same problem statement

❖ Take home assignment (~30%)

What has been achieved?

The facilitator has ensured that the student has done their own work, but also allowed AI exploration and co-learning. There now exist an audit ready “trail” to prove student competence.

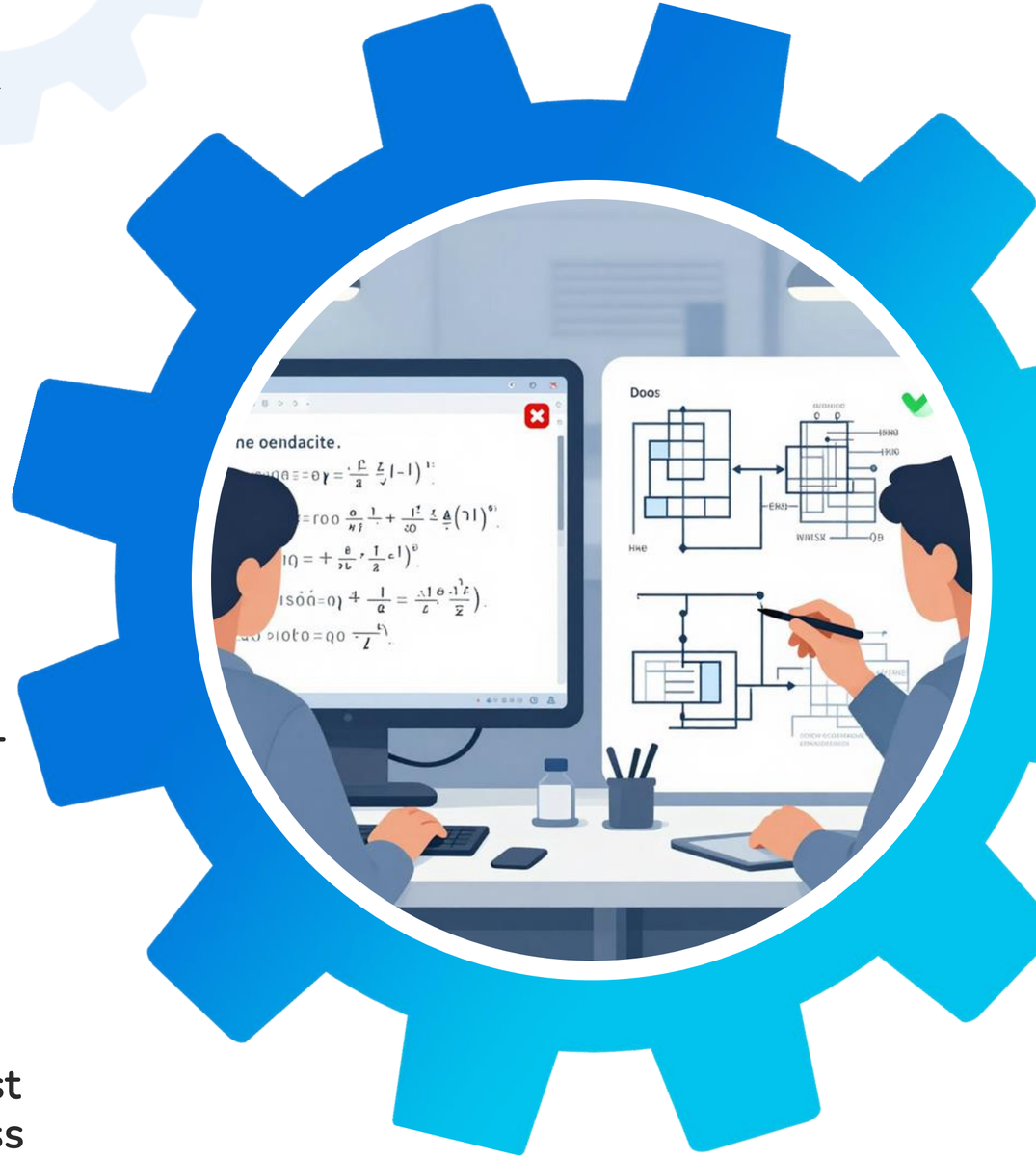
PHASE 3: ENGINEER THE AI

Compare AI derivation with own · Identify discrepancies · Justify with engineering principles · Verify using simulation software

❖ Verbal assessment (~30%)

Teaching student how to prompt responsibly: AI as a tutor, critic & reviewer

How you prompt AI determines whether it replaces your engineering thinking or sharpens it. The same tool can either bypass understanding or deepen it, the difference lies entirely in how the student engages with it.



AI as abused generator

"Give me the state-space model."

AI as abused generator

"Solve the mass-spring-damper system for me."

AI as Tutor / Critic

"Review my free-body diagram; identify missed assumptions."

AI as Tutor / Critic

"Check my state-space dimensions and suggest physical reasonableness tests."

AI MAKES MISTAKES — DON'T ACCEPT OUTPUT VERBATIM

1 Base Question

AI-Generated Output (Mass-Spring-Damper):

$$\dot{x} = Ax + Bu \quad | \quad y = Cx + Du$$

$$A = \begin{bmatrix} 0 & 1 \\ -k/m & -b/m \end{bmatrix} \quad B = \begin{bmatrix} 0 \\ 1/m \end{bmatrix}$$

2 Trick the AI

Use careful "prompt engineering" to get many variations.

"Give the state-space model for a mass-spring-damper system."

3 Many AI Outputs

Generate 20+ outputs.

Some are correct, some contain errors.



Correct Wrong Unclear

4 Student Task

- Work in groups
- Analyze each output
- Compare & debate
- Decide: Correct or Wrong?

EXAMPLES OF AI OUTPUTS (MIX OF CORRECT AND INCORRECT)

Output #1 ✓

$\dot{x} = Ax + Bu \quad | \quad y = Cx + Du$

$$A = \begin{bmatrix} 0 & 1 \\ -k/m & -b/m \end{bmatrix} \quad B = \begin{bmatrix} 0 \\ 1/m \end{bmatrix}$$

Output #2 ✗

$\dot{x} = Ax + Bu \quad | \quad y = Cx + Du$

$$A = \begin{bmatrix} 0 & 1 \\ k/m & -b/m \end{bmatrix} \quad B = \begin{bmatrix} 0 \\ 1/m \end{bmatrix}$$

Output #3 ✓

$\dot{x} = Ax + Bu \quad | \quad y = Cx + Du$

$$A = \begin{bmatrix} 0 & 1 \\ -k/m & -b/m \end{bmatrix} \quad B = \begin{bmatrix} 0 \\ 1/m \end{bmatrix}$$

• • •

Output #21 ✗

$\dot{x} = Ax + Bu \quad | \quad y = Cx + Du$

$$A = \begin{bmatrix} 1 & 0 \\ -k/m & -b/m \end{bmatrix} \quad B = \begin{bmatrix} 1/m \\ 0 \end{bmatrix}$$

Output #22 ✓

$\dot{x} = Ax + Bu \quad | \quad y = Cx + Du$

$$A = \begin{bmatrix} 0 & 1 \\ -k/m & -b/m \end{bmatrix} \quad B = \begin{bmatrix} 0 \\ 1/m \end{bmatrix}$$

ACHIEVEMENT

Students discover through analysis and discussion that **AI can be wrong.** They become more critical and cautious — and never accept AI output verbatim.



Can Make Mistakes ≠ Not Always Correct = Be Critical. Verify. Decide.

Make AI part of the assessment; audit the AI engineer!

Part 2

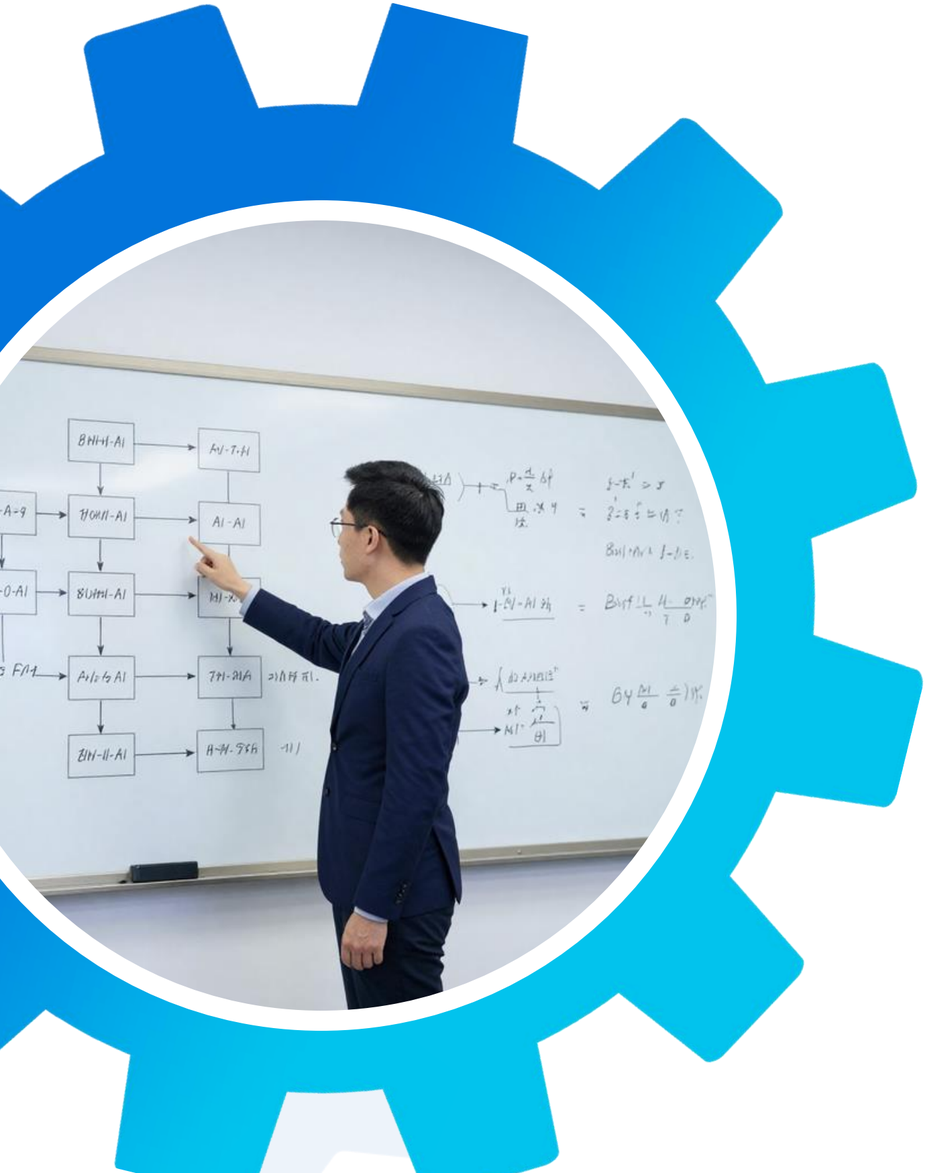
Students are given a complete AI-generated engineering solution package and tasked with critically auditing it as a practicing engineer would, in a face-to-face test environment.

How students are assessed

- Identify assumptions, reasoning errors, and unsupported claims in the AI solution.
- Detect numerical errors and physical inconsistencies using independent verification.
- Assess and defend whether the AI-generated conclusion is trustworthy and complete.

What I had to change in my classroom?

Part 1



TRADITIONAL APPROACH	EMERGING APPROACH

What I had to change in my classroom?

Part 2

Practical meaning

- Don't design assessments pretending AI doesn't exist. Students are already using it.
- Don't assess only outputs AI can trivially generate. Reframe what you measure.
- Do design activities where AI use requires more engineering thinking, not less.

A shift in assessment philosophy was required!

The expectation I set for my students

Problem formulation and assumptions

Define the problem independently. State assumptions explicitly. Show your initial reasoning before engaging AI.

AI interaction

Document how AI was used. Identify where AI influenced your decisions. Challenge AI outputs with engineering principles.

Verification and reflection

Verify results using math, simulation, or physical reasoning. Reflect on what AI contributed vs. what you contributed.

To conclude, how do I (you)?



Thank you for listening

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