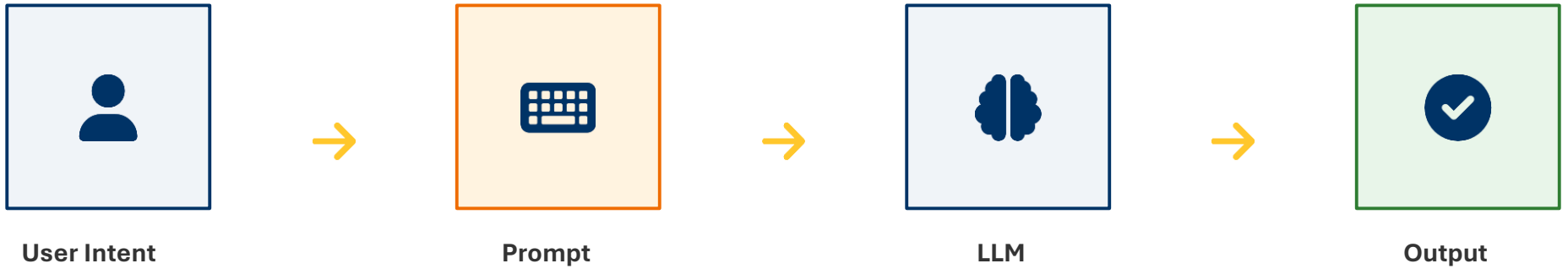
Prompt Engineering Fundamentals

"Prompt Engineering is the strategic process of structuring text to guide **Generative AI models** toward accurate, relevant, and high-quality outputs."



What is Prompt Engineering?

Anatomy of an Effective Prompt

Task Definition

Clearly state what you want the model to do (e.g., "Summarize", "Translate", "Code").

Context

Provide background information, role, or scenario to ground the model's response.

Input Data

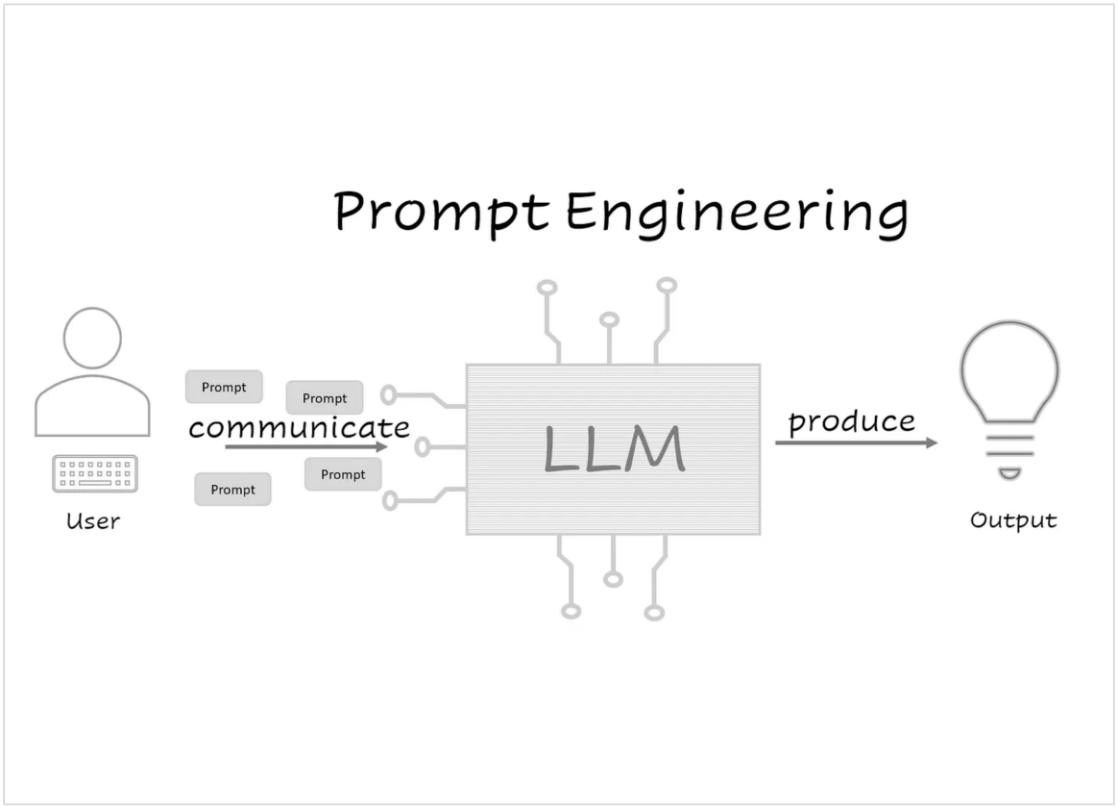
The specific text, code, or data the model needs to process.

Constraints

Limitations on length, style, format, or what to avoid.

Output Indicator

Specify the desired format (JSON, Table, Python Code, Bullet Points).



Why Prompt Engineering Matters

Impact on Model Performance

Accuracy & Relevance

Precise prompts drastically reduce hallucinations and ensure the model stays on topic.

Consistency

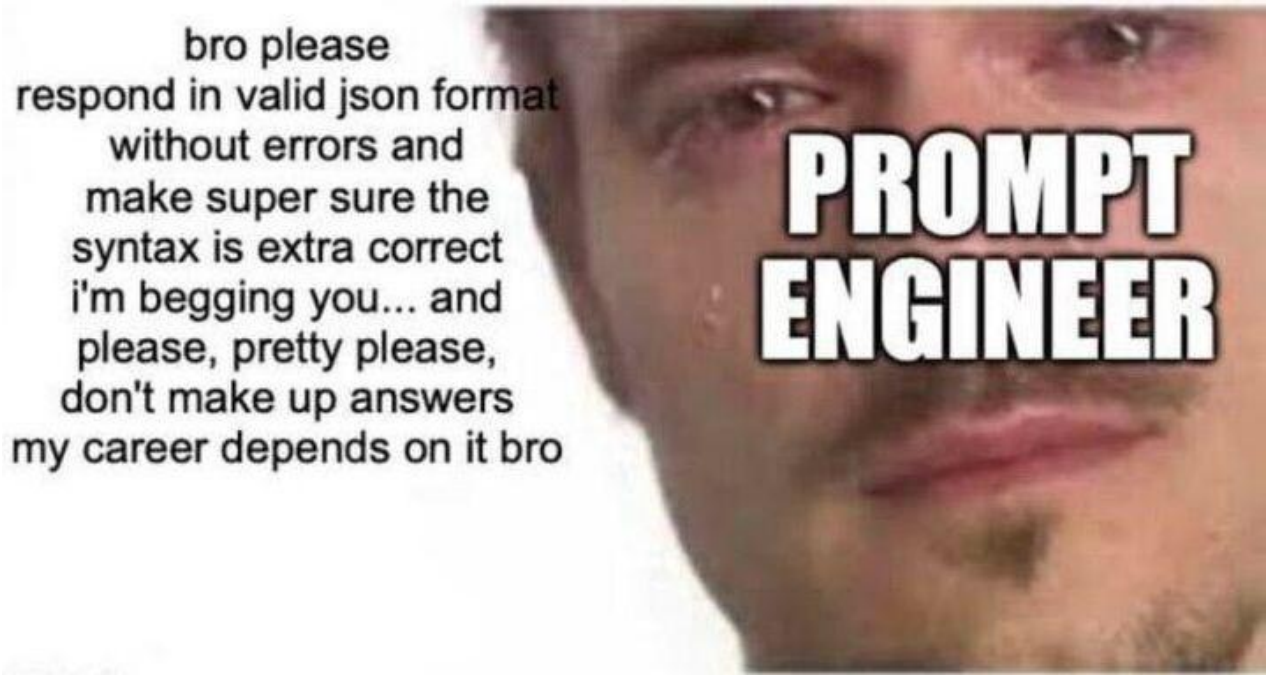
Standardized structures lead to reliable, reproducible outputs across different runs.

Efficiency

Reduces the need for multiple follow-up corrections, saving time and token costs.

Safety & Robustness

Well-engineered prompts include constraints that prevent unsafe or biased generation.



Bad Prompt Example 1: Generic Request

Why Vague Inputs Lead to Vague Outputs

The Prompt

> "Explain prompt engineering."

The Result

AI Response:

"Prompt engineering is the practice of designing inputs for AI models to produce optimal outputs. It is used in natural language processing..."

(A generic, Wikipedia-style definition that lacks depth or specific application.)

Why This Fails

- **No Audience:** Who is this for? A 5-year-old? A PhD student?
- **No Depth:** It doesn't ask for examples, strategies, or code.
- **No Goal:** What should the reader *do* with this information?
- **No Format:** Paragraph? Bullet points? Slide deck?

Good Prompt Example 1: Educational Context

Clear Role, Audience, and Constraints

The Prompt

> "You are an AI instructor. Explain prompt engineering to engineering students in 3 bullet points, focusing on how it affects LLM output quality."

The Result

AI Response:

Precision:
Well-structured prompts reduce ambiguity, ensuring the model performs the specific task requested.

Consistency:
Clear instructions lead to reproducible results across multiple runs.

Relevance:
prevented the model from generating generic or off-topic information.

Why This Works

- **Role Defined:** "AI Instructor" sets a professional, authoritative tone.
- **Audience:** "Engineering Students" implies technical depth is allowed.
- **Format:** "3 bullet points" forces conciseness.
- **Focus:** "Output quality" narrows the scope.

Bad Prompt Example 2: Coding Request

Missing Technical Context

The Prompt

> "Write me code to analyze data."

The Result

AI Response:

"To analyze data, you can use Python's Pandas library. Here is a simple example:
import pandas as pd
df = pd.read_csv('data.csv')
print(df.describe())"

(The model guessed the language, the file format, and the type of analysis. It might be wrong on all counts.)

Why This Fails

- **No Language:** Python? R? SQL? JavaScript?
- **No Dataset:** Is it a CSV? Excel? Database?
- **No Objective:** Statistical analysis? Visualization? Cleaning?
- **No Constraints:** "Use only standard libraries" vs "Use Pandas".

Good Prompt Example 2: Specific Python Task

Explicit Instructions for Code Generation

The Prompt

> "Write a Python script that loads my Excel file named 'sales.xlsx' and performs statistical analysis on it using the Pandas library."

The Result

```
import pandas as pd

# Load the Excel file
df = pd.read_excel("sales.xlsx")

# Perform statistical analysis
stats = df.describe()

print(stats)
```

Why This Works

- **Language Specified:** "Python script".
- **Input Defined:** "Excel file named 'sales.xlsx'".
- **Tool Chosen:** "Using Pandas library".
- **Objective Clear:** "Statistical analysis".

Bad Prompt Example 3: Business Request

Lack of Context Leads to Generic Advice

The Prompt

> "Help me improve my business."

The Result

AI Response:

"To improve your business, consider these strategies:
1. Focus on customer satisfaction.
2. Improve your marketing efforts.
3. Optimize your operations.
4. Manage your finances better."

(This applies to a bakery, a tech startup, or a car wash. It helps no one.)

Why This Fails

- **No Industry:** SaaS? Retail? Manufacturing?
- **No Objective:** More revenue? Less churn? Hiring?
- **No Constraints:** Budget? Team size? Timeline?
- **No Context:** Is the business failing or growing?

Good Prompt Example 3: Strategic Business Analysis

Context-Aware and Actionable

The Prompt

> "You are a business analyst. Provide 3 actionable recommendations to improve customer retention for a subscription-based SaaS startup, assuming a limited marketing budget."

The Result

AI Response:

Automated Onboarding:
Implement a low-cost email sequence to guide new users to their "aha!" moment quickly.

Usage Monitoring:
Identify users who haven't logged in for 14 days and send a personalized re-engagement nudge.

Community Building:
Create a free user forum to foster peer support, reducing support costs while increasing stickiness.

Why This Works

- **Role:** "Business Analyst" (Analytical, structured).
- **Industry:** "SaaS Startup" (Recurring revenue focus).
- **Goal:** "Improve Customer Retention".
- **Constraint:** "Limited Budget" (Focus on organic/low-cost tactics).

Bad Prompt Example 4

The Undefined Task

THE PROMPT

"Summarize this report." [Attached 50-page PDF]

Why It Fails

- **No Length Constraint:** One sentence? Five paragraphs?
- **Missing Format:** Bullet points? Executive summary?
- **No Focus Area:** Financials? Technical details? Market analysis?
- **No Audience:** CEO? Engineers? Public?

Likely Result

"[The model produces a generic 3-paragraph summary that misses the specific financial data you actually needed, forcing you to re-prompt.]"

Good Prompt Example 4

The Precise Summary

THE PROMPT

"Summarize the attached financial report for the CFO. Focus specifically on Q3 revenue growth and identified risk factors. Format the output as a bulleted list with a maximum of 5 key points."

Why It Works

Audience:	"For the CFO" (Implies high-level, numbers-focused).
Specific Focus:	"Q3 revenue growth and risk factors".
Format:	"Bulleted list".
Constraint:	"Max 5 key points" (Prevents verbosity).

Result

Q3 Revenue increased by 15% YoY driven by cloud adoption.
Supply chain disruptions pose a moderate risk to Q4 delivery.
...

Bad Prompt Example 5

THE PROMPT

"Write a Python script to scrape data."

Why It Fails

- **Missing Target:** Which website? (Structure varies wildly).
- **Undefined Data:** What fields? (Prices? Titles? Dates?).
- **No Libraries:** BeautifulSoup? Selenium? Scrapy?
- **No Constraints:** Error handling? Rate limiting? Output format (CSV/JSON)?

Likely Result

"[Generates a generic BeautifulSoup example for 'example.com' that is useless for your actual target site and lacks necessary error handling.]"

Good Prompt Example 5

THE PROMPT

"Write a Python script using BeautifulSoup to scrape product titles and prices from 'example-shop.com'. Save the data to a CSV file named 'products.csv'. Include error handling for network timeouts and missing elements."

Why It Works

- **Library:** "Using BeautifulSoup" (Defines tool).
- **Target Data:** "Product titles and prices" (Specific fields).
- **Output:** "CSV file" (Specific format).
- **Robustness:** "Include error handling" (Production ready).

Result

```
import requests
from bs4 import BeautifulSoup
import csv

try:
  response = requests.get(url, timeout=10)
  # ... code continues with error handling ...
```

Prompting Best Practices: The Do's

Strategies for Success

KAUST Academy

Be Specific

Leave as little room for interpretation as possible. Define length, tone, and audience explicitly.

"Write a **500-word** technical article for **engineers**..."

Use Delimiters

Use punctuation to clearly separate instructions from input data to prevent confusion.

"Summarize the text delimited by triple quotes: **"'[Insert Text]'"**"

Ask for Structured Output

Request formats that are machine-readable or easy to parse, like JSON, HTML, or CSV.

"Output the result as a **JSON object** with keys: 'summary', 'sentiment'."

Iterate and Refine

Treat prompting as an iterative process. If the first result isn't perfect, adjust your constraints and try again.

"That was too detailed. **Rewrite it to be more concise** and remove jargon."

Prompting Best Practices: The Don'ts

Pitfalls to Avoid

Don't Be Vague

Avoid ambiguous instructions that force the model to guess your intent.

~~"Write something cool."~~
Better: "Write a sci-fi story about Mars."

Don't Assume Knowledge

The model doesn't know your specific context, internal acronyms, or unstated preferences.

~~"Fix the bug in the code."~~
Better: "Fix the SyntaxError on line 5..."

Don't Overload

Asking for too many complex tasks in a single prompt can confuse the model. Break it down.

~~"Translate, summarize, code, and email..."~~
Better: Chain prompts step-by-step.

Avoid Negatives

Models struggle with "Don't do X". It's more effective to state what to do instead.

~~"Don't write long sentences."~~
Better: "Keep sentences under 15 words."

Prompting Techniques

Zero-Shot Prompting: Example

Relying on Pre-Trained Knowledge

Concept

You ask the model to perform a task **without providing any examples**. The model must rely entirely on its internal training data to understand the instruction.

Best for: Common tasks like translation, summarization, or general knowledge questions where the model already "knows" what to do.

User Input

Classify the sentiment of the following text:
"The food was okay, but the service was incredibly slow."

↓

AI Output

Sentiment: Negative

Few-Shot Prompting: Example

Teaching the Model by Example

Concept

Providing a few examples (shots) of input-output pairs helps the model understand the specific format, tone, or logic required.

Why it works: LLMs are excellent pattern matchers. They continue the pattern you establish in the context window.

Text: "That movie was fantastic!"
Sentiment: Positive

Text: "I wasted 2 hours of my life."
Sentiment: Negative

Text: "It was okay, nothing special."
Sentiment: Neutral

Text: "The acting was great, but the plot was boring."
Sentiment: Mixed

Instruction Following: Complex Constraints

Adhering to Strict Formatting Rules

The Prompt

"Write a poem about AI."

Constraints:

- ☑ Exactly 4 lines long
- ☑ Rhyme scheme AABB
- ☑ Must include "silicon"
- ☑ Do NOT use the word "robot"

Deep inside the silicon mind,
Answers flow for all mankind.
Learning fast with every byte,
Guiding us into the light.

Chain-of-Thought: Step-by-Step Example

Problem: "Roger has 5 balls. He buys 2 cans of tennis balls. Each can has 3 balls. How many balls does he have now?"

Standard Prompting

AI Response:

The answer is 11.

(Without reasoning, the model might guess or hallucinate on more complex math.)

Chain-of-Thought

AI Response:

Roger started with 5 balls.
2 cans of 3 balls means 2 * 3 = 6 balls.
5 + 6 = 11.

The answer is 11.

Magic Phrase: "Let's think step by step."

Meta-Prompting: The Optimization Loop

Using AI to Improve AI Inputs

Example:
User: "Write me a prompt that helps me learn Python."
AI (Meta-Prompt): "Here is a better prompt: 'Act as a Python tutor. Create a 4-week study plan for a beginner, including daily exercises and resources.'"

Persona Prompting

Adopting a Role for Tailored Outputs

Definition

Assigning a specific role or persona to the AI model. This context steers the model's vocabulary, tone, complexity, and perspective to match the intended audience.

Why it works: It narrows the search space in the model's training data, focusing on the subset of language patterns associated with that profession or character.

PERSONA: 5-YEAR-OLD

"Explain Quantum Physics to a 5-year-old."

"Imagine you have a magic ball that can be red and blue at the same time until you look at it!"

PERSONA: PHD PHYSICIST

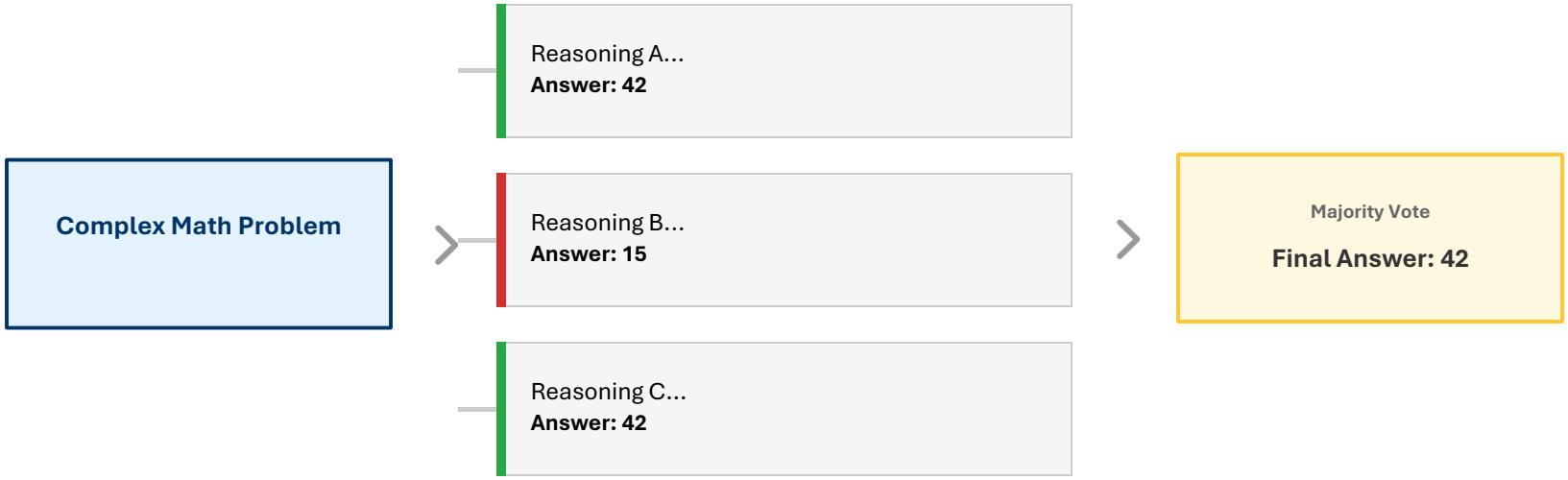
"Explain Quantum Physics to a PhD student."

"Quantum mechanics describes systems where the wavefunction evolves unitarily according to the Schrödinger equation..."

Self-Consistency

Majority Voting for Robustness

Instead of taking the first answer, we generate multiple Chain-of-Thought reasoning paths and select the most frequent final answer. This mimics "double-checking" your work.



Quiz Time

Check Your Understanding

1. What is the most effective way to improve a vague prompt?

- A) Make it shorter
- B) Add specific constraints and context
- C) Use more capital letters

2. Which role is used to define the persistent persona of the AI?

- A) User
- B) Assistant
- C) System