



Practical Uses of AI

Martin Reynolds



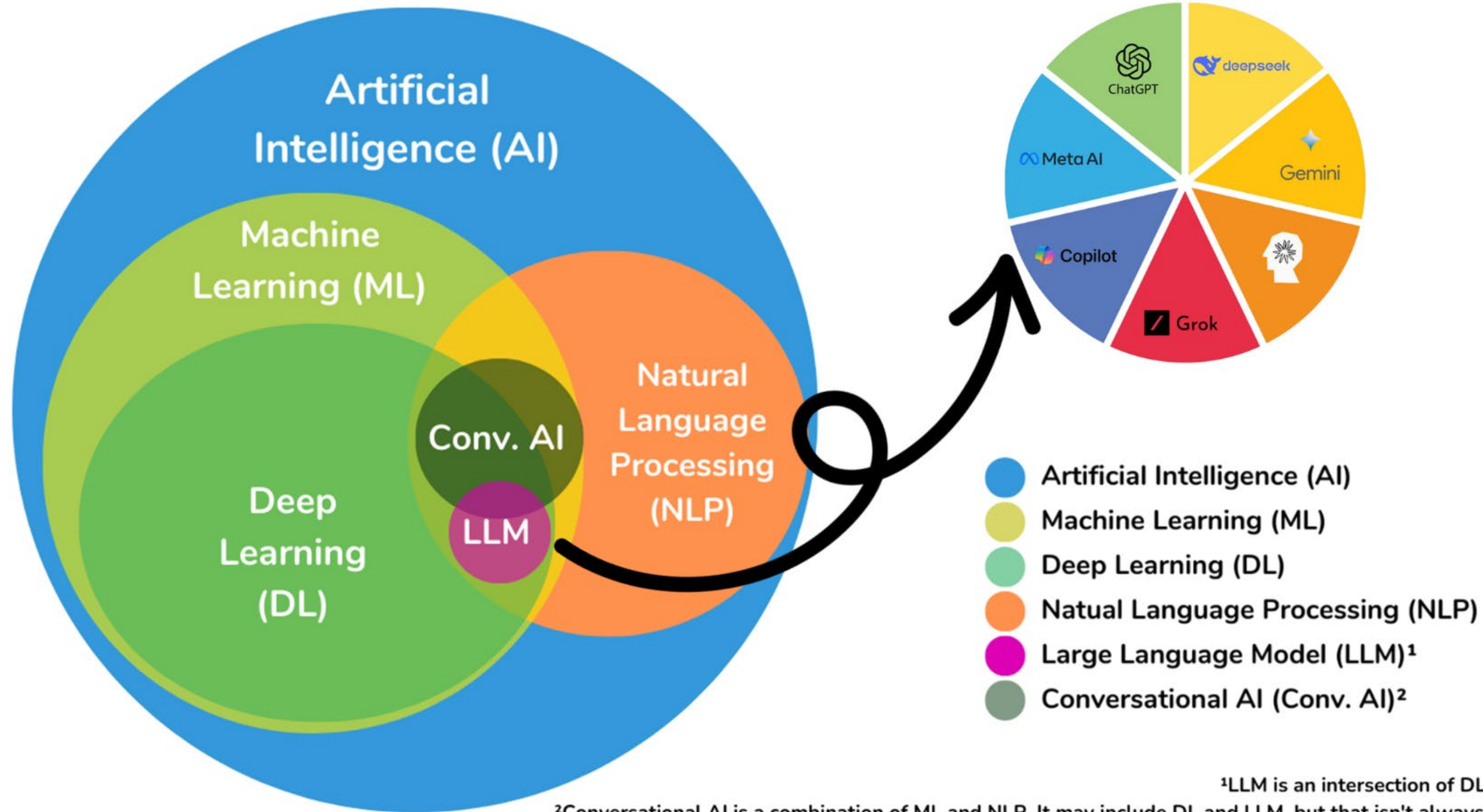
Flexible Engineering, on-demand

Agenda

- AI – What is it?
- Basic tools
- AI Integration
 - Agentic
 - A2A
 - MCP
- Maintenance Systems
 - Current methods
 - How to integrate AI
 - Future uses (Human Centric)



What is AI?



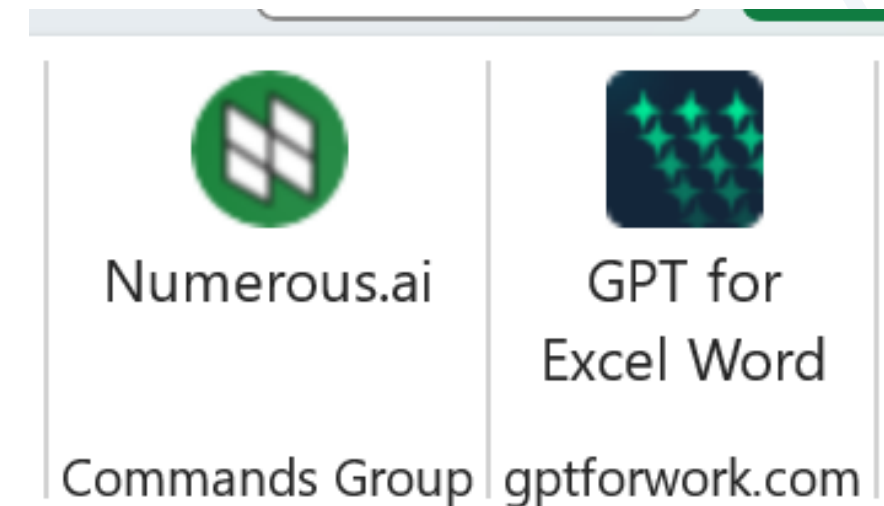
Spreadsheets

C4 =NUM.AI("translate the following to german",A4)

	A	B	C	D
1	Material Properties Table Example			
2				
3	Material	Density [kg/m^3]	German	
4	Mild steel	7850	Baustahl	
5	Titanium	4500	Titan	
6	Aluminium	2700	Aluminium	
7	Stainless Steel	8000	Edelstahl	
8	PVC pipe	1400	PVC-Rohr	
9	Brass	8,400	Messing	
10	Copper	8960	Kupfer	
11	Wrought Iron	7800	Schmiedeeisen	
12				

B4 =NUM.AI("Return the material property value requested in the units highlighted within square brackets",B\$3,\$A4)

	A	B	C	D	E	F	G	H	I	J
1	Material Properties Table Example									
2										
3	Material	Density [kg/m^3]	German							
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9	Brass	8,400	Messing							
10	Copper	8960	Kupfer							
11	Wrought Iron	7800	Schmiedeeisen							
12										



GENERAL FUNCTIONS

- =NUM.AI(...)**
Use GPT to answer questions, extract info, and more
- =NUM.INFER(...)**
Teach GPT to categorize or reformat by providing examples of what you want
- =NUM.WRITE(...)**
Have GPT write messages and longer text

FORMULAS

- Generate formula**
- Explain formula**

DATA

- Classify**
Classify something as one of multiple categories
- Reformat**
Reformat data to your desired format
- Extract**
Pull specific information from text
- Sentiment analysis**
Analyze tone and emotion of a text

TEXT

- Rewrite text**
Change the tone, format, length or voice of a text
- Translate**
Convert text to a different language

INFORMATION

- Make educated guess**
(Like guessing name from an email)
- Get basic information**
(Like getting population of a country)

Customised LLMs

Give me the calculation to determine hoop stress in a thin walled cylinder.



Calculation of Hoop Stress in a Thin-Walled Cylinder

References:

1. (Shigley's Mechanical Engineering Design, 9th Edition, Richard G. Budynas & J. Keith Nisbett).
2. (Roark's Formulas for Stress and Strain, Warren C. Young & Richard G. Budynas).

1 - Introduction

The hoop stress (also called circumferential or tangential stress) in a thin-walled cylindrical pressure vessel is the internal stress that acts along the circumference of the cylinder due to internal pressure. It is a crucial parameter in the design of pressure vessels, pipelines, and storage tanks.

For a thin-walled cylinder, the wall thickness t is significantly smaller than the internal diameter d_i (typically, $t/d_i < 0.1$). In such cases, the radial stress is negligible compared to the tangential (hoop) and axial stresses, and simplified formulas can be used.

2 - Assumptions

- The cylinder is long enough to ignore edge effects.
- The wall thickness t is small compared to the radius r , ensuring uniform stress distribution.
- The material is homogeneous and isotropic.
- Internal pressure p is uniformly distributed.
- The external pressure is negligible.

3 - Inputs

- p = Internal pressure (Pa, psi)
- d_i = Internal diameter of the cylinder (m, in)
- t = Wall thickness of the cylinder (m, in)

4 - Calculation Body

For a **thin-walled** pressure vessel, the hoop stress is given by the equation:

$$\sigma_t = \frac{pd_i}{2t} \quad (\text{Eq. 3-52, Shigley})$$

where:

- σ_t = Hoop stress (Pa, psi)
- p = Internal pressure (Pa, psi)
- d_i = Internal diameter (m, in)
- t = Wall thickness (m, in)

Additionally, the **maximum hoop stress** is:

$$\sigma_t^{\max} = \frac{p(d_i + t)}{2t} \quad (\text{Eq. 3-53, Shigley})$$

which considers the average diameter $d_i + t$ rather than the internal diameter alone.

For **closed cylinders**, there is also an axial (longitudinal) stress:

$$\sigma_l = \frac{pd_i}{4t} \quad (\text{Eq. 3-54, Shigley})$$

which is half the hoop stress and acts along the length of the cylinder.

5 - Example Calculation

Given Data:

- Internal pressure: $p = 2 \text{ MPa}$ (Mega Pascal)
- Internal diameter: $d_i = 500 \text{ mm}$
- Wall thickness: $t = 10 \text{ mm}$

Step-by-Step Computation:

Using the thin-walled formula:

$$\sigma_t = \frac{(2 \times 10^6) \times 500}{2 \times 10}$$

$$\sigma_t = \frac{10^9}{20} = 50 \text{ MPa}$$

The **maximum hoop stress**:

$$\sigma_t^{\max} = \frac{(2 \times 10^6) \times (500 + 10)}{2 \times 10}$$

$$\sigma_t^{\max} = \frac{(2 \times 10^6) \times 510}{20} = 51 \text{ MPa}$$

The **longitudinal stress**:

$$\sigma_l = \frac{(2 \times 10^6) \times 500}{4 \times 10}$$

$$\sigma_l = 25 \text{ MPa}$$

6 - Summary

- **Hoop Stress:** 50 MPa
- **Maximum Hoop Stress:** 51 MPa
- **Longitudinal Stress:** 25 MPa

Coding - python

- Standard code compilation through notebook, called through command prompt, LLM
- Integrated Design Environment (IDE)
 - Spyder, Pycharm – support for mathematical and scientific libraries
 - VS Code – good general coding IDE with multi-language support, integrates Github CoPilot
 - File structure
 - Code completion
 - Audit trails

ChatGPT 4o

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Take the following table and reproduce this as a python script that allows the user to type in a significant wave height (Hs) and the script should calculate the dynamic factor by interpolation only. It should calculate the dynamic factor for different loadcases.

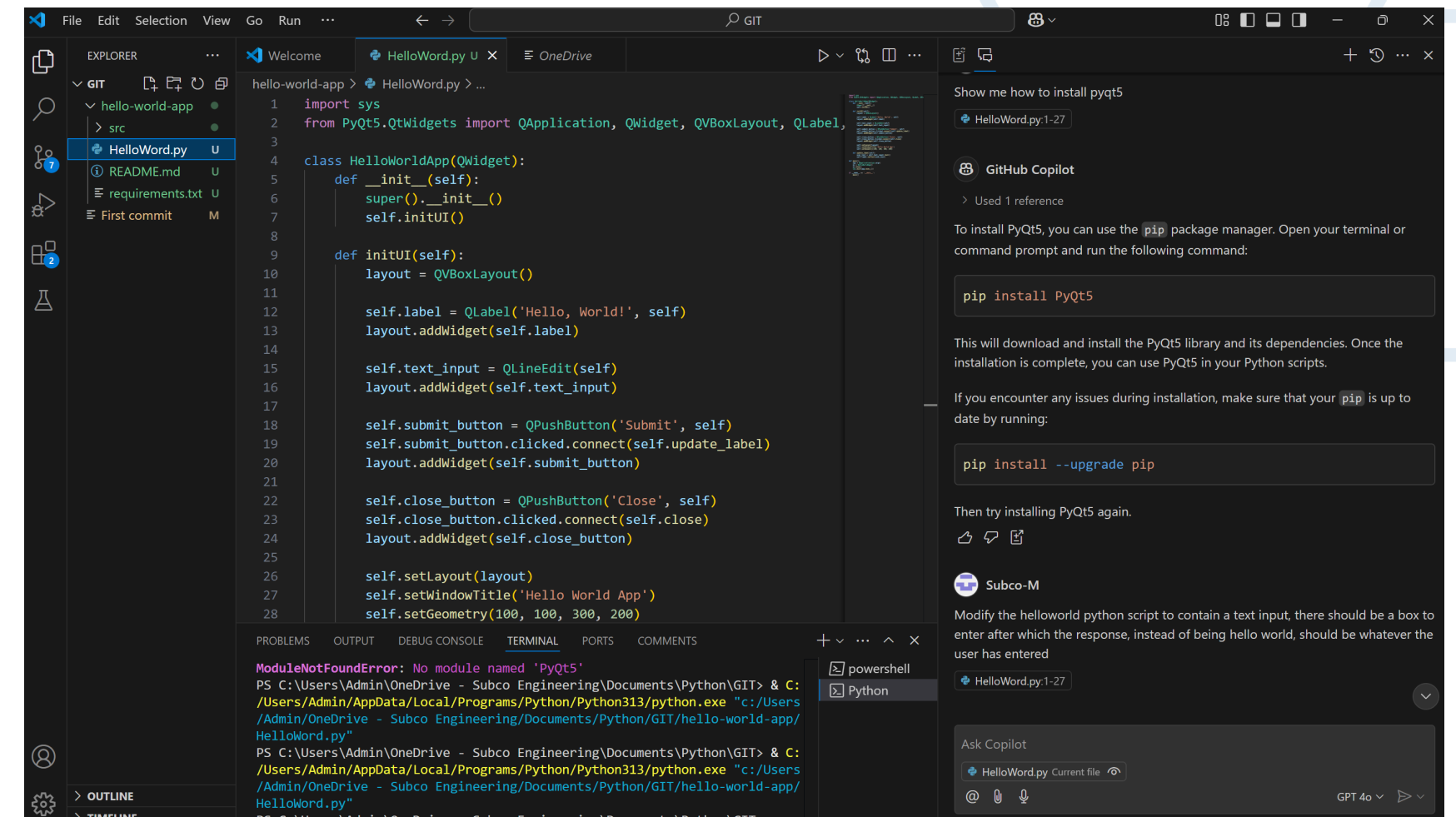
Here's the Python script for interpolating the dynamic factor based on significant wave height (Hs) input and calculating for different load cases.

This script is designed with reference to the data in your table. It will interpolate the dynamic factor F_d for each load case and sea state.

```
Dynamic Factor Interpolation

1 import numpy as np
2
3 def interpolate_dynamic_factor(hs):
4     # Define the sea state data with corresponding wave heights and dynamic factor
5     sea_states = [2.0, 3.9, 5.0, 7.0]
6     dynamic_factors = {
7         "Submerged near surface": [2.25, 2.5, 2.72],
```

Message ChatGPT



Coding – python - executables

4.9 Rope safety factors

4.9.1 The minimum safety factor for ropes used for manned submersibles is to be taken as 8,0 for steel wire ropes and 10,0 for man-made fibre ropes. Where manned diving operations take place in conditions in excess of Sea State 4, where the hoist factor, F_h , is greater than 1,7, the rope safety factor is to be increased as follows:

$$SF_{SWR} = 8,0 \times \frac{F_h}{1,7} \text{ for steel wire ropes, or}$$

$$SF_{synthetic} = 10 \times \frac{F_h}{1,7} \text{ for synthetic fibre ropes.}$$

4.9.2 The safety factor for wire ropes used for unmanned submersibles is to be determined from the following expression:

$$SF_{swh} = \frac{10^4}{\frac{200}{27}SWL + \frac{43000}{27}} \frac{F_{h,swh}}{1,7}$$

where

SF_{swh} = safety factor required at significant wave height (swh)

$F_{h,swh}$ = hoisting factor at a specific swh derived in accordance with Ch 4, 4.4 Dynamic forces

SWL = safe working load of the submersible handling system

LLOYD'S REGISTER

107

CODE FOR LIFTING APPLIANCES IN A MARINE ENVIRONMENT, JULY 2022

Cranes and Submersible Lifting Appliances

Chapter 4

Section 5

For submersible handling systems with $SWL \leq 10t$, $SF = 6,0 \frac{F_{h,swh}}{1,7}$.

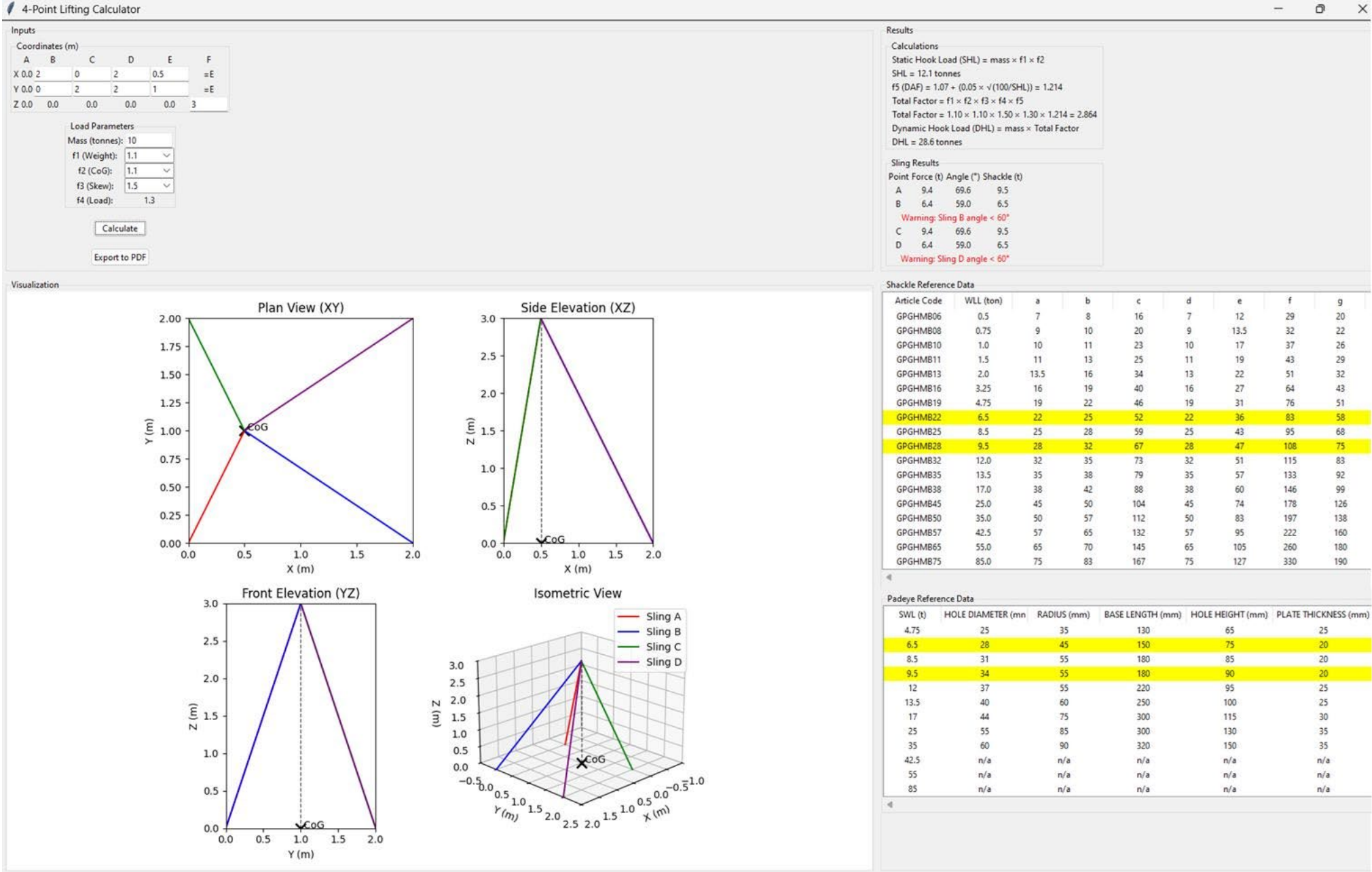
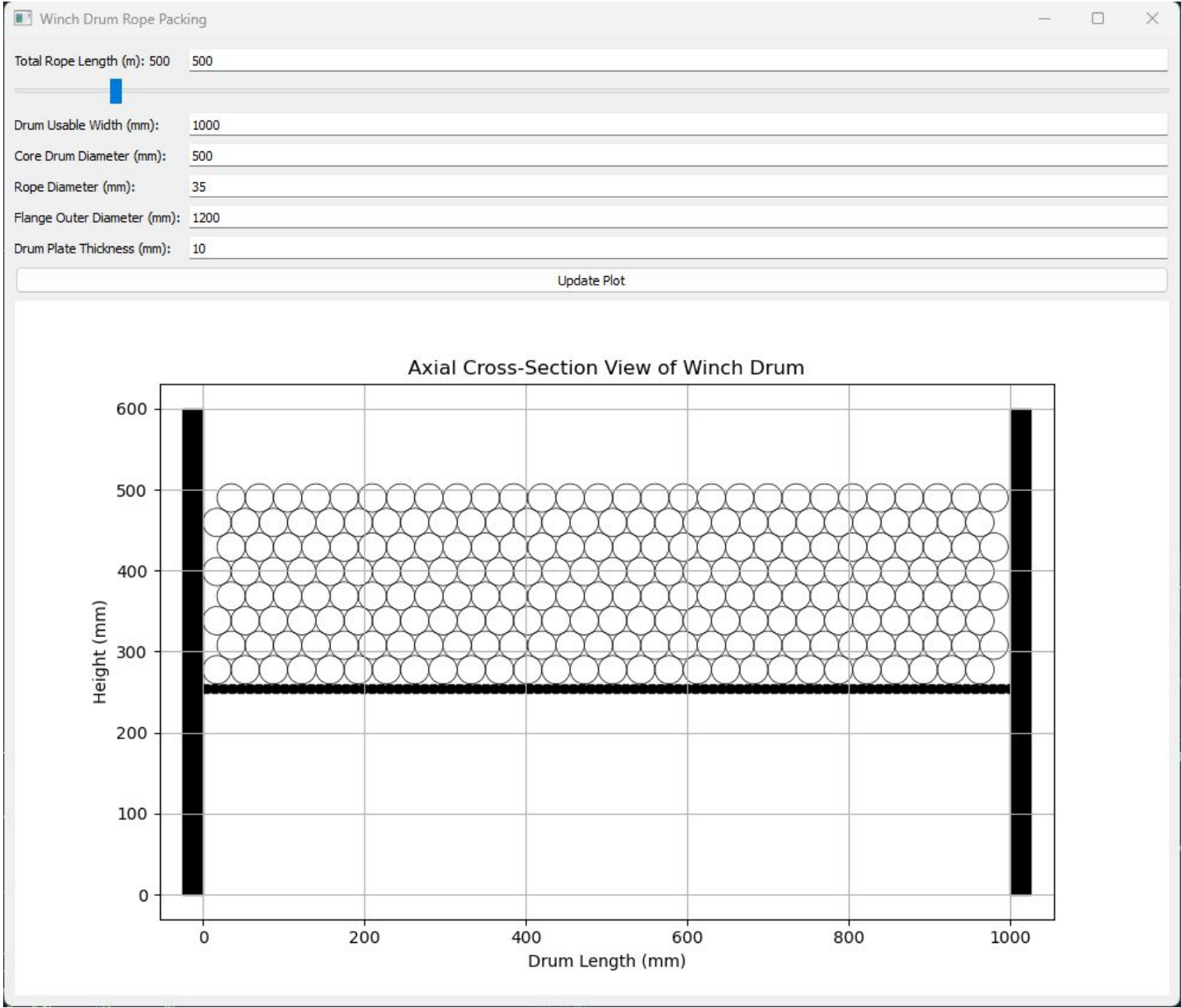
and $SWL \geq 160t$, $SF = 3,6 \frac{F_{h,swh}}{1,7}$

The factor $\frac{F_{h,swh}}{1,7}$ is not to be taken as less than 1,0.

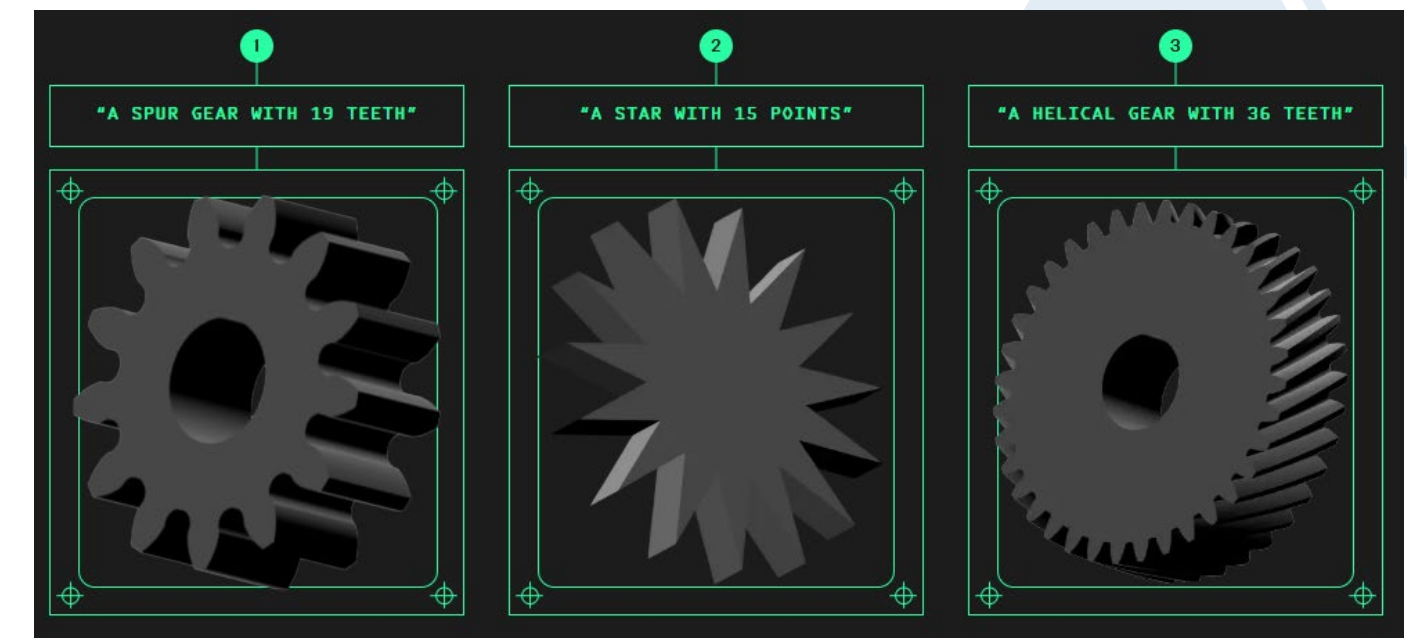
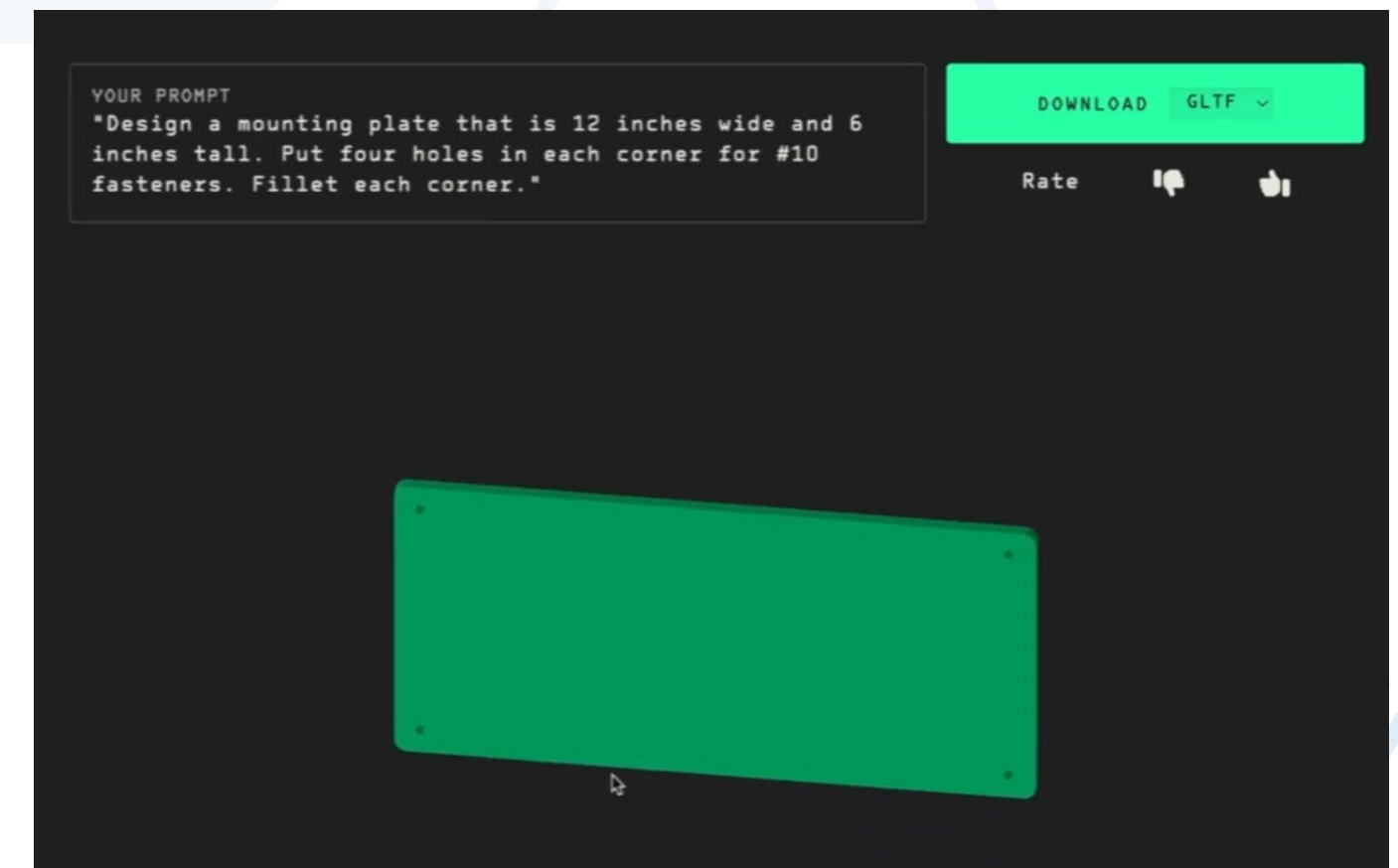
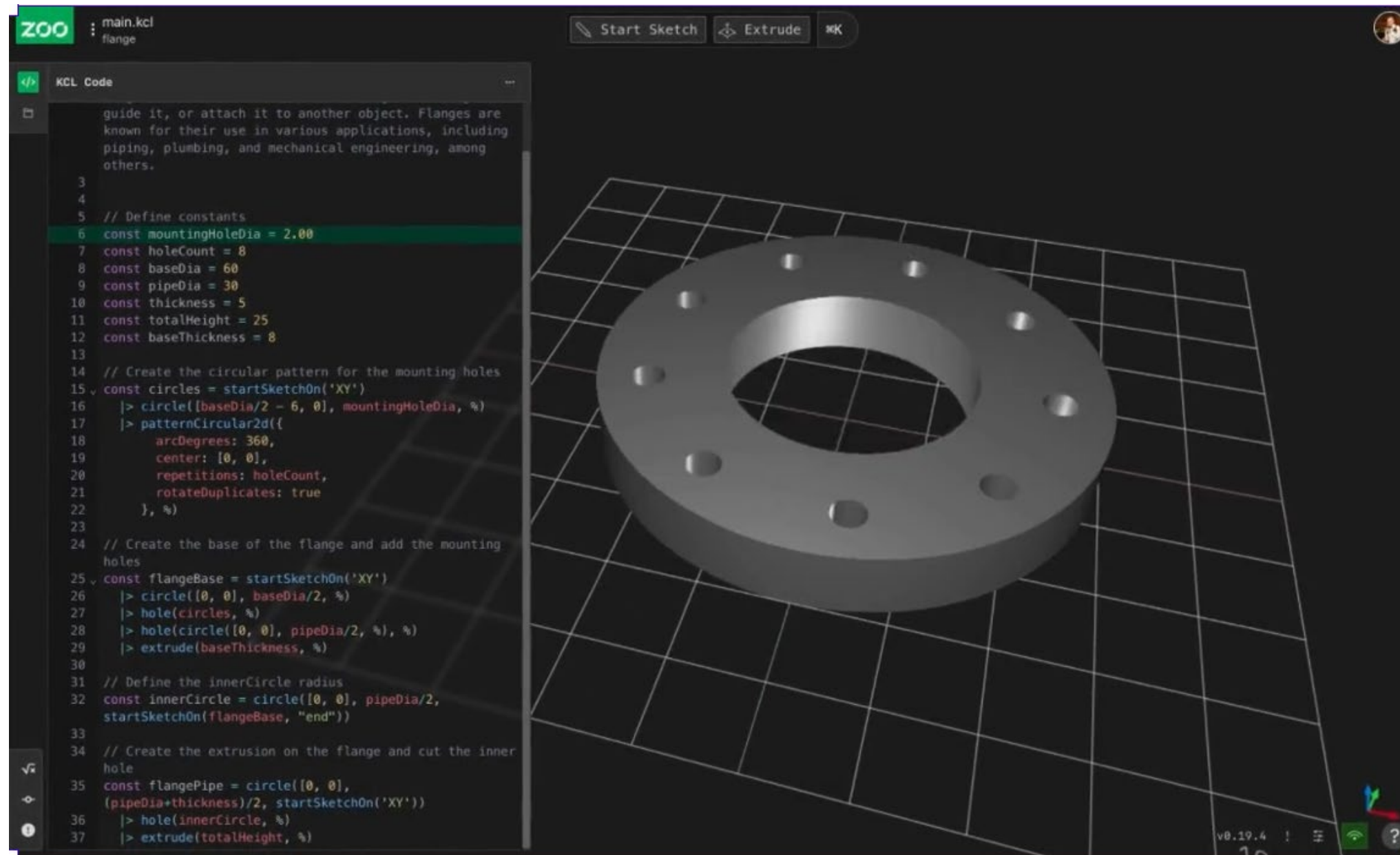
I would like you to take the following screenshots, which are from an engineering design code, then create a python script that I can convert to an executable to perform calculations. I would like to check your understanding of the problem before writing this script, so do not write the script yet but instead show a summary of your understanding.

The screenshot shows a software application titled "Rope Safety Factor Calculator". It has a light gray background and a white border. The interface includes several input fields and a calculation button. The "Select Rope Type" dropdown is set to "Steel Wire Rope". The "Select Submersible Type" dropdown is set to "Unmanned Submersibl". The "Enter Safe Working Load (SWL):" field contains the value "10". The "Enter Hoisting Factor:" field contains the value "1.2". Below these fields is a button labeled "Calculate Safety Factor". At the bottom of the window, the result "Safety Factor: 7.06" is displayed.

Coding – python - executables

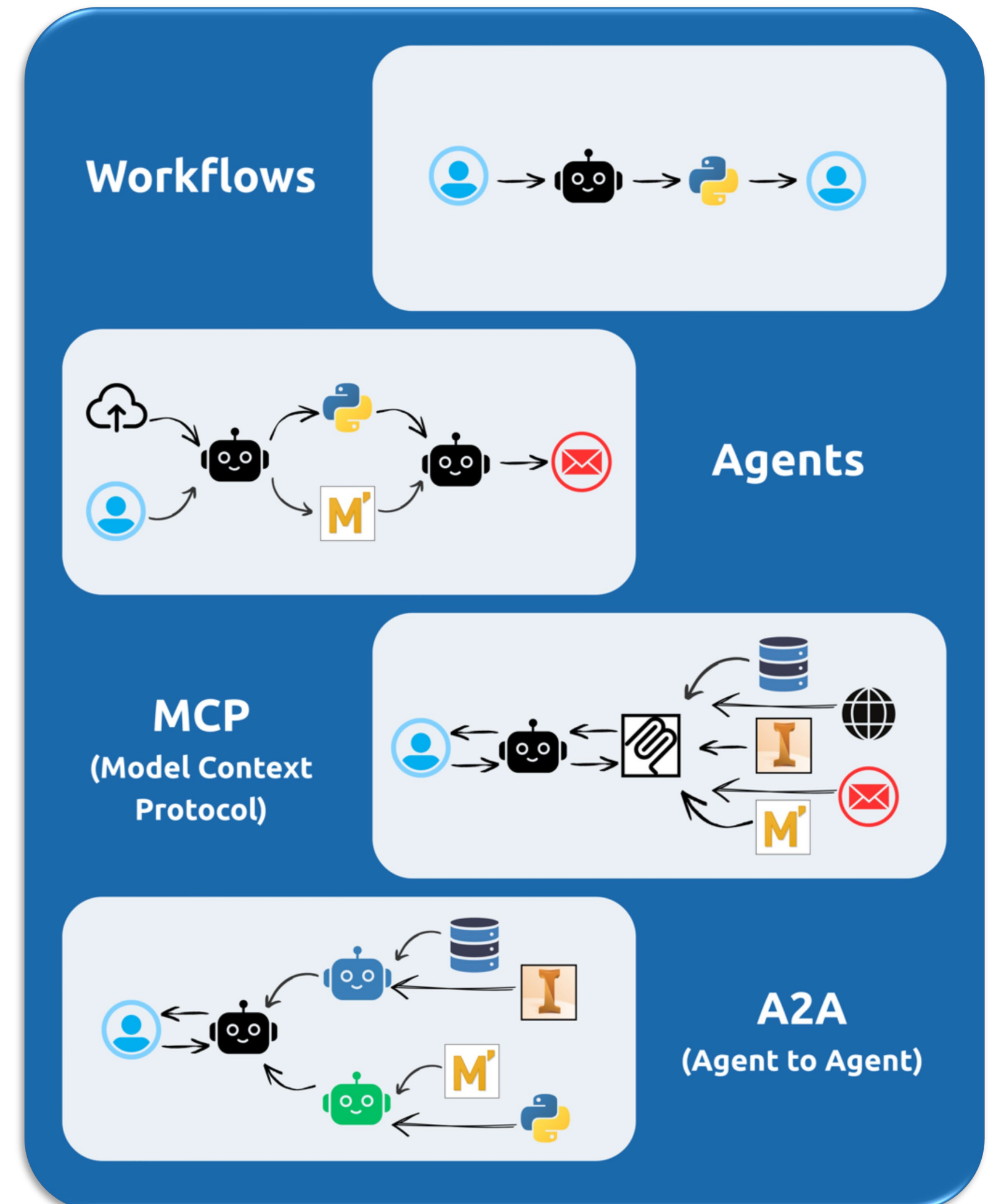


Text-to-CAD



AI Integration

- Workflows
 - Connect applications and user prompts via API's
 - 3rd party workflow automation software (Zapier, Make, N8N)
 - Triggers, Actions, Results
- Agents
 - Decision making, semi or fully -autonomous
- MCP (Model Context Protocol)
 - Defines how AI applications connect and interact with external tools, data sources, and systems
- A2A (Agent to Agent)
 - Defines how agents can interact
 - Can use MCP to connect Agents with resources
 - Specialised tasks



Maintenance Systems

Preventative




Predictive



Human Centric



Human Centric Maintenance

- Natural Language Queries
 - Input: *Show compressors exceeding normal vibration levels this week*
 - Output: *Interactive spectrum chart*
Priority-ranked list (e.g., "Unit G205: 142% baseline vibration- imminent bearing failure risk")
- Prescriptive Notifications
 - Input: *Set up an alert to send a message via teams when maintenance on any hydraulic pump is required within the next week*
 - Output:  *Predictive Alert: Hydraulic Pump P402*
Diagnosis: Seal degradation (73% likelihoodrootcause)
Recommended Actions: Replace seals before 2026-01, Parts Needed: SK#7452
- Reporting
 - Input: *Create a monthly report to show what equipment requires maintenance within the next month*
 - Output: *Monthly report with itemised list for maintenance repairs required, ranked by likelihood of failure and location [cooler failure (25%): bearing damage 20%, sensor failure 5%]*



SUBCO

Flexible Engineering, on-demand