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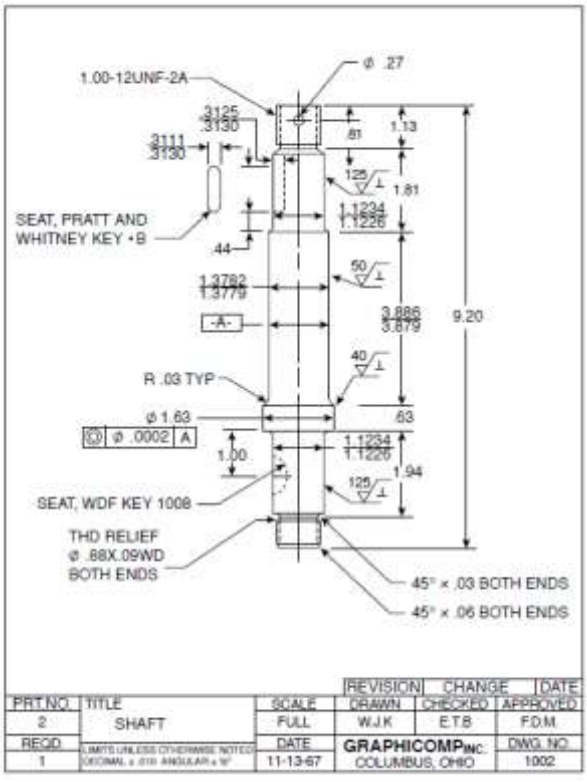
Module 3: Design & Engineering

Background

Engineering sketches

- Drawing is very important in design because a lot of information is created and transmitted in the drawing process.
- Design drawings include sketches, freehand drawings, and
- computer-aided design and drafting (CADD) models that extend from simple wire-frame drawings through elaborate solid models
- In brief, graphic images are used to communicate with other designers, the client, and the manufacturing organization. Sketches and drawings:
    - serve as a launching pad for a brand-new design;
    - support the analysis of a design as it evolves;
    - simulate the behavior or performance of a design;
    - record the shape or geometry of a design;
    - communicate design ideas among designers;
    - ensure that a design is complete (as a drawing and its associated marginalia may remind us of still-undone parts of that design);
    - communicate the final design to the manufacturing specialists.



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MATHEMATICAL MODELING IN DESIGN

- MATHEMATICAL MODELS are central to design because we have to be able to predict the behavior of the devices or systems that we are designing.
- It is important for us to ask: How do we create mathematical models? How do we validate such models? How do we use them? And, are there any limits on their use?
- We will focus on representing the behaviour and function of real devices in mathematical terms.
- Basic Principles of Mathematical Modeling
    - Why do we need a model?
    - For what will we use the model?
    - What do we want to find with this model?
    - What data are we given?
    - What can we assume?
    - How should we develop this model, that is, what are the appropriate physical principles we need to apply?
    - What will our model predict?
    - Can we verify the model's predictions (i.e., are our calculations correct?)
    - Are the predictions valid (i.e., do our predictions conform to what we observe?)
    - Can we improve the model?

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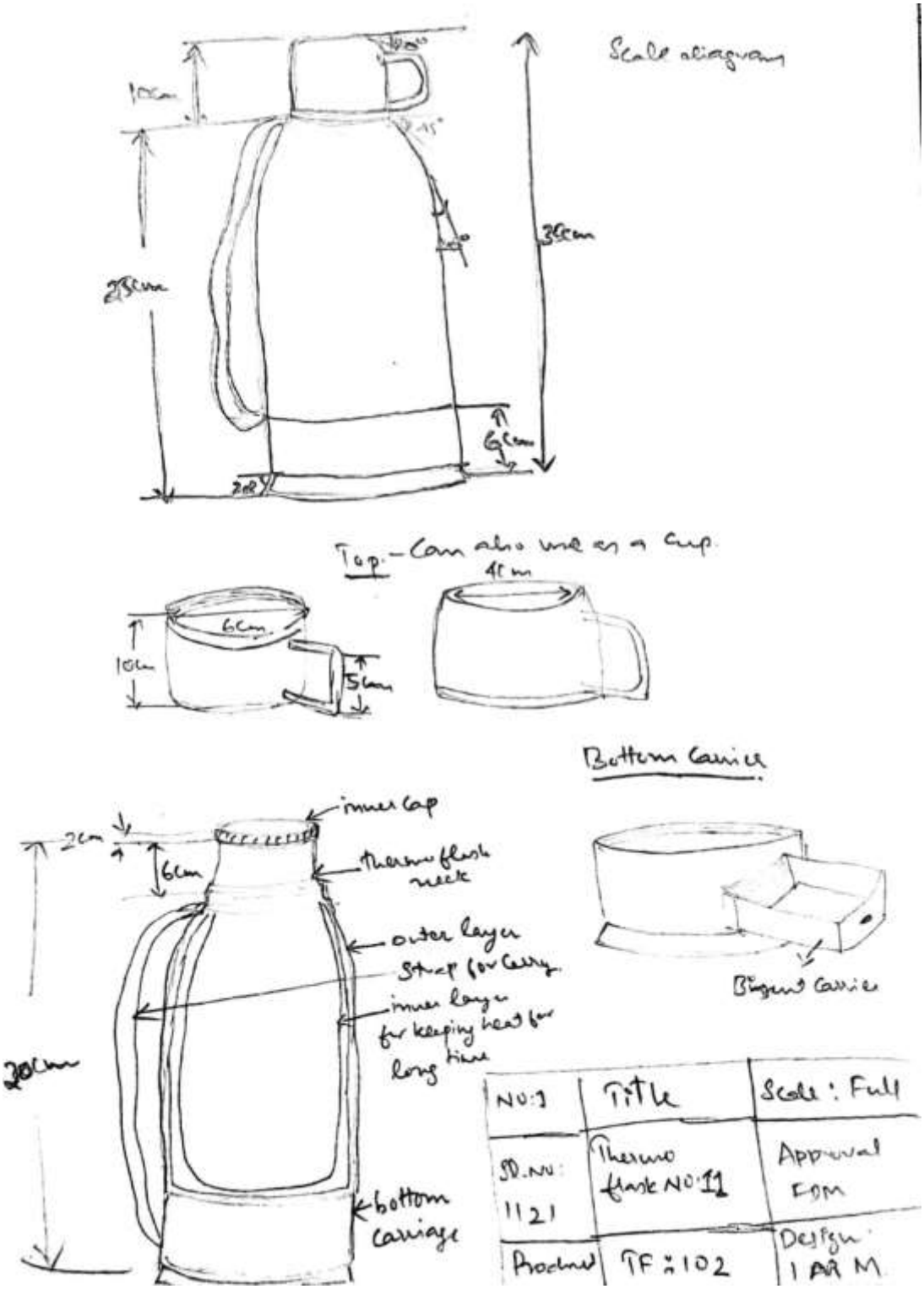
Q1) Graphically communicate the design of a thermo flask used to keep hot coffee. Draw the detailed 2D drawings of the same with design detailing, material selection, scale drawings, dimensions, tolerances, etc. Use only hand sketches.

Solution:



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Material selection

Top cap:

- This section can also be used a cup for drinking coffee
- Since it has to withstand hot coffee, we must use a high-quality plastic material which can support minimum 200 ^{0}C on inside
- The plastic is coated with a low weight steel material
- The colour of the material can be of three choices – Black, red & steel colour

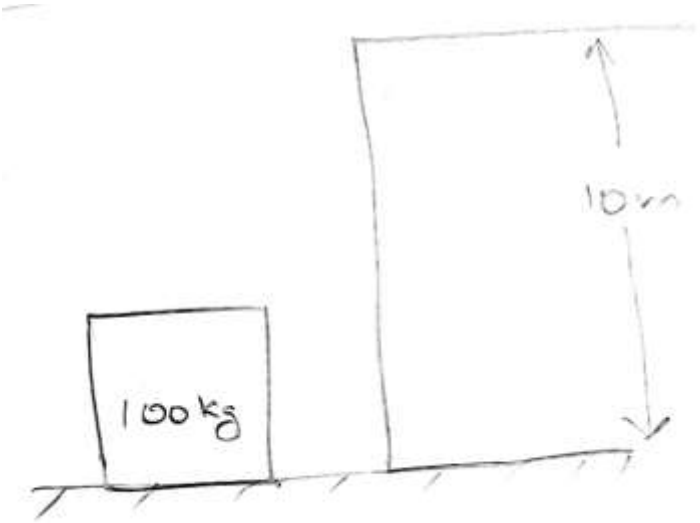
Body:

- Body is the main part of the flask
- Which will keep the hot coffee for long time.
- It contains an inner part and outer part
- Outer part is commonly used flask material which is a weight less steel material
- Inner part is glass which is coated with material which will not conduct temperature
- The inner section temperature should not affect the outer part

Bottom cap

- The bottom carrier can be used as a biscuit carrier
- The material use for this carrier can be the same material as flask is made

Q2) Describe the role of mathematical modelling in design engineering. Show how mathematics and physics play a role in designing a lifting mechanism to raise 100 kg of weight to a floor at a height of 10 meters in a construction site.



- In the question the task is to move the 100kg of weight to 10-meter height
- We can pull the wight using pullies to the requires height
- The given data
    - Weight of the item – 100kg
    - Height/displacement to be move – 10 meters

Let us discuss some basic physics principle for the particular job. To lift the weight we need to know how much power used for this job

To calculate the power let us use the basic equation of power expression

$$P = \frac{W}{T}$$

Where

W = work done

T = Time

The expression for word done is

$$W = F * S$$

Where

F = Force

S = displacement

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To find the force we need the force expression

$$F = m * a$$

Where m is the mass and a is the acceleration

Let us assume a = 9.8 m/s and the value of m is given which is 100 kg

So

$$F = 100 * 9.8 = 980N$$

From the value of the force we can calculate the work

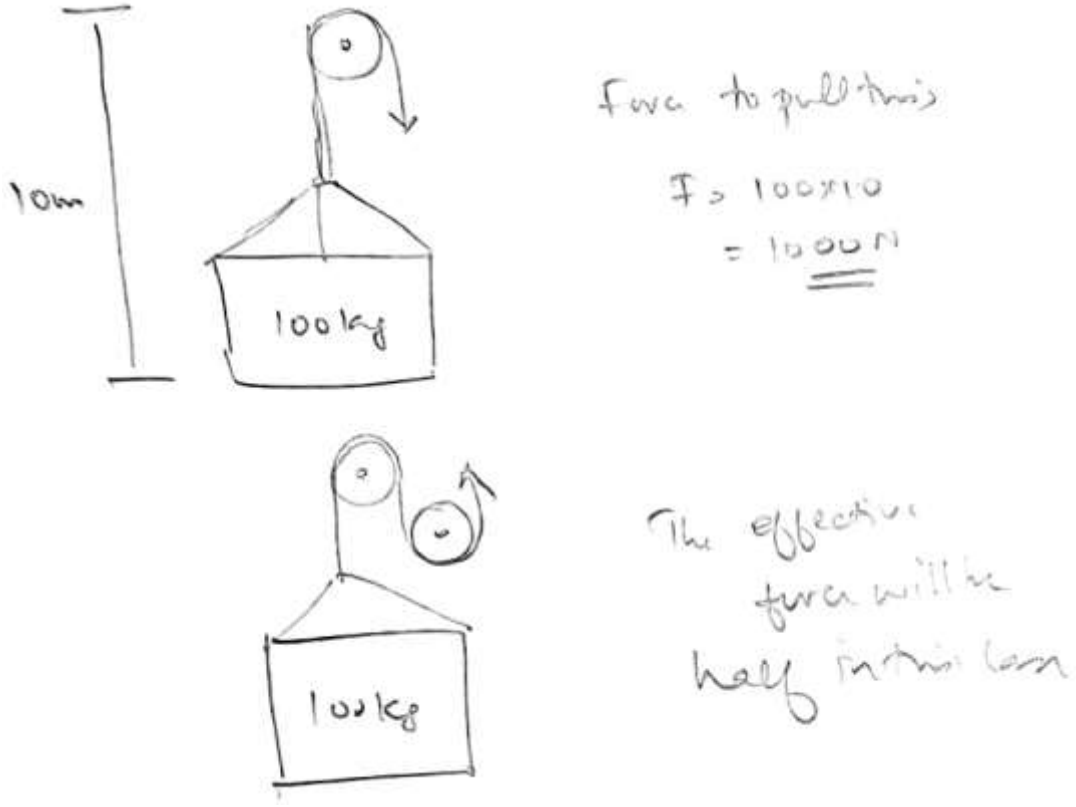
$$W = 980 * 10 = 9800J$$

Now power

Let us assume T=60 seconds

$$P = \frac{9800}{60} = 163.3\, w$$

The pully system can be used to lift the weight



From the given diagram we can see that using physics principle the and technique can reduce the power to pull the weight. So we can conclude that the physics and mathematical principle can aid the engineering design.