Module III

Design Communication
(Languages of Engineering Design)

Contents

- Design Communication (Languages of Engineering Design)
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- Mathematical Modelling in Design
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Communicating Designs Graphically

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.
- Graphic images are used to communicate with other designers, the client, and the manufacturing organization.

Communicating Designs Graphically

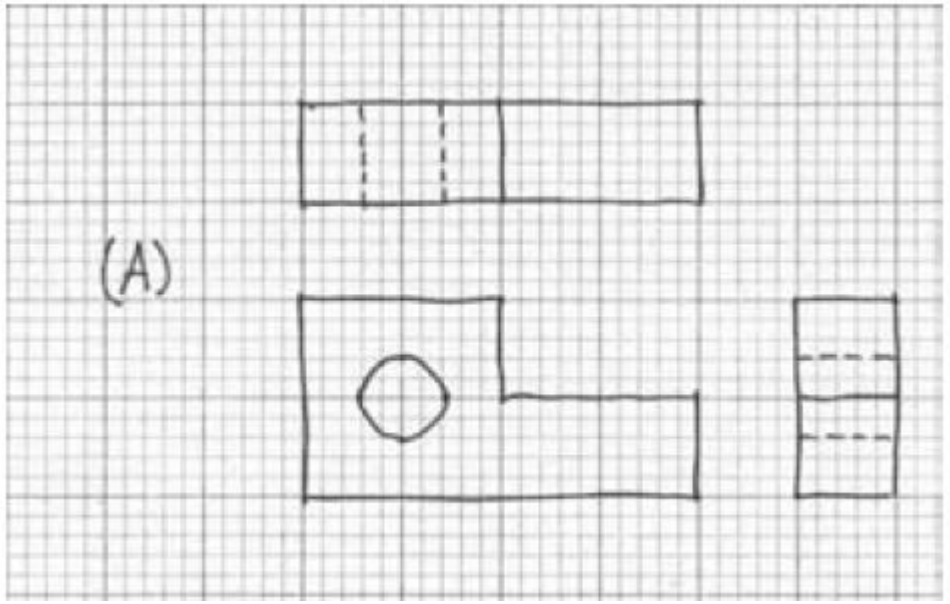
- Sketches and drawings:
  - Serve as a launching pad for a brand-new design.
  - Support the analysis of a design as it evolves.
  - Simulate the behaviour or performance of a design.
  - Record the shape or geometry of a design.
  - Communicate design ideas among designers.
  - Communicate the final design to the manufacturing specialists.

Communicating Designs Graphically

- SKETCHING

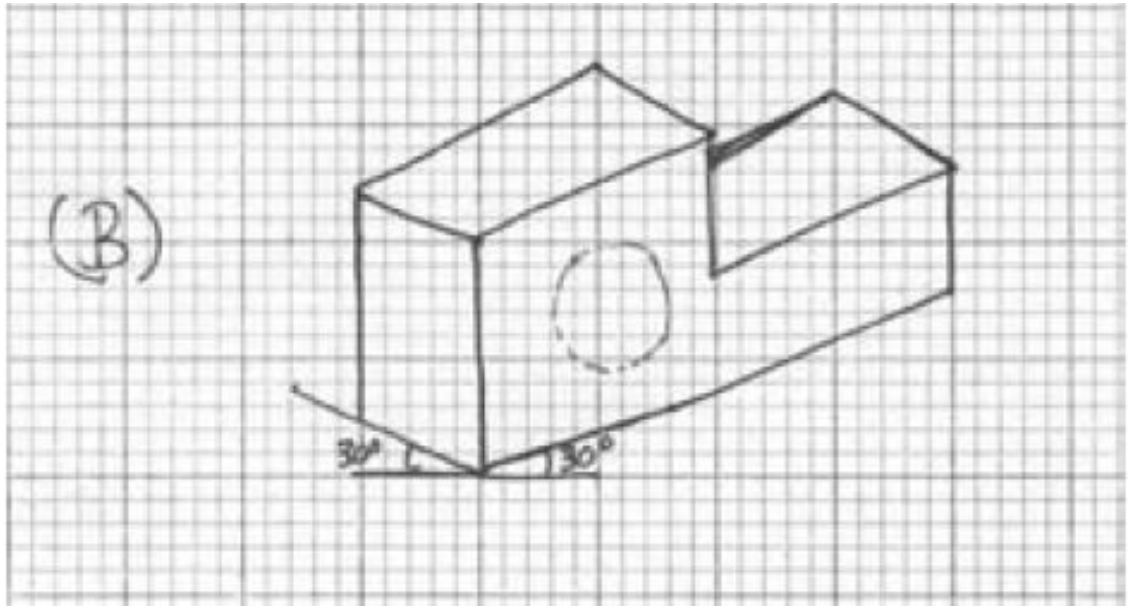
- Sketching is a powerful tool in design because it enables us to convey our design ideas to others quickly and concisely.
- Types of sketches that designers routinely use to convey design information.

a) **Orthographic sketches** lay out the front, right and top views of a part.



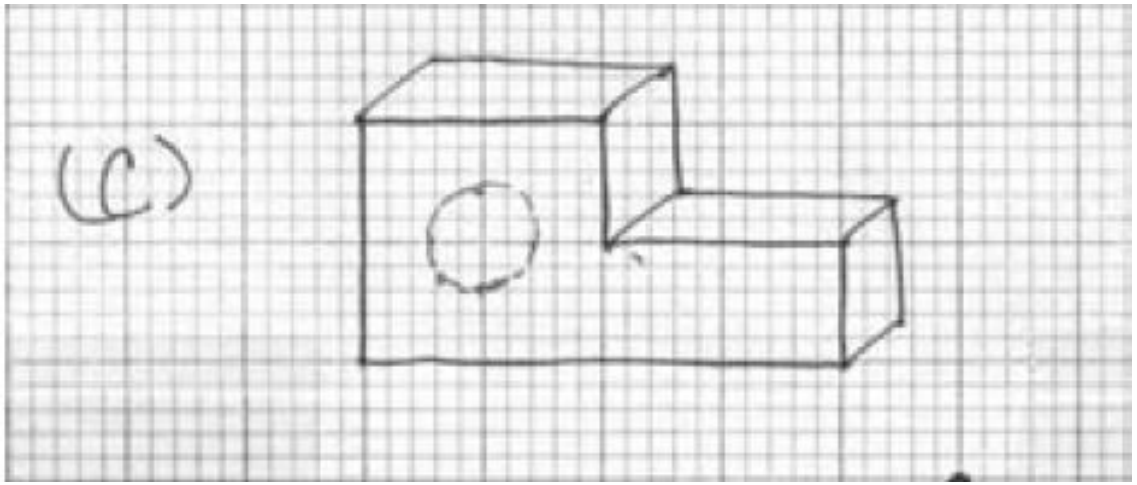
Communicating Designs Graphically

b) **Axonometric sketches** start with an axis, typically a vertical line with two lines 30°or 45^0 from the horizontal. This axis forms the corner of the part. Then vertical lines are darkened. All lines in these sketches are either vertical or parallel to one of the two 30° lines. Details of the part are added last.



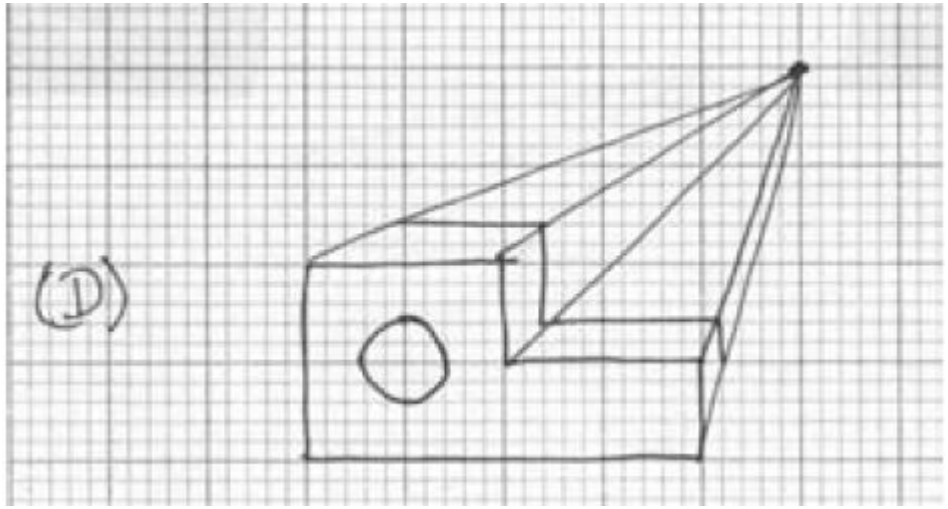
Communicating Designs Graphically

c) **Oblique sketches** are probably the most common type of quick sketch. The front view is blocked in roughly first, depth lines are then added, and details such as rounded edges are added last.



Communicating Designs Graphically

d) **Perspective sketches** are similar to oblique sketches in that the front view is blocked in first. Then a vanishing point is chosen and projection lines drawn from the points on the object to the vanishing point. The depth of the part is then blocked in using the projection lines. Finally, details are added to the part.



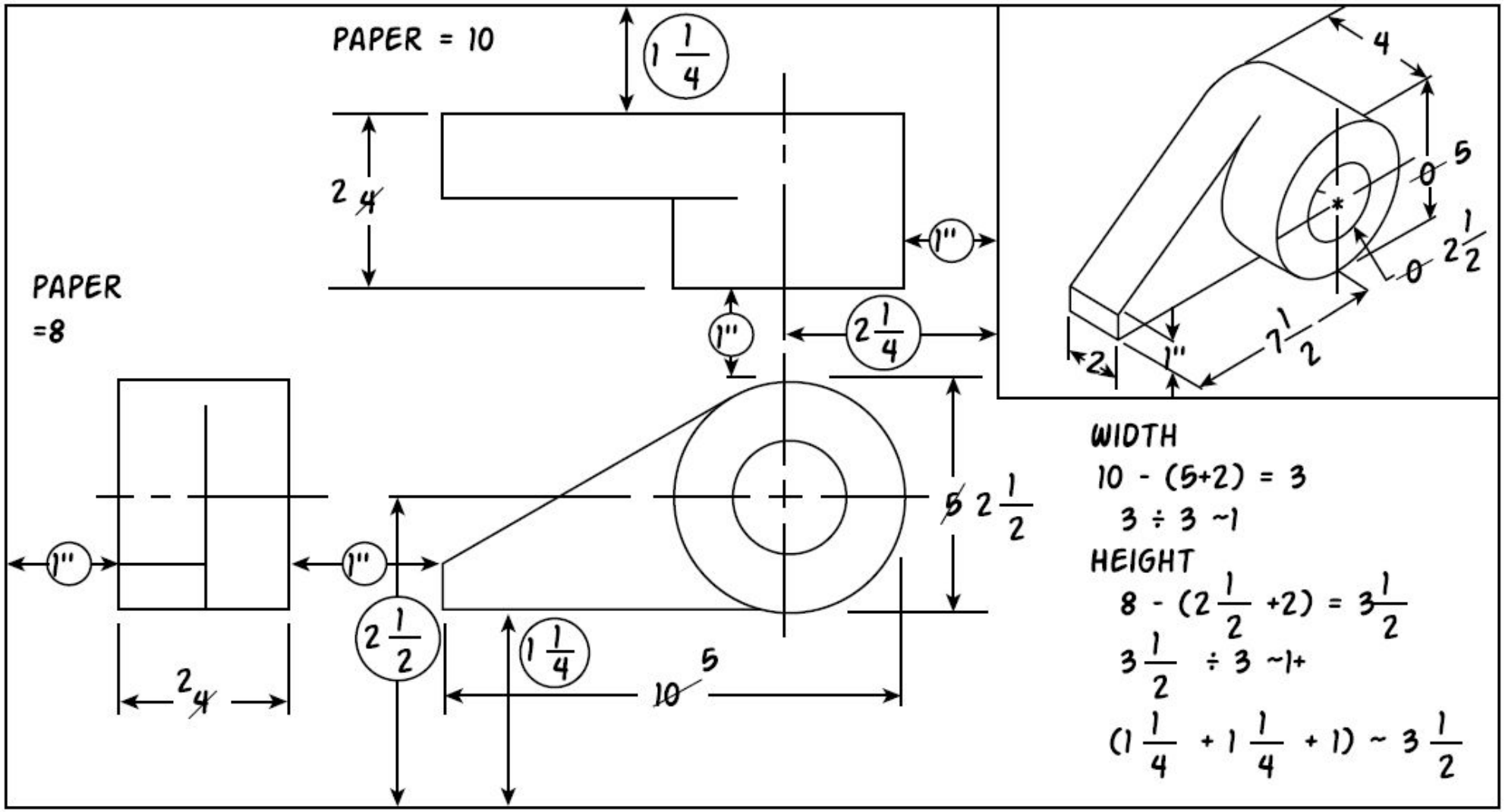
Communicating Designs Graphically

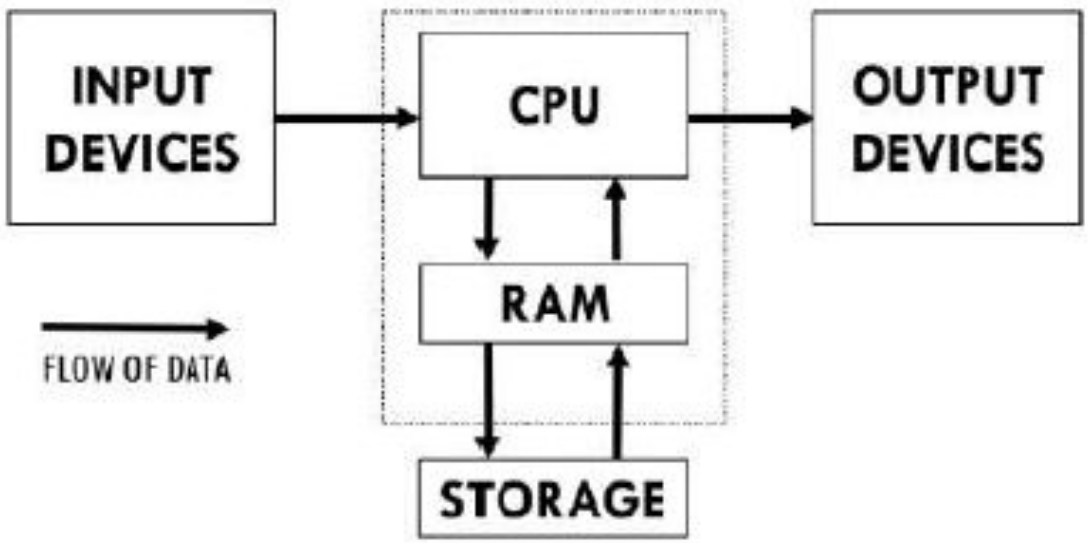
- Design Drawings

a) Layout drawings

- Working drawings that show the major parts or components of a device and their relationship.
- They are usually drawn to scale.

Communicating Designs Graphically

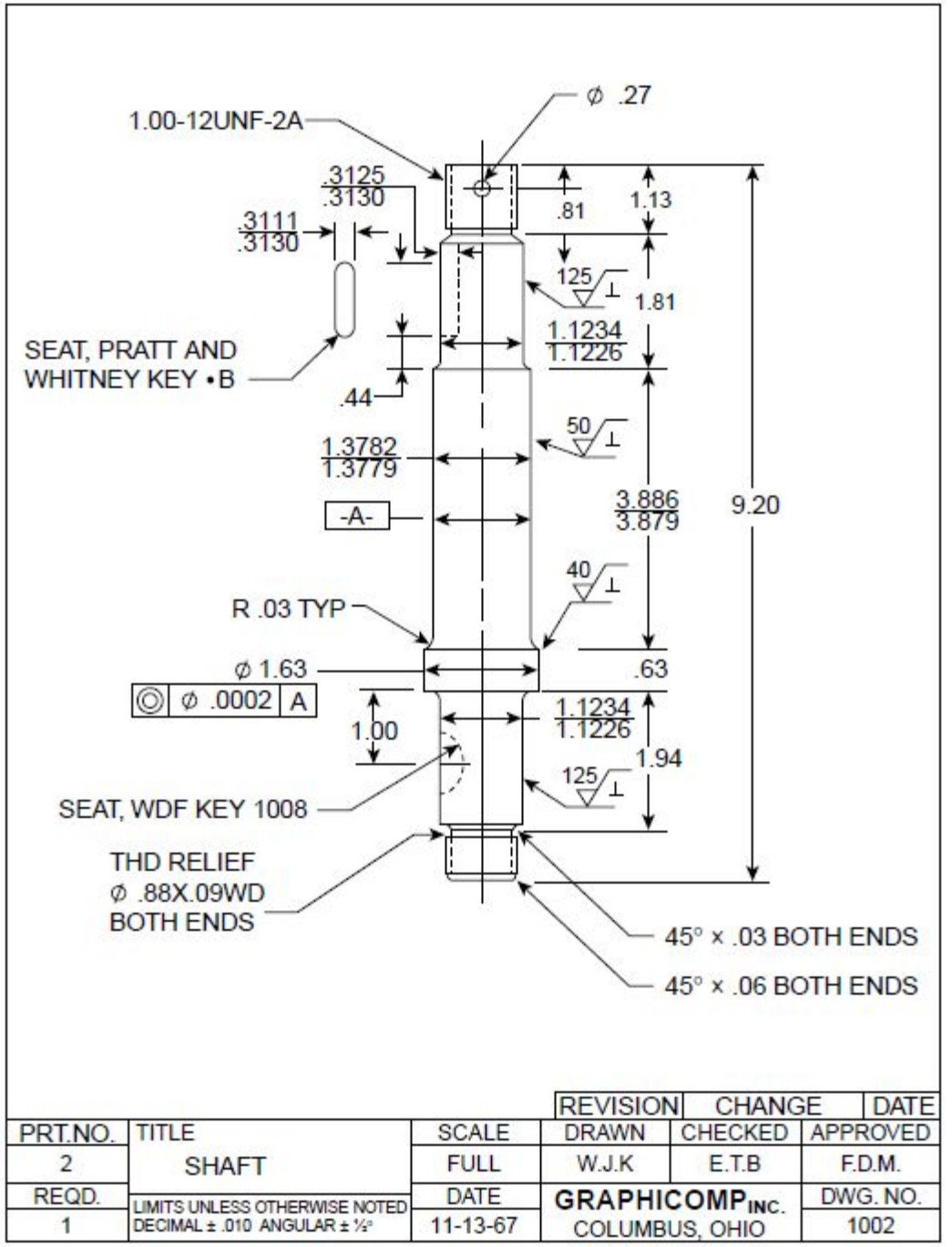


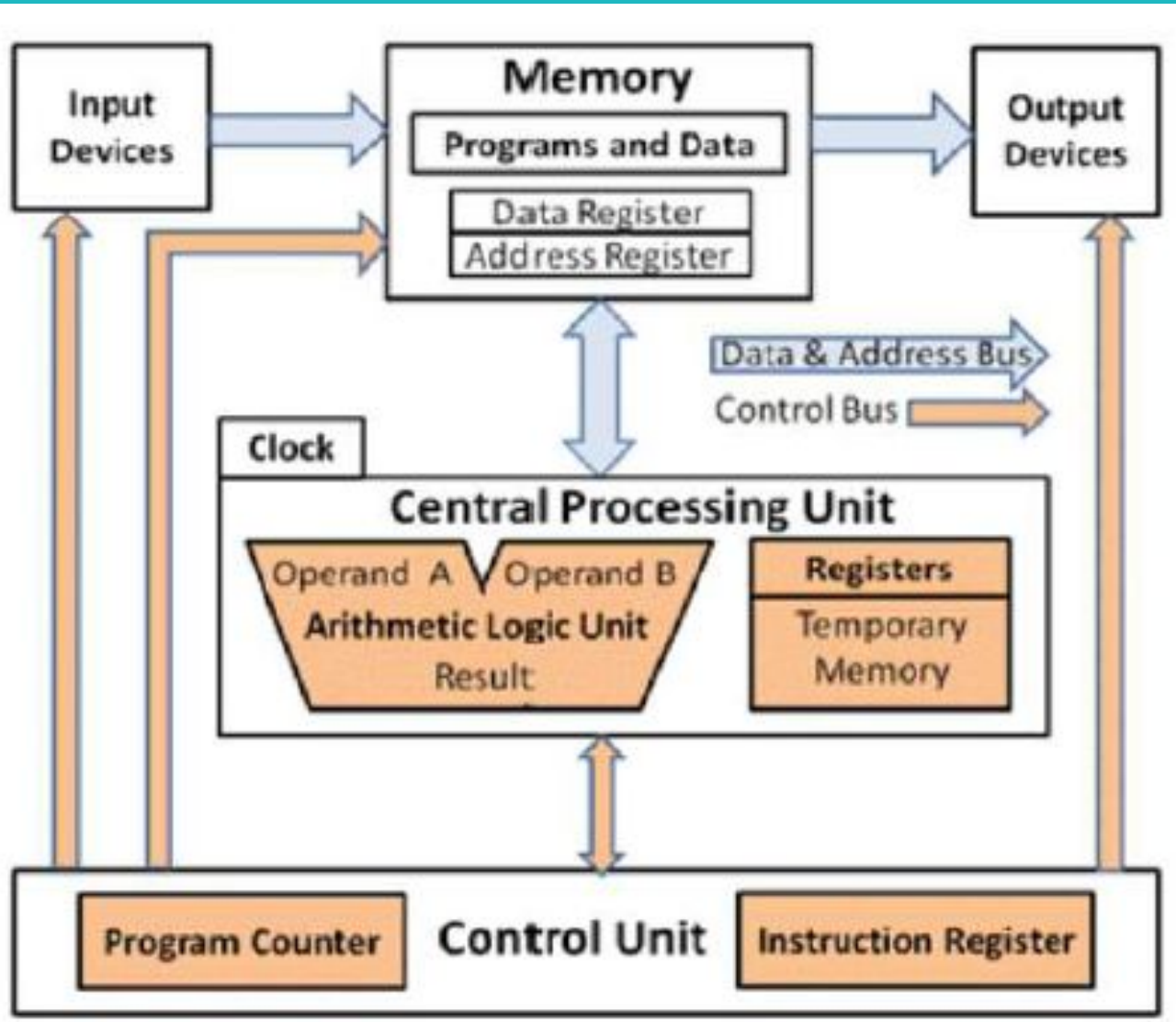

INPUT DEVICES
CPU
OUTPUT DEVICES
RAM
STORAGE
FLOW OF DATA

Communicating Designs

b) *Detail drawings*

- Show the individual parts or components of a device and their relationship.
- These drawings must specify materials and any special processing requirements.
- Detail drawings are drawn in conformance with existing standards, and are changed only when a formal change order provides authorization.

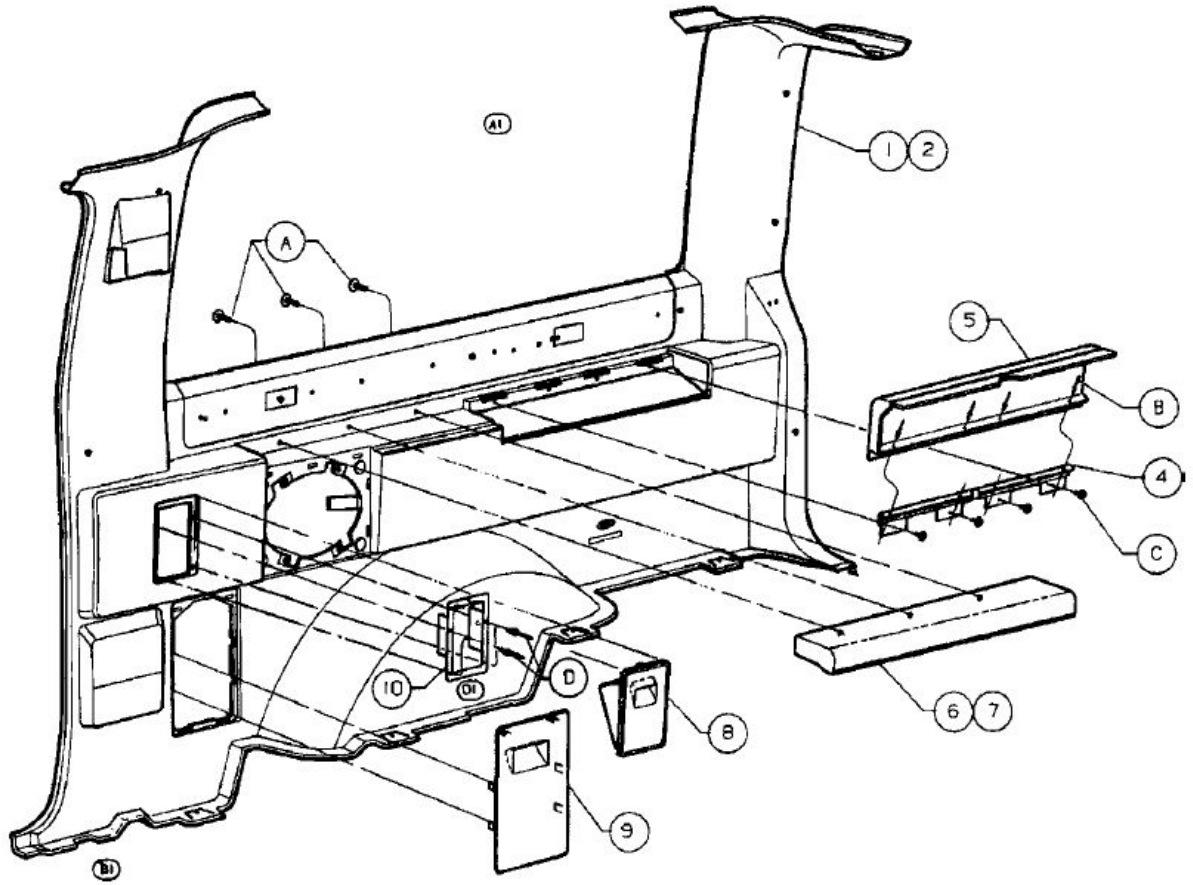



Input Devices
Memory
Programs and Data
Data Register
Address Register
Output Devices
Data & Address Bus
Control Bus
Clock
Central Processing Unit
Operand A
Operand B
Arithmetic Logic Unit
Result
Registers
Temporary Memory
Program Counter
Control Unit
Instruction Register

Communicating Designs Graphically

c) *Assembly drawings*

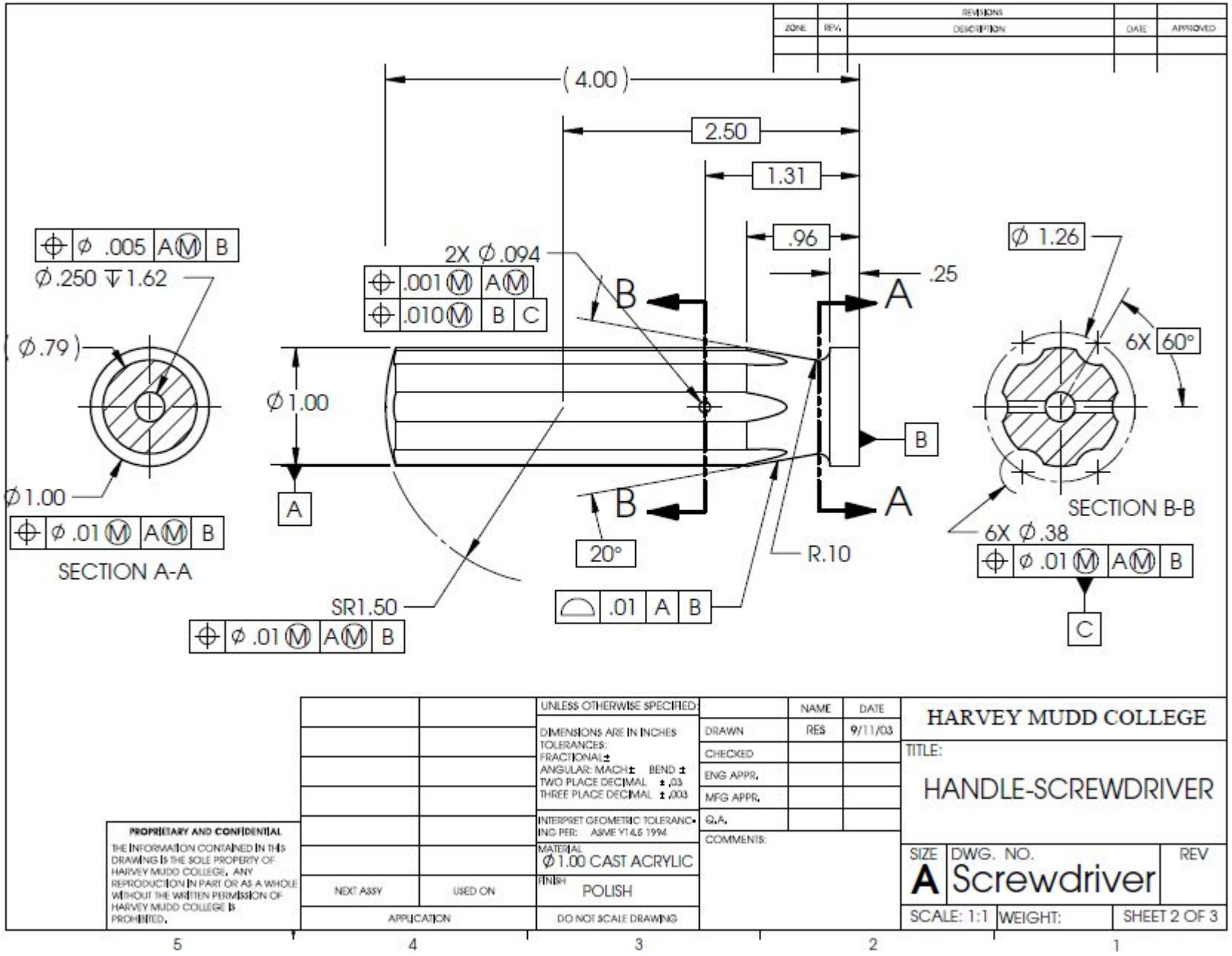
- Show how the individual parts or components of a device fit together.
- An exploded view is commonly used to show such “fit” relationships.
- We identify components by part numbers or entries on an attached bill of materials;
- They may include detail drawings if the major views in the assembly drawings cannot show all of the required information.




Casing
CD-DVD
Power
Supply
Microprocessor
Microprocessor
fan
RAM
Video Card
Hard Disk drive
Sound Card
Motherboard

Communicating Designs Graphically

- There are certain essential components that every drawing must have to ensure that it is interpreted as it is intended.
- These components include:
  - Standard drawing views;
  - Standard symbols to indicate particular items;
  - Clear lettering;
  - Clear, steady lines;
  - Appropriate notes, including specifications of materials;
  - A title on the drawing;
  - The designer's initials and the date it was drawn;
  - Dimensions and units; and
  - Permissible variations, or tolerances.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Ø .005 A M B
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SR1.50
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.01 A B
SECTION B-B
6X Ø.38
Ø .01 M A M B
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THREE PLACE DECIMAL ± .003
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Communicating Designs Orally and in Writing

Introduction

- We communicate final design results in several ways, including oral presentations, final reports (that may include design drawings and/or fabrication specifications), and prototypes and models.
- The primary purpose of such communication is to inform our client about the design, including explanations of how and why this design was chosen over competing design alternatives.
- **Report writing** is an essential part of a design project.

General Guidelines for Technical Communication

1. Know your purpose.
2. Know your audience.
3. Choose and organize the content around your purpose and your audience.
4. Write precisely and clearly.
5. Design your pages well.
6. Think visually.
7. Write ethically!

General Guidelines for Technical Communication

1. **Know your purpose**
   - This is the writing analog of understanding objectives and functions for a designed artifact.
   - Understand what the designed object must be and must do.
   - Design documentation seeks to inform the client about the features of a selected design.

General Guidelines for Technical Communication

2. **Know your audience**
   - When documenting a design, it is essential that a design team structure its materials to its targeted audience.
   - Taking time to understand the target audience will help ensure that its members appreciate your documentation.

General Guidelines for Technical Communication

3. **Choose and organize the content around your purpose and your audience**

- The key element is to structure the presentation to best reach the audience.
- There are many different ways to organize information.
  - Going from general concepts to specific details.
  - Going from specific details to general concepts.
  - Describing devices or systems.

General Guidelines for Technical Communication

4. **Write precisely and clearly**

- Some specific elements that seem to occur in all good writing and presentations.
- These include effective use of short paragraphs that have a single common thesis or topic.
- Direct sentences that contain a subject and a verb; and active voice and action verbs that allow a reader to understand directly what is being said or done.

General Guidelines for Technical Communication

5. **Design your pages well**

- A long section divided into several subsections helps readers to understand where the long section is going, and it sustains their interest over the journey.
- Tables should be treated as a single figure and should not be split over a page break.
- Simple and direct slides encourage readers to listen to the speaker without being distracted visually.
- It is a mistake to fill slides with so many words that audiences have to choose between reading the slide and listening to the speaker, because then the presenter's message will almost certainly be diluted or lost.

General Guidelines for Technical Communication

6. **Think visually**

- Just as designers often find that visual approaches are helpful to them, audiences are helped by judicious use of visual representation of information.
- Given the enormous capabilities of word processing and presentation graphics software, there is no excuse for a team not to use visual aids in its reports and presentations.

General Guidelines for Technical Communication

7. **Write ethically!**
   - All results or test outcomes, even those that are not favorable, are presented and discussed.
   - Ethical presentations also describe honestly and directly any limitations of a design.
   - It is also important to give full credit to others, such as authors or previous researchers, where it is due.

Oral Presentations

- **Telling a crowd what's been done**
  - Most design projects call for a number of both formal and informal presentations to clients, users, and technical reviewers
  - Because of the variety of presentations and briefings that a team may be called upon to make, it is impossible to examine each of them in detail.
  - However, there are key elements common to most of them.

Oral Presentations

- Foremost among these needs to

1. Identify the audience
2. Outline the presentation
3. Develop appropriate supporting materials
4. Practice the presentation

Oral Presentations

1. *Knowing the Audience*

- Who's Listening?
- A team planning a briefing should consider factors such as varying levels of interest, understanding, and technical skill, as well as the available time.
- Once the audience has been identified, a team can tailor its presentation to that audience.

Oral Presentations

- As with other deliverables, the presentation must be properly organized and structured:
  - The first step is to articulate a rough outline;
  - The second is to formulate a detailed outline;
  - The third is to prepare the proper supporting materials, such as visual aids or physical models.

Oral Presentations

2. *The Presentation Outline*

- A presentation must have a clear structure.
- A sample outline

a) *A title slide*

- Identifies the client(s), the project, and the design team or organization responsible for the work being presented. This slide should include company logos.

b) *A roadmap for the presentation*

- Shows the audience the direction that the presentation will take. This can take the form of an outline, a flowchart, a big picture slide, etc..

Oral Presentations

c) *A problem statement*
   - Includes highlights of the revised problem statement that the team produced after research and consultation with the client.

d) *Background material* on the problem, including relevant prior work.

e) The key *objectives, constraints and functions*

f) *Means* for achieving those functions

g) *Design alternatives*

h) Highlights of the *evaluation procedure* and outcomes

i) The *selected design*, explaining why this design was chosen.

Oral Presentations

j) A *demonstration* of the prototype

k) *Conclusion*(s), including the identification of any future work that remains to be done, or suggested improvements to the design.

Oral Presentations

3. *Presentations are Visual Events*

- At the earliest stages of the presentation planning, the design team should find out what devices are available and the general setting of the room in which it will be presenting.
- This includes its size and capacity, lighting, seating, and other factors.
- It is always wise to bring along backups (e.g., files on drives, transparencies, hard copies) to back up a slide presentation

Oral Presentations

- Important tips
  - Limit the number of slides
  - Be sure to introduce yourself and your teammates on the title slide
  - Beware of “clutter.” Slides should be used to highlight key points. The speaker should be able to expand upon the points in the slides.
  - Make points clearly, directly, and simply.
  - Use color skillfully.
  - Use animation appropriately.
  - Consider carefully the size and distance of the audience if images of design drawings are being shown.

Oral Presentations

4. *Practice Makes Perfect*

- Another important element of effective presentation is to use words and phrases that are natural to the speaker.

The Project Report

- The process of writing a final report, is best managed and controlled with a structured approach.
- One structured process that a design team might follow would include the following steps
  - Determine the purpose and audience of the technical report.
  - Construct a rough outline of the overall structure of the report.
  - Review that outline within the team and with the team's managers or, in case of an academic project, with the faculty advisor.

The Project Report

- Construct a Topic Sentence Outline (TSO) and review it within the team.
- Distribute individual writing assignments and assemble, write, and edit an initial draft.
- Solicit reviews of the initial draft from managers and advisors.
- Revise and rewrite the initial draft to respond to the reviews.
- Prepare the final version of the report and present it to the client.

The Project Report

- Major sections
  - Title
  - Abstract - a one-paragraph summary of a research project
  - Introduction and overview- enough information to understand the purpose and scope of the project
  - Problem statement and problem definition, including relevant prior work or research.
  - Design alternatives considered.
  - Evaluation of design alternatives and basis for design selection.
  - Results of the alternatives analysis and design selection.
  - Conclusion
  - Other materials that the client may require.

Prototyping and Proofing the Design.

- Focus on how to translate our design ideas into models and prototypes that can be used to test our design concepts and communicate our ideas to the client.
- Prototypes, models, and proofs of concept are made by their designers.
- **Prototypes -** original models on which something is patterned.
- They are also defined as the first full-scale and usually functional forms of a new type or design of a construction (such as an airplane).
- Prototypes are working models of designed artefacts.
- They are tested in the same operating environments in which they're expected to function as final products.

The decision to build a prototype depends on

- The size and type of the design space
- The costs of building a prototype
- The ease of building that prototype
- The role that a full-size prototype might play in ensuring the widespread
- Acceptance of a new design
- The number of copies of the final artefact that are expected to be made or built

To construct a prototype:

- Who is going to make it?
  - factors enter into the decision about who makes our model: expertise, expense, and time.
- Can we buy parts or components?
- How and from what, will the prototype be made?
  - Create detailed, annotated drawings and plans before we start cutting or machining.
  - True prototypes are typically made from the same materials that are intended for the final design.
- How much will it cost?

Techniques to construct a prototype:

- **Mock-ups**
  - Construct a mock-up of a 3D part from 2D cut-outs
  - 2D parts can be made using a vinyl cutter or a laser cutter, and parts are then assembled into 3D mock-ups of a design
  - Materials used for these mock-ups might be foam, thin plastic, or wood
- **Machining**
  - Machining parts or all of our prototypes ourselves in a machine shop
- **Rapid prototyping technologies:**
  - fast and cheap ways to fabricate prototypes
  - Rapid prototyping techniques use 3D CAD models as inputs, and convert these 3D les into thin 2D layers to build the 3D part
  - Rapid prototyping technologies include stereo-lithography and selective laser sintering, which involve using a laser to harden either a resin bath or a polymer powder in a particular con guration to build each layer.

Prototyping and Proofing the Design.

- A **model** is a miniature representation of something, or a pattern of something to be made, or an example for imitation or emulation.
- Models to represent some devices or processes.
- They may be paper models or computer models or physical models.
- To illustrate certain behaviours or phenomena as we try to verify the validity of an underlying (predictive) theory.
- Models are usually smaller and made of different materials than are the original artifacts they represent, and they are typically tested in a laboratory or in some other controlled environment to validate their expected behaviour.

Prototyping and Proofing the Design.

- A **proof of concept**, refers to a model of some part of a design that is used specifically to test whether a particular concept will actually work as proposed.
- Doing proof-of-concept tests means doing controlled experiments to prove or disprove a concept.
- ***PoC shows that a product of feature can be developed where as prototype shows how it will be developed.***

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.
- A representation in mathematical terms of the behavior of real devices and objects.
- Matches observation with symbolic representation.
- Informs theory and explanation.
- Physics and mathematics – key to mathematical modeling.
- Models built on assumption.
- Helps us to understand behavior of the designed system.

The success of a mathematical model depends on how easily it can be used, and how accurately it predicts and how well it explains the phenomenon being studied

- A mathematical model is represented as a functional relationship of the form

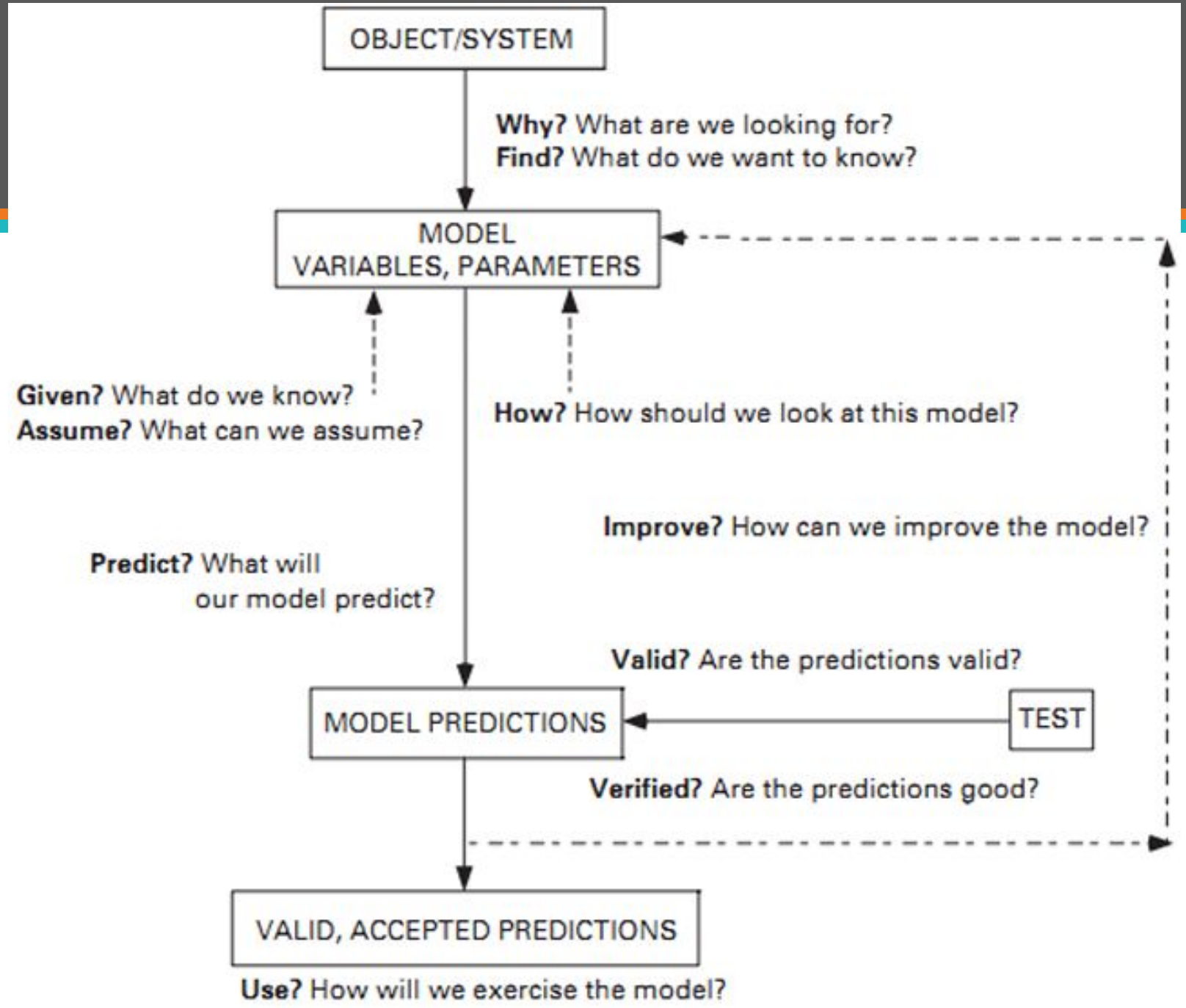
Dependent independent forcing

Variable $= f$ variables, parameters, functions

- *Dependent variable*: Characteristic that usually reflects the state of the system
- *Independent variables*: Dimensions such as time and space along which the systems behavior is being determined
- *Parameters*: reflect the system's properties or composition
- *Forcing functions*: external influences acting upon the system

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?


OBJECT/SYSTEM
Why? What are we looking for?
Find? What do we want to know?
MODEL
VARIABLES, PARAMETERS
Given? What do we know?
Assume? What can we assume?
How? How should we look at this model?
Improve? How can we improve the model?
Predict? What will
our model predict?
Valid? Are the predictions valid?
MODEL PREDICTIONS
TEST
Verified? Are the predictions good?
VALID, ACCEPTED PREDICTIONS
Use? How will we exercise the model?

Some mathematical tools for design modeling

- ***Dimensions and Units***
  - Every independent term in every equation we use has to be ***dimensionally homogeneous or dimensionally consistent,*** that is, every term has to have the same net physical dimensions.
  - Dimensionally consistent equations are called ***rational equations***.
  - The physical quantities used to model objects or systems represent **concepts**, such as ***time, length, and mass***, to which we attach numerical measurements or values.

Mathematical Modeling in Design

- Two classes for the physical quantities:
  - ***Fundamental or primary quantities :***
    - It can be measured on a scale that is independent of those chosen for any other fundamental quantities. For example, mass, length, and time are usually taken as the fundamental mechanical dimensions or variables.
  - ***Derived quantities:***
    - Generally follow from definitions or physical laws, eg : force is a derived quantity that is defined by Newton's law of motion.

Mathematical Modeling in Design

F= ma

- If mass, length, and time are chosen as primary quantities, then the dimensions of force are (mass x length)/(time)^2 .
- If M, L, and T stand for mass, length, and time, respectively, then

$$[F = \text{force}] = (\text{M} \times \text{L})/(\text{T})^2$$

- Similarly,

$$[\text{A=area}]=(\text{L})^2 \quad \text{and} \quad [\rho = \text{density}] = \text{M}/(\text{L})^3.$$

- The units of a quantity are the numerical aspects of a quantity's dimensions expressed in terms of a given physical standard

- The speed of a particle, V, due to the acceleration of gravity, g, when dropped from a height, h, is given by $V = \sqrt{2gh}$
- Both sides of eq. have the same net physical dimensions (L/T)
- This eqn id ***Dimensionally homogeneous*** because it is totally independent of the system of units being used to measureV, g, and h.
- unit-dependent versions of such equations

$$V(\text{m/s}) = \sqrt{2(9.8)h} \cong 4.43\sqrt{h}$$

- If we were working with American units only

$$V(\text{ft/sec}) = \sqrt{2(32.17)h} \cong 8.02\sqrt{h}$$

Mathematical Modeling in Design

- ***Significant Figures***
  - In scientific notation, the number of significant figures (NSF) is equal to the number of digits counted from the first nonzero digit on the left to either

    (a) The last nonzero digit on the right if there is no decimal point, or

    (b) The last digit (zero or nonzero) on the right when there is a decimal point.

    This notation or convention assumes that terminal zeroes without decimal points to the right signify only the magnitude or power of 10
  - We should always remember that the results of any calculation or measurement cannot be any more accurate than the least accurate starting value.

Measurement	Significant Figures	Assessment
5415	Four	Clear
5400	Two (54×10^2) or three (540×10^1) or four (5400)	Not clear
54.0	Three	Clear
54.1	Three	Clear
5.41	Three	Clear
0.00541	Three	Clear
5.41×10^3	Three	Clear
0.054	Two	Clear
0.0540	Two (0.054) or three (0.0540)	Not clear
0.05	One	Clear

Mathematical Modelling

THE BASICS AND IMPORTANCE

Deciding the problem

Step 1

Assumptions

Step 2

Defining Variables

Step 3

Approximation

Step 4

Results

Step 5

- Design a foldable steel table. Draw the detailed 2D drawings of the same with design detailing, scale drawings and dimensions. Use only hand sketches.
- Prepare a technical report for a newly designed portable ladder with neat sketches for presenting to a client.