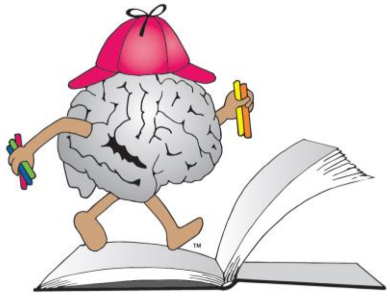

CLOSE Reading of the Science practices

<table>
<tr><th>Science</th><th>Engineering</th></tr>
<tr><td colspan="2">Figure 1: Asking questions and defining problems</td></tr>
<tr><td>Science begins with a question about a phenomenon (fact, feature, or event of scientific interest) These can be observable and rare. Scientists
Formulate (develop) empirically (through observation and experience) answerable questions about phenomena (facts, features or events) to
Establish (begin with) what is already known and to
Determine (figure out) what questions have yet to be satisfactorily (proven by evidence) answered.</td><td>Engineering begins with a problem that needs to be solved
Ask questions to clarify problem
Determine criteria (a standard by which something can be judged or decided)for a successful solution
Identify constraints (limitations or restrictions)</td></tr>
<tr><td colspan="2">Figure 2: Developing and Using Models</td></tr>
<tr><td>Science often involves the construction(building) and use of models (representations of persons or things) and simulations (something made to look, feel, or behave like something else so that it can be studied)
Models enable (allow) predictions (pre-meaning before, dict meaning to say. Say what will happen in the future. A guess based on evidence)
Test hypothetical (possible ideas, situations, claims, theories, propositions, conjectures,) explanations.</td><td>Engineering
Makes use of models (representations of persons or things) and simulations (something made to look, feel, or behave like something else so that it can be studied) to analyze (separate into parts for examining) extant (remaining) systems to identify flaws (weaknesses or limitations) that might occur, or to test possible solutions to a new problem.
Design and use models of various sorts to test proposed (suggested, recommended) systems and to recognize the strengths and limitations (flaws) of their design.</td></tr>
</table>

Figure 3: Planning and Carrying Out Investigations

Scientific investigations may be ***conducted*** (carried out) in the ***field*** (natural environment of the discipline) or **laboratory** (room or building equipped-with scientific experiments and tools)
A major practice of scientists is

- **Planning** and **carrying** out investigations that require ***clarifying*** (making something clear) what counts as ***data*** (information)and
- **Identifying** ***variables*** (elements, features, or factors that might change) in experiments

Engineering investigations are ***conducted*** (carried out) to

- ***Gain*** (collect) data essential for ***specifying*** (selecting) ***criteria*** (a standard by which something can be judged or decided) or ***parameters*** (a numerical or other measureable factor that defines or sets the condition of its operation. **Hint: the root meter means measure**.) and test ***proposed*** (suggested, recommended) designs.

Engineers must, like scientists

- **Identify** ***relevant*** (important to investigation) ***variables*** (elements, features, or factors that might change)
- **Decide** how ***variables*** will be measured
- **Collect** (record) data for analysis

Their ***investigations*** (research, observations) help them to identify the

- *Effectiveness*, (degree in which something is successful in producing desired results)
- *Efficiency* (the capacity to produce desired results), and
- *Durability* (ability to last-withstand wear) of designs under different conditions.

Figure 4: Analyzing and Interpreting Data

Scientific investigations produce *data* (information) that must be ***analyzed*** (separated into parts for examining) in order to ***derive*** (get, gain, or take) meaning. Because data do not speak for themselves, scientists use a ***range*** (variety) of tools-including tabulation (i.e., calculator), graphical, interpretation, visualization, and statistical analysis-to identify the significant features and patterns in the data. ***Sources of error*** (situations that may occur while doing experiments i.e. incomplete definitions, failure to account for a factor, environmental factors…) are identified and the ***degree*** (level) of uncertainty calculated.

Engineering investigations include:

- **Analysis** of data collected in the tests of designs. This
  - **allows** comparison of different solutions and
  - **determines** how well each solution meets specific design criteria-(which design best solves the problem within given constraints.
- **Engineers,** like scientists, require a range (variety) of ***tools*** to ***identify the major patterns*** (traits, observable characteristics) and ***interpret*** (explain) the results.

<table>
<tr><th colspan="2">FIGURE 5: USING MATHEMATICS AND COMPUTATIONAL THINKING</th></tr>
<tr><td>

In science, ***mathematics*** (abstract science of number, quantity, and space) and ***computation*** (includes both arithmetical and non-arithmetical steps and follows a well-defined model understood and described as, for example, an ***algorithm***)* **(Wikipedia)** are ***fundamental*** (basic) tools for representing physical variables and their relationships.
Mathematics and computation are used for a range of tasks:

- **Constructing** simulations
- ***Statistically*** (Statistics are numerical data collected and classified-i.e. Measure of Central Tendency, mean, mode, median) analyzing data
- **Recognizing**, **expressing**, and **applying** ***quantitative relationships*** (Comparing things with regard to quantity, magnitude, degree or rate)

Mathematical and computational approaches:

- **Enable** prediction of the behavior of physical systems along with the testing of such predictions.
- ***Statistical techniques*** are also invaluable for identifying significant patterns and establishing correlational relationships.

</td><td>

In **engineering**, mathematical and computational representations of established relationships and principles are an ***integral*** (important) part of the design process.
Ex. Structural engineers **create** mathematical-based analysis of ***designs*** (plans) to ***calculate*** (assess, determine) whether they can stand up to expected stresses of use ***(durability)***and if they can be completed within acceptable ***budgets*** (money set aside to pay for project)
Moreover (additionally), simulations provide an effective ***test bed*** (proving ground) for the development of designs as ***proposed*** (suggested, recommended) solutions to problems and their improvement if required.

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<table>
<tr><th colspan="2">FIGURE 6: CONSTRUCTING EXPLANATIONS AND DESIGNING SOLUTIONS</th></tr>
<tr><td>

The **goal of science** is the ***construction*** (development) of ***theories*** (beliefs, claims) that provide ***explanatory accounts*** (Ideas can be explained. Defined as attempt to connect ideas to understand cause and effect) of the ***material*** (nature, phenomena of the physical world) world.
Theories have:

- ****Multiple*** independent lines (Models that have been tested from as many angles as possible) of ***empirical*** (can be observed/experienced) evidence
- ***Greater explanatory*** power (connects ideas to understand cause and effect)
- ***Breadth***(wide range) of phenomena (facts, features, events) it accounts for

</td><td>

The **goal of engineering** design is a ***systematic*** (organized plan) solution to problems that is based on scientific knowledge and models of the material world. Each ***proposed*** (suggested, recommended) solution results from a process of ***balancing*** (weighing, comparing, judging) competing criteria of desired functions, technical ***feasibility*** (possibility), cost, safety, ***aesthetics*** (set of principles underlying and guiding the work and ***compliance*** (following the rules) with legal requirements.
Usually there is no one best solution, but rather a range of solutions. The ***optimal*** (best, most favorable) choice depends on how well the ***proposed*** (suggested, recommended) solution meets criteria and constraints.

</td></tr>
</table>

• *Explanatory coherence* (logical, makes sense, consistency) and ***parsimony*** (carefulness not to rely on things that cannot be proved) **** "The Plate Tectonic model of the Earth is supported by multiple independent lines of evidence-magnetic stripes in rocks showing sea-floor spreading, the global distribution of earthquakes and** volcanoes**, comparable fossils found on widely separated continents and satellite measurements." September 9, 2013-https://www.google.com/search?***	
FIGURE 7: ENGAGING IN ARGUMENT FROM EVIDENCE	
In **science**, reasoning and argument are ***essential*** (necessary) for clarifying strengths and weaknesses of a ***line of evidence*** and for identifying the best explanation for a ***natural phenomenon*** (i.e. shifting of the ocean floor, hurricanes, the rotation of the earth, and eruptions of volcanoes). **Scientists must**: • **Defend** their explanations, • **Formulate** evidence based on a solid foundation of data, • **Examine** their understanding in light of the evidence and comments by others • And **collaborate** with peers in searching for the best explanation for the phenomena being investigated.	In **engineering**, reasoning and argument are ***essential*** (necessary) for finding the best solution to a problem. **Engineers:** • **Collaborate** (work with) their peers throughout the design process. With a ***critical*** (important) stage being the selection of the most promising solution among a ***field*** (selection) of competing ideas. • **Use** systematic methods to compare alternatives, • **Formulate** evidence based on test data, • **Make** arguments to defend their conclusions, • **Critically** evaluate the ideas of others, and • **Revise** their designs in order to identify the best solution.
FIGURE 8: OBTAINING, EVALUATING, AND COMMUNICATING INFORMATION	
Science cannot ***advance*** (go forward) if scientists are unable to communicate their ***findings*** (results) clearly and persuasively or learn about the findings of others. **A major practice of science is thus to:** • **Communicate** ideas and the results of inquiry-orally; in writing; with the use of tables, diagrams, graphs and equations • **Engage** in extended discussions with peers **Science** requires the ability to ***derive*** (take) meaning from scientific texts such as papers, the internet, symposia, or lectures to ***evaluate*** (assess) the scientific ***validity*** (accuracy) of the information thus acquired and to **integrate** that information into proposed explanations.	**Engineering** cannot produce new or improved technologies if the advantages of their designs are not communicated clearly and persuasively. **Engineers need to be able to:** • **Express** (communicate) their ideas orally and in writing; with the use of tables, graphs, drawings or models; • **Engage** (participate) in extended discussions with peers • **Derive** (make) meaning from colleagues' texts, • **Evaluate** information and apply it usefully.