**Lab Learning Objective(s):** Upon completion of this lecture, the student should be able to

* List the appropriate SI prefix to denote the order of magnitude of a quantity.
* List the QFT question-storming rules and explain their importance.
* Apply the QFT to generate many questions on a topic.
* Identify open vs. closed questions and change a question from one form to another.
* Identify the Need, Approach, Benefits, and Competition (NABC) in an idea pitch.
* Apply the NABC method to advocate for an idea.

**A motivation for question forming and the Question Formulation Technique (QFT):**

* The QFT is a pedagogical approach, created by the Right Question Institute, to improve the ability of students to formulate their own questions.
* ***Question formulation*** is a *critical life skill*, as it links us to that which is *unknown* to us and *opens* it up for our *exploration*.
* Examples illustrating the importance of question forming:
  + You’re sitting at the doctor’s office after receiving a scan that was prescribed due to some pain you were having. The doctor walks in to discuss what has been found and the prognosis. She finishes a long discussion of your medical condition – most of which you didn’t understand – with: “Do you have any questions?”
  + Your beloved car, which you’ve driven since you were a teenager, breaks down on the side of the road and you have it towed to the local mechanic. After taking a look at the car, the mechanic gives you a couple of options, but doesn’t seem fully confident that either will fully fix the car.
  + On your first assignment as an engineer, your supervisor gives you a brief summary of the project on which you’ll be working for the next few months and describes several of the expected tasks that must be completed. You understand some of what has been said, but are unsure of many of the details.
* In each example, the ability to formulate questions is critical to moving from a state of not knowing to a state of understanding.
  + Notice that in each case, questions must be formulated on that which is unknown to us.
  + In your engineering education (possibly even in this class) there will be plenty of times when the instructor will explain a difficult concept, with which you may have no prior experience, and end the explanation with “any questions?” or “is that clear?”.
  + If the explanation is not clear, it is important to be the one to ask a question, because if there is an aspect of the explanation that is unclear to you, then it is probably unclear to at least a few others in the classroom who didn’t think to ask the question.
  + It is critical to be able to probe the unknown with questions.
* “*There are no stupid questions*”
  + Some students are afraid to ask “a stupid question” or “an ignorant question”.
  + Since all questions are aimed to probe the unknown, all questions come from a lack of knowing.
  + Asking probing questions shows potential! Question formulation is at the heart of all scientific and mathematical discoveries after all!
  + Teachers want their students to probe the unknown, even if they’ve just attempted to explain a particular topic.
* That being said…
  + It is important for the student to identify the specific aspects of the explanation or topic that are still fuzzy.
  + Some teachers don’t like to hear blanket statements of ignorance, such as “I don’t get anything you’re talking about”, or very general questions such as “What are you saying?” These types of statements and questions do very little to pinpoint what is misunderstood and are not conducive for exploration or discussion.
  + Many teachers also don’t like purely logistical questions like “will this be on the exam?” (especially if the question is answered in the syllabus, study guide, or other resource already available to the student)
  + Generally speaking, teachers don’t like cynical questions such as, “why do we have to know this?” Your instructors dedicate themselves to providing a strong education, and sometimes the underlying purpose may be unclear to the student until a later time.
* The skill of question forming is empowering!
  + A good question is like a key that can unlock the door that leads to knowledge and understanding. But just like a key, the question is just a tool to unlock the door. Walking through the door is the subsequent exploration of the topic that leads to understanding (and often more questions).
  + Creating your own questions that probe a complex topic is very satisfying. As the question is your own creation, you’ll have a greater motivation to explore it to see where it leads.

**QFT Goals and Thinking modes**

* The goal of the QFT is to train students to be able to ask many questions on a topic, to be able to modify the form of the questions, to refine the questions, and to be able to analyze and prioritize the questions.
  + At the end of the QFT exercise students will have a list of many questions, with varying levels of exploration capability, and many of which will focus on different aspects of the topic under consideration.
  + These questions can be useful for various types of exploration, whether it is a laboratory experiment, design project, research paper, or a direct exploration of one or more of the specific questions.
* There are three characteristic *thinking modes* used in the QFT:

1. **Divergent thinking**
   * Free thinking that is unconstrained and noncritical.
   * Divergent thinking is used in the ideation process and brainstorming.
2. **Convergent thinking**
   * Analytical thinking that breaks down and categorizes or brings together and synthesizes.
   * Convergent thinking is used in the problem formulation process, in analysis, and in elements of design.
3. **Metacognition**
   * Reflective thinking that considers the motivations, misconceptions, thought processes, and other elements that lead to cognition.
   * Metacognition is used in reflective writing when we discuss our learning experiences and how they have led to understanding a topic.

**QFT Framework**

* Students get in small groups (three or four) for the QFT exercise (either 1 lab group of 3 or combine lab pairs for 4). The roles used in QFT are similar to the roles used in ENGR 1041/1051:
  + A **recorder** is selected among the group to do the writing.
    - Note that the recorder is the only assigned role in Step 1 (the steps are described below).
  + A **coordinator** is selected to *facilitate the discussion* of refining the questions (in step 2) and prioritizing the questions (in step 3), and *monitors the decision making process* in those steps.
  + A **reviewer** is selected to keep the group moving toward the goal of the specific step and to assist the recorder to be sure there are no errors in the final prioritized list of questions (Step 3).
  + A **consultant** is selected to be sure all team members have an opportunity to give input and to interface with the instructor.
    - Note that the reviewer and consultant roles will be combined in groups of 3.
  + The roles should be recorded in your submission and shuffled throughout the course of the semester.
* There are five stages in the QFT framework we consider:

1. **Produce many questions** [divergent thinking]
2. **Improve the questions** [convergent thinking]
3. **Prioritize the questions** [convergent thinking]
4. **Explore the questions** [divergent and convergent thinking]
5. **Reflect on the process** [metacognition]

**Step 1: Produce Many Questions**

* The process of producing many questions is called **question-storming**.
* The topic of focus for question-storming is called the Question Focus (or just QFocus).
  + The **QFocus** is a statement (possibly with associated imagery) given by the instructor to focus and direct the question-storming process.

There are *four cardinal rules* for question-storming:

1. **Ask as many questions as possible in the allotted time.**
2. **Do not answer or discuss the questions and do not judge the quality of the questions!**
3. **Write the question exactly as stated (include even grammatical errors!)**
4. **Articulate everything as a question (no statements).**
   * The 1st rule aims to keep you focused on the task of asking tons of questions.
   * The 2nd and 3rd rules create a *safe space* in which to ask the questions. In question-storming there are truly no stupid questions!
   * The last rule is a guideline to be mindful of individually. It is important to formulate everything as a question, but not at the expense of maintaining a safe and judgmental-free space for question-storming. Hence, if someone provides a statement rather than a question, the recorder should transcribe it exactly as it is stated, including any grammatical errors!

* The recorder can and should also participate in the question-storming process. Be sure to speak aloud your own question you are recording though so the rest of the group hears! Often one question can lead to others.
* As a first example of the QFT in action, let’s consider SI units, which were covered yesterday in class.
* As a reminder…
* **SI prefixes** 
  + SI prefixes are used to compactly represent very large or small values
* **Think-Pair-Share Exercise Lab 0**: Spend a couple of minutes to write the SI prefix symbols individually (write in the columns labeled **Ind**) in Table L0-1. Use the Word Bank below. After you complete this column, discuss with a partner or group of three. Reach consensus and write in the symbols in the column labeled **Pair**. Finally, we’ll review the SI names and prefix answers as a class, which you may fill in the answer columns labeled **Ans.**

**Table L0-1**: SI Prefixes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Power of 10** | **Prefix Symbol (Ind)** | | **Symbol (Pair)** | **Name (Ans)** | **Symbol (Ans)** |
| 1024 |  | |  |  |  |
| 1021 |  | |  |  |  |
| 1018 |  | |  |  |  |
| 1015 |  | |  |  |  |
| 1012 |  | |  |  |  |
| 109 |  | |  |  |  |
| 106 |  | |  |  |  |
| 103 |  | |  |  |  |
| 10-3 |  | |  |  |  |
| 10-6 |  | |  |  |  |
| 10-9 |  | |  |  |  |
| 10-12 |  | |  |  |  |
| 10-15 |  | |  |  |  |
| 10-18 |  | |  |  |  |
| 10-21 |  | |  |  |  |
| 10-24 |  | |  |  |  |
| **Prefix Word Bank** | | |
| **Prefix Name** | **Symbol** | |
| **atto** | **a** | |
| **exa** | **E** | |
| **femto** | **f** | |
| **giga** | **G** | |
| **kilo** | **k** | |
| **mega** | **M** | |
| **micro** | **μ** | |
| **milli** | **m** | |
| **nano** | **n** | |
| **peta** | **P** | |
| **pico** | **p** | |
| **tera** | **T** | |
| **yocto** | **y** | |
| **yotta** | **Y** | |
| **zepto** | **z** | |
| **zetta** | **Z** | |

* One of the major reasons SI units have been adopted is to *streamline* the relationships between the units representing physical quantities and to *simplify* the relationships between small and large quantities.
* To get an idea of how SI units simplify the representation of units of *length*, compare the SI representation to the Imperial System of Units:
  + SI units of length
    - meter [m]
    - To denote smaller units of length than a meter, just use one of the SI prefixes with a negative exponent. To denote larger units of length, just use of the SI prefixes with a larger exponent.
  + Imperial units of length
    - thou [th]
    - inch [in] = 1000 th (similar to how 1 m = 1000 mm)
    - foot [ft] = 12 in
    - yard [yd] = 3 ft
    - chain [ch] = 22 yd
    - furlong [fur] = 10 ch
    - mile [ml] = 8 fur = 8 10 22 3 = 5280 ft
    - league [lea] = 3 ml
* As a second example, consider the representation of *power* in SI units versus the multiple representations of power common in imperial units
  + SI units of power
    - 1 watt [W] = 1 joule/second [J/s]
    - To denote smaller units of power than a watt, just use one of the SI prefixes with a negative exponent. To denote larger units of power, just use of the SI prefixes with a larger exponent.
  + Imperial units of power
    - Mechanical power
      * foot-pound-force/second [ft-lbf/s]
      * horsepower [hp]
      * 1 hp = 550 ft-lbf/s
    - Thermal power
      * British thermal unit/hour [btu/hr]
      * 1 hp = 2544.43 btu/hr
* Hopefully, it is clear now how much SI units streamline and simplify the relationships between magnitudes of physical quantities. The SI system also makes derived units simpler since the principal units are streamlined.
* **QFT Exercise Lab0:** **Write the QFocus here**
* QFT Rules

1. Ask as many questions as possible in the allotted time.
2. Do not answer or discuss the questions and do not judge the quality of the questions!
3. Write the question exactly as stated (include even grammatical errors!)
4. Articulate everything as a question (no statements allowed).

* *Produce Many Questions*: [7 minutes]

**Step 2: Improve the Questions**

* Once the time for question-storming expires, the next step is to *refine the questions* (and possibly few statements) that have been generated.
* In this step, any *statements* should be rephrased as *questions*.
* Any questions that are unclear to the recorder or other members of the group may be clarified or rephrased. Be sure to write the questions so they are clear even without the context of the QFocus!
* Questions that are very similar may be combined.
* Questions that are **closed-ended** – meaning they may be answered in one or a few words – may be rephrased as **open-ended** – meaning they require exploration. Mark a “C” or “O” next to each unrefined question to denote whether it is closed-ended or open-ended.
* The recorder should re-write the questions in refined form, noting which questions have been combined or eliminated from the unrefined list. This list will be one of the items to be submitted for each QFT exercise.
* *Improve the Questions*: [5 minutes]

**Step 3: Prioritize the Questions**

* After creating the refined list of questions, the group should reach consensus on the top five questions, in the order of importance. The main criteria to use in this process is to consider which questions best target an aspect of the topic that can be *further explored* and which are the *most relevant to the topic*. Consider how deep the question is. The deeper, or more probing, the question is, the higher it should be on the list.
* Once the group prioritizes the top questions, each individual should select their favorite question among the top five questions. Note that each member of the group should select a different question.
* *Prioritize the Questions*: [top 5 questions best for exploration] [3 minutes]



**Step 4: Explore the questions**

* For 3 of the QFT exercises done in lab throughout the semester – excluding the QFT done this week – each student must take one of their favorite questions from Step 3 (or even Step 2) and explore the question through research in search of one or more answers that address the question.
  + The question should be unique for each student (i.e., students should not select the same question to explore)
* Note that often the research will lead to more questions. This is great! And it’s expected! Record the subsequent questions too!
* At least one peer-reviewed or peer-edited technical resource, such as a journal article, conference paper, or textbook (other than our textbook) should be cited in the exploration of your top question. Note that the source should be closely related to your question!
  + One hint to finding good sources for your question is to pick out key words from your question to use as search queries in one of the databases available from the library.
* After exploring the question to see where the question leads (to some answers, other questions and so on), the student should write a 1 or 2-page summary of the exploration experience describing new questions and any discoveries found in the exploration process. At least one paragraph should be dedicated to describing the technical source that is cited and evaluating how well it aided in your exploration of the question.

**Step 5: Reflect on the process**

* After at least 2 of the QFT explorations have been submitted, students must write a ½ to 1 page reflection on the lab QFTs focusing on how the QFT exercises and explorations helped in the following:
  + Your ability to ask a lot of questions on electric circuits topics
  + Your ability to ask relevant questions on electric circuits topics
  + Your tendency to question information that is given without sufficient justification.
  + Identification of gaps in your circuit knowledge
  + Taking ownership of circuit-related questions and concepts
  + Identifying and evaluating technical sources of information for research and exploration
  + Discovering new passions related to circuits
  + Connecting life experiences with circuit content
  + Considering a problem from multiple viewpoints
  + Being able to teach and learn from peers through sharing questions and information
  + Developing an appreciation of hard work
  + Recognizing the benefits of focused and fervent effort
  + Did the QFT process engage you more in the electric circuit content?

**Need-Approach-Benefits-Competition (NABC) Approach to Formulation of Value Propositions:**

* Developed by Stanford Research Institute (SRI)
* The NABC formulation is a way to frame any idea to understand its essential elements:
  + What is the underlying **Need** the idea addresses? Is the need *important* and not sufficiently addressed by other ideas?
  + What is the **Approach** taken by the idea to address the need? How will the idea be delivered? What does it look like and what is unique about it?
  + What are the **Benefits** specific to the idea – taking into account the relevant costs required to realize the idea – that make it a stand out idea? How are the benefits specific to the audience?
  + What are the **Competing** ideas that can be considered alternatives to your idea? What makes your idea stand out? How does your idea excel compared to the competition?
* The NABC framework can be used to pitch any sort of idea, whether it is an
  + Engineering design
  + Business model
  + Research idea
  + Creative development
  + New technique or process to do \_\_\_\_\_\_\_\_\_.
* NABC places the audience at the *core* of the development process and should be used at all stages of development of an idea, as it can bring the strengths and weaknesses of the idea to the forefront and thus reduce development time.
* **NABC Example:** Video On-Demand Pitched to Cable Company (circa 2006)
  + **Need**
    - Movie rentals = $5 billion business opportunity
    - Currently NO market share
    - People don’t like
      * Returning rentals
      * Late fees
  + **Approach**
    - Video on demand using cable
      * Access all movies
      * Use unused cable channel (no changes to system)
      * No capital needs to be invested
      * Same price as video store rental ($6.99 at the time)
  + **Benefits per Costs**
    - Receive $5 revenue per rental
      * Profit Margin of 20%
    - Same experience as VCR/DVD without need to return!
      * Late fees are gone!
    - Estimated market share = 20%!
  + **Competition**
    - Video on demand system is patented
      * Only one of its kind at the moment
    - Online rentals
      * Disadvantage = handling costs of 75 cents/unit
      * Sending videos back is inconvenient for customers
      * No spontaneous rentals
* Kickstarter NABC Pitch Identification:
  + Get in groups and navigate to Kickstarter.com
  + Find a kickstarter campaign of interest to your group, watch the video, read the description, and then identify the N, A, B, and C elements from the pitch.
  + Note which elements are well supported, clear, and compelling in the pitch
  + Note which elements are poorly supported, unclear, or missing in the pitch.
  + Is the pitch effective in your opinion?
  + Is there a positive correspondence between how well the elements of NABC are delivered in the pitch and your opinion of the pitch’s effectiveness?
* Kickstarter Campaign Project selected: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Need:
* Approach:
* Benefits (per costs):
* Competition: