Thought and argument are like exercise: there is a level of exertion and a point at which you might just quit. The conscious effort that you put into critical thinking is actually a decision. When we reason there is a moment in which we choose to stop thinking and we probably give up… and very rarely is it based on ability. More often, the ***level*** of thinking at which we stop or choose to proceed is a choice. Are we intellectually lazy? Or are we courageous? I had a math professor who stated once that our ability to stick to a problem for days and fill blackboards full of equations in pursuit of an answer was called “academic guts”. We took 15 weeks to solve a single math problem. His name was Gelbaum, and he wrote books. He was intellectually courageous.

It is an organizational tool, and instructive, to highlight four sequential levels of thought: Emotion, Nuance, Data, Improvement.

***The First Level: Emotion***

The first level of thought is undoubtedly ***emotional***. Arguments that start and end based on feelings with no data, nor reasoning, stop at the first level. Unfortunately, cable news and most political arguments are of the first-level type. “We can’t have single payer healthcare because that would be socialism.”, “I voted for X because he’s the type of person that I would have a beer with.”, “Masks are an invasion of freedom.”, “People are poor because of their own bad choices.” are all arguments made from the first level. First-level people vote, and some get elected. It’s not uncommon. But no scientist who stops at the first level is successful, and should not be a scientist. Or an engineer. Scientists in England resisted Einstein’s theories because of their loyalty to Newton. That’s a serious first-level barrier.

Most dangerously, fear drives the first level and fear tends to stop the advance. Fear of others who are different, fear of things that are different, fear of a new approach, is severely limiting and begs for further thought. Should we fear other cultures or seek integration? I spent 6 mos. in Mexico with an employee from the U.S. who would only eat at McDonalds. And Mexican food IN MEXICO is some of the best food in the world. But it is a paradox of the next level of thought that we recognize that such is the nature of choice.

Most unscrupulous means of argument (called “logical fallacies) are designed to keep us emotional and prevent us from moving on from level one. This includes argument from authority, red-herrings, strawmen, what-aboutism, and these three:

***Ad Hominem*** *- From the Latin for “to the person”, an ad hominem is an attack against the arguer rather than the argument. This doesn’t mean that you simply call the person a jerk; rather, it means that you use some weakness or characteristic of the arguer to imply a weakness of the argument. ”I think Volvos are fine automobiles.” … ”Of course you’d say that; you’re from Sweden.”*

***Appeal to Dead Puppies*** *- Sometimes tugging at the heartstrings with a tragic tale is enough to quash dissent. Who wants to take the side of whatever malevolent force might be associated with death and suffering? The Appeal to Dead Puppies draws a pathetic, poignant picture in order to play on your emotions. Recognize it when you hear it, and keep your emotions separate from the facts. ”Thank you, door-to-door solicitor, but I choose not to purchase your magazine subscription.” …. ”But then I’ll be forced to turn to drugs and gangs.”*

***Slippery Slope*** *- A*[*slippery slope argument*](https://www.developgoodhabits.com/slippery-slope/)*is one that assumes something catastrophic will result from an event that is insignificant when looking at the bigger picture.  If you related to the first example given in this article of assuming you were going to get fired over a small mistake at work, then you may be able to identify with this logical fallacy. Another example of this would be an argument suggesting that if you don’t study every day of the week, you won’t do well in school. And, if you don’t do well in school, you won’t get a good job. Since you will be living without a good job, you will be homeless. This suggests that not studying every day will result in eventually becoming homeless. However, this argument is making a lot of assumptions and taking them to an extreme measure. It is leaving out all other factors that would have to occur to result in a person becoming homeless.*

***The Second Level: Nuance***

The second level of thought shows the beginnings of ***nuance.*** “Nuance” simply acknowledges that things are a bit more complicated than what strict emotions would allow. Maybe a specific case shouldn’t be taken generally. Maybe the other person has a point. Perhaps there’s an experiment that would show us the true state of affairs. Even “let’s wait and see” is nuanced. A second-level response to the question of masks and freedom is simply “Being virus-free is also a type of freedom”.

I was vacationing in California once when a native asked me “How can you *possibly* live in Buffalo?”. Kind of snooty. I replied “There are many kinds of ‘beautiful’.” His first level met my second.

The second level shows early signs of critical thinking. It hasn’t *categorized* it yet, or organized the different sides of the argument, or begun to search for truth, but nuance recognizes that the situation might call for it. The step from first to second level is perhaps the most difficult because it opens a trap door into having to think hard. Many people are content to sit at the emotional level. It takes commitment to move on, although scientists and engineers find this jump rather easy. And it is OK to bring emotion along with it.

The second level brings along breadth, the introduction of side topics which expand the base of knowledge. A social issue might have economic implications that emotions are hiding. A political issue might need to differentiate effects between rich and poor. You might need to now include a minority opinion in your assesment of a situation. Level one is typically single-topic. Level two is not.

Perhaps the biggest benefit of second level thought is the introduction of skepticism, basically not believing what you’re told.

***The Third Level: Data***

The third level of thought is where it all gels. It is characterized by ***data and facts***. Our willingness to gather data and recognize facts is our hunt for a better world. “How do countries with socialized medicine rank compared to privatized insurance?”. “What has been shown to break the cycle of poverty?”. “By what metrics should we judge the effectiveness of our economic policies?”.

The third level is where thought and argument leaves behind untruthfulness, which is often rampant at level one and even at level two. But at level three there is no room for lies, rumors, superstition, or playing loose with the truth. Scientists live at level three: ***data*** yields ***information***, which becomes ***knowledge***, which allows for ***insight***, which matures into ***wisdom***. Although level 2 nuanced thinking gives us a hint at truth, it is in level 3 that we can actually discern it, and the discovery of truth is not to be trivialized.

Level three thought requires an intuition into experimentation, metrics, and math. There are four questions to ask ourselves when we enter the third level of thinking:

1. Exactly what data can be used to express a system? This is a question of ***pre-analysis*** and applicability.

2. How should it be measured? and

3. How should it be analyzed, once gathered? This is a question of ***post-analysis.***

4. Is the data accurate?

The four questions comprise an *experiment*. Experiments need not be formal. We all perform experiments when we gather information and use it. To that end, there are two very important maxims to remember as we traverse our professional and personal lives:

 “You can never have too much information”, and

 “Don’t make a decision until you have to.” The reason being, there might be more useful information to come.

Sometimes data gathering is trivial (“It appears that when we stopped abusing our customers, our sales went up”) and sometimes it is increasingly complex e.g. the Hawthorne effect: when an employer put in enhance lighting, productivity went up. When they later removed lighting, productivity went up!

As engineers, our job is to find simple, elegant solutions to complex problems that have never been solved before (when we solve problems that HAVE been solved before, our job turns to research and application). But solving a new problem requires detailing - or information gathering - organizing, and categorizing. Take Graphical User Interfaces - GUIs - for example… what input do we need from a user in order to drive our system, and how do we get it dependably and unambiguously? Designing interfaces is all about gathering information (i.e. third level thought).

And a special caution: make sure that the data is **true, and applies to the problem at hand.** You know what they say: “85% of statistics are made up”, including that one. And that brings me to (perhaps) the central point of this essay, or at least its most important… ***the Internet is NOT a source of accurate, dependable, trustworthy data.*** In fact, if you use Wikipedia as a reference for your writings in this course, I will deduct points. The references at the end of a Wikipedia article might be an acceptable starting point. It is because of runaway, unverified, widespread data on the Internet that we have conspiracy theories, and no good can come of that.

Scientists have found a way to validate and propagate data. And their/our situation is notable in that we uncover previously undiscovered data and need to convey it in a trustworthy manner. Otherwise, it’s just another mythology. We cannot believe data because someone says it, and we will always be able to find an Internet source for even the most suspect story (which brings to mind an old Russian saying: “He lies like an eyewitness.”). The motto of the British Royal Society (perhaps the oldest scientific organization in the world, formed back when science was called philosophy) is  'Nullius in verba', taken to mean 'take nobody's word for it'. It is an expression of the determination of Fellows to withstand the domination of authority and to verify all statements by an appeal to facts determined by experiment. Our method is the scientific method: verify through experimentation and publish the results to be relentlessly and forever reviewed by our peers. And, fortunately, many of our peers are hyper-critical rivals looking for every opportunity to trip us up. If our data can withstand peer-reviewed publication, can be repeated through new experiments, and continues to be the best possible theory in the face of competition, then we can use it until something better comes along. When scientist and evolutionist Bill Nye debated creationist Ken Ham, the moderator asked them “What would get you to change your mind?”. The creationist said “nothing”. The scientist said “new data”. And there it is.

***The fourth level: Improvement***

What do we do with the information we’ve gathered and analyzed? That’s easy. we improve our “situation”, whatever that situation is. We close the loop. We feed back. A therapist might help you understand your behavior, but it is the following period of self-improvement that makes you happy, or effective. It is fourth level thought that ultimately improves our self-worth, because then our thoughts improve our lives.

*“Solving problems and improving lives”*

Engineers are paid to think, yes, but then to apply our thoughts to solving problems and improving lives. The best example I can think of to apply 4 levels of thought is the weather. We hate being caught in the rain (level 1), but complaining about the weather does nothing. Maybe we don’t have to tolerate that (level 2). Let’s figure out if it’s going to rain, perhaps by looking out the window (level 3). Hmm, it’s wet out there. I’ll take an umbrella (level 4). Now, imagine applying that process to the forecast, warning, and evacuation of Florida during a hurricane.

The simple act of learning from our mistakes is fourth level thought. Engineering advances through errors, which is why we should never ne ashamed of making mistakes. We should only be ashamed if we repeat them.

** ***In closing***

Our greatest living philosopher – Bob Dylan – wrote a song about critical thought called ***My Back Pages*** (the version by the band America is my favorite) in which he speaks of ideas as a map. And although he rails against professors (“the mongrel dogs who teach”), he laments us running out of ideas - the edges of the map - and about the hard work of intense thought (“crimson flames” and “flaming roads”):

*Crimson flames tied through my ears
Rolling high and mighty traps
Pounced with fire on flaming roads
Using ideas as my maps
"We'll meet on edges, soon," said I
Proud 'neath heated brow
Ah, but I was so much older then, I'm younger than that now*

Although the song hits you right at level 1, the curiosity in level 2 might drive you to listen to the entire song and appreciate the lyrics’ mentions of thought, writing, learning, prejudice, and politics. And the pride of being a thinker, and how it keeps us young.