# Propositional Calculus – Part 1: Introduction

Propositional calculus is one of the oldest forms of logic. It lies at the heart of all syllogisms, deductions, inductive inferences, and the like. It is the system that allows us to deal with logic problems such as determining the truth of the following argument:

<It is raining

If it is raining then I am depressed

I am depressed>

or of this argument:

<It is sunny

If it is sunny then it is bright

If it is bright then I should wear sunglasses

I should wear a raincoat.>

Note that is doesn’t judge the truth or falsehood of the premises (It is raining or it is sunny) or of the conditionals (If it is…), it only judges the truth content of the conclusion based on these assumptions (premises and conditionals). It won’t know whether or not it is raining, but it will be able to tell me that I am depressed when it is raining (not true – I like the rain) or that I shouldn’t wear a raincoat when it is sunny. Note also that the system is not equipped to handle syllogism using the quantifiers all, some, or none. Thus the true syllogism

<All men are mortal

Socrates is a man

Socrates is mortal>

and the false syllogism

<All cats have fur

All cats are mammals

All mammals have fur>

are outside of its ability to evaluate.

Despite these limitations, the system is fairly powerful and can be used in successful applications of artificial intelligence to solve real-world, interesting problems.

Amazingly propositional logic is able to pack a lot of power into a fairly brief amount of symbolism. The system as a whole consists of 2 objects, 5 expressions that define relations between the objects, 10 rules for manipulating the relations, and 3 helper symbols that act as traffic cops to impose order on the steps.

The simplest object of the system is an atomic proposition, like the statement ‘It is raining’. This proposition, usually denoted by a single capital letter – ‘R’ for ‘It is raining’. More complex propositions are built out of the atomic propositions using the 5 logical expressions, subject to certain rules. Any primitive proposition and all valid compound propositions are collectively known as well-formed formulae (wffs – pronounce ‘woofs’, like the sounds dogs make). Often wffs are denoted by Greek symbols, like $$\phi$$ or $$\psi$$.

The 5 logical expressions denote relations associated with the propositions. There is one prefix expression, where the expression symbol operators on only one proposition, and 4 infix expressions that link two propositions together.

The prefix expression is the ‘not’ which translates the proposition ‘It is raining’ into the negative proposition ‘It is not the case that it is raining’. This somewhat more clunky way of expressing the negation (rather than ‘It is not raining’) seems to be preferred since it makes adding or removing a negation as simple as adding or removing the phrase ‘It is not the case that’ to the front of an existing proposition.

The four infix expressions link two propositions together. These are:

* Conjunction – ‘It is raining’ and ‘It is cold’
* Disjunction – Either ‘it is raining’ or ‘it is sunny’
* Conditional – If ‘it is raining’ then ‘the ground is wet’
* Biconditional – ‘It is raining’ if and only if ‘water droplets are falling from sky’

Since the conjunction, disjunction, and biconditional expressions are symmetric upon interchange of the two propositions (or wffs) there is no special name for the first or second slots. The conditional, however, requires a sense of cause-and-effect and, as result, the first slot is called the antecedent and the second slot the consequent. In the conditional ‘If it is raining then I am depressed’, ‘it is raining’ is the antecedent and ‘I am depressed’ is the consequent.

The systems objects and expressions can be summarized as

|  |  |  |  |
| --- | --- | --- | --- |
| Expression | Name | Symbol | Example |
| It is not the case that | Negation | ~, $$\neg$$, ! | $$~R$$ |
| … and … | Conjunction | $$\land$$, & | $$R & S$$ |
| Either … or … | Disjunction | $$\lor$$ | $$R \lor S$$ |
| If … then … | Conditional | $$\rightarrow$$ | $$R \rightarrow S$$ |
| … if and only if … | Biconditional | $$\leftrightarrow$$ | $$R \leftrightarrow S$$ |

In addition to the expression symbols, there are a few additional helper symbols that keep things neat. The first is the ‘implies’ symbol $$\implies$$. It is sometimes called ‘infer that’ and then is denoted by $$\vdash$$. Either basically denotes the final conclusion (the output) of the argument. So the first proposition translates into

$$R$$

$$R \rightarrow D$$

$$\implies D$$

where R is the proposition ‘It is raining’ and D is the proposition ‘I am depressed’. The second set of symbols are the parentheses ‘(‘ and ‘)’ which are used to group terms together to avoid ambiguous expressions such as $$A \land B \land C$$, which could mean ‘I did A and then I did B and C’ or ‘I did A and B and then I did C’ or other meanings.

The next piece is the rules of inference that allow proper manipulation of one set of wffs into another. These rules are:

1. Modus ponens: a conditional implies the consequent if the antecedent is true
2. Negation Elimination: $$~~\phi \implies \phi$$
3. Conjunction Introduction: $$\phi, $\psi \implies \phi \land \psi$$
4. Conjunction Elimination: $$\phi \land \psi \implies \phi, \psi$$
5. Disjunction Introduction: $$\phi \implies \phi \lor \psi$$ for any $$\psi$$
6. Disjunction Elimination: $$\phi \lor \psi, \phi \rightarrow \chi, \psi \rightarrow \chi \implies \chi$$
7. Biconditional Introduction: $$(\phi \rightarrow \psi), (\psi \rightarrow \phi) \implies \phi \leftrightarrow \psi$$
8. Biconditional Elimination: $$\phi \leftrightarrow \psi \implies \phi \rightarrow \psi, \psi \rightarrow \phi$$
9. Conditional Proof (CP): accepting a proposition $$P$$ that proves another $$Q$$ then $$P \rightarrow Q$$
10. Reductio ad Absurdum (RAA): A contradiction to $$~\phi \implies \phi$$

Note that the truth value of the propositions are assumed to be known from the outset (with the exception of the conditional proof and reduction ad absurdum, where the assumption is made during the course of the argument). The purpose of the system is to determine the truth of the conclusion based on the truth values of assumptions. The formal inference rules act as a computer program that transforms input to output.

Next week’s column will apply the Propositional Calculus to prove some interesting outcomes and to show how unexpected inferences can result. All of that is a prelude to the final, fun application of preventing an AI explorer from dying due to misadventure before he can go ‘there and back again’.

# Saving the Environment One Electric Car at Time

Well Elon Musk is at it again. Cleverly launching a feel-good

# Story Construction: Sheriff of Babylon

Some months ago, I went into a wide survey of the various ways that comics creators actually make their comics. The interaction between writer and artist was a particular focus and two main ways for putting the scripts together:

* Script first – writer delineates what’s to be on each page: number of panels, dialog, action, points-of-view, etc.
* Plot-first – writer gives a general outline of the plot and the artist provides the panels to which the writer adds dialog and captions.

This week I would like to cover how the creative team on *The Sheriff of Babylon* does their thing. Ironically, I don’t read the title and the material that I am presenting and analyzing is taken from the back of issue #2 of the Vertigo title *The Dark & Bloody*. I can’t say why this piece got included but I am glad that it did as it is always helpful to see how someone does it.

A bit of dwerping around on the internet has revealed to me that *The Sheriff of Babylon* is a 8 issue limited series from Vertigo written by Tom King with art by Mitch Gerads. Vertigo describes the comic series as:

<Baghdad, 2003. Florida Police officer-turned-military contractor, Chris Henry is tasked with training a new Iraqi police force. When one of his trainees ends up dead, Chris is forced to team up with Nassir, the last remaining cop in Baghdad. Pulling the strings to bring them together is the mysterious Sofia, an American-educated Iraqi who has returned to take control of the city’s criminal underworld. This miniseries is a thrilling wartime crime drama told amid one of the most tumultuous times in modern history.>

The behind-the-scenes look covers the creation of page 7 of issue #4 and is written by Mitch Gerads. He breaks the creation down into seven steps.

Step 1: First he gets the script from Tom King

<insert Step 1>

Gerads makes a point of saying that the script arrives about a week before he even starts and that allows him to ‘live with it for a while’, by which he means that he reads it several times and plays the action out mentally before he starts forming them on paper.

Step 2: Gerads develops the layouts in a quick and loose fashion, which he calls ‘Mitch Gibberish’. The idea here is to get the overall look and feel into the rest of the creative team’s hands. Unfortunately, he doesn’t get into any back-and-forth that may exist where King or editor Jamie Rich may ask for adjustments.

<insert Step 2>

Step 3: Gerads tries to bring a sense of realism to the book since the events are based on real-life. He, apparently does this by looking at photography of Iraq, military hardware, etc. He also shoots photo references in which he acts out the parts (or gets help from his family – here pictured his twelve-year-old cousin Coop).

<insert Step 3>

Step 4: He says that he tweaks and arranges all of these photographs into a reference collage in Photoshop as a prelude to drawing.

<insert step 4>

Step 5: According to Gerads, The Sheriff of Babylon is done completely digitally. So he then turns the reference layout into a digital blue-line drawing and then covers the drawing with digital inks, resulting in a black-and-white layout.

<insert step 5>

Step 6: Once the inks are done, Gerads hands off the pages to the color flatter, Joseph Franzzetta, who blocks in random colors so that Gerads can continue to draw.

<insert step 6>

What I believe is happening in Step 6 is that Franzzetta gets the art carefully colored with a palette that can be easily remapped to whatever Gerads want it to be. For example, the green sky in the image above maps to the sandy colored sky in the final done in

Step 7: Gerads does the final coloras and formats it before sending it off to the printer. Sadly, he doesn’t provide much in the way of how he formats and if formatting includes the speech balloons.

<insert Step 7>

So there you have it, a quick look at how the art is done on *The Sheriff of Babylon* following the script-first technique.

Saving the World One Electric Car at a Time

There is no doubt about it, Elon Musk knows how to generate excitement and how to sell product. Tesla motors recently announced plans for the relatively affordable Model 3, a much less expensive version of their famous electric car ([although some beg to disagree](http://www.theatlantic.com/technology/archive/2016/04/tesla-model-3-/477243/)).

One of the selling points that Musk accentuates is the notion that buying a Tesla helps save the planet. Driving an electric car contributes to the environmental changes so desperately needed for the big blue marble. This very claim about lifestyle is just ludicrous.

Don’t get me wrong. I like the idea of competition in the market place and a greater number of choices available for the consumer. And I like the idea of electric cars in general and the Tesla in particular. What I don’t like is some of the shoddy economic thinking that drives certain people to think that the Tesla Model 3 will be the revolutionary next word in environmental stewardship.

The simple reason for this is the enduring and unassailable law of economics – everything has a cost. This is what is known in common parlance as ‘there’s no such thing as a free lunch’. But surely, goes the common wisdom, driving an electric car is much friendlier to the environment; it has zero emissions.

Well Frederic Bastiat would be quick to point out that such a conception is based on thinking that is only looking at what is seen. The so-called hidden costs remain just that, hidden. What are this hidden costs? The generation of the electricity still comes from almost exclusively from fossil fuels. This fact leads to two complications that may actually be serious enough to turn the notion that electric cars are contributing to the solution on its head.

The first and most benign complication is [something about which I’ve written before](http://commoncents.blogwyrm.com/?p=73). The tax structures and incentives that are currently in place encourage the electric car owner to be a free rider; to use public goods without contributing his fair share. Since the maintenance of the public roads depends on revenue almost exclusively arising from gasoline taxes, the electric car owner gets to use the roads without directly paying for the maintenance. It is entirely possible that law makers will then have to keep gasoline prices low enough to encourage more of the conventional drivers to buy enough fuel to offset the loss. This additional consumption has the opposite effect on the environment that what was originally intended.

The second and much more serious complication is that fossil fuels are the primary source of electrical energy in this country. So as more electric cars find their way on the road, the use of fossils fuels will recede from the public view and become hidden behind the long lines of copper that remove us from the power plants where the chemical energy is converted into electrical. There may even be a thermodynamic argument that shows that it is more inefficient to generate the needed energy and transmit it to the electric car than it is to simply burn gasoline in an internal combustion engine. I don’t know one way or another – I simply know that very few talk about this hidden face.

Of course, the typical zealot who thinks only about the upside to the electric car will point out that the great and powerful Musk has a solar panel business as well and that we can all simply move to renewable energy powered by the Sun. Unfortunately, that doesn’t work.

The table below has a modest estimate of the cost required to outfit the country with solar panels that exclusively provide the energy needs of the USA. The amount of available solar energy is over estimated in several spots (6 hours/day is about 30% too large; 40% of total power captured is 10-20% too large). The efficiency of the solar panels is put in the middle range of what is currently achievable and the cost is brought down by at least two orders of magnitude. The estimate for total energy used in the US is taken as the lowest value found (about 10% low).

|  |  |  |  |
| --- | --- | --- | --- |
| *Physical Parameter* | *Value* | *Units* | *Source/Comment* |
| USA area | 9.86E+12 | m^2 | <https://en.wikipedia.org/wiki/United_States> |
| Solar Irradiance | 1350 | Watts/m^2 | <https://en.wikipedia.org/wiki/Sunlight> |
| Sunlight portion of a day | 6 | hours | <http://www.wholesalesolar.com/solar-information/sun-hours-us-map> |
| Year | 31557600 | seconds | 365.25 days x 86400 seconds/day |
| Usuable year | 7889400 | seconds | 6 hours/day |
| Total energy | 1.05E+23 | Joules |  |
| Panel Efficiency | 0.15 |  | Based on current technology |
| Irradiance | 0.4 |  | Assume 40 % of total irradiance is usable] |
| Total usable energy | 6.30E+21 | Joules |  |
| Total USA Energy use | 9.00E+16 | BTU | http://www.eia.gov/consumption/ |
| Total USA Energy use | 9.50E+19 | Joules | <http://www.digikey.com/en/resources/conversion-calculators/conversion-calculator-btu-to-joules?WT.srch=1> |
| Total solar panel area | 1.49E+11 | m^2 | total USA energy use/Total usable energy x USA Area |
| Cost per m^2 | 500 | Dollars | Gross underestimate of current costs |
| Total cost | 7.43E+14 | Dollars | That's 74.3 trillion dollars |
| GDP | 1.68E+13 | Dollars |  |

So even if the country were of a mind to do nothing but make solar panels, it would take over 5 years just to outfit our national needs (that means no growing crops, to manufacturing food or housing or anything else, no health care, no fun).

There would also be serious environmental effects with so much solar panel manufacturing. The chemicals and materials are far from safe (many are downright toxic) and the industrial process requires energy itself. Clearly solar power isn’t the answer.

The energy densities needed to transform the national use from fossil fuels to clean energy are really only found in nuclear power but even that approach is not without cost and risk; even if the cost and risk were appropriately mitigated there still remains the political opposition to this energy source; an opposition that is firmly rooted in an irrational fear of a nuclear holocaust that ever far less dangerous than global warming; and this fear is, itself, deeply rooted in the same muddled thinking that leads these same people to cling to the notion that solar is the answer.

So at the end of the day, I’m all for the consumer buying a Tesla just so long as he understands that he while he may be saving money he isn’t saving the environment; that he has yet to find a way to get a free lunch.

<http://www.realcleartechnology.com/2016/04/04/tesla039s_model_3_lives_up_to_the_hype_33406.html>

<http://www.realcleartechnology.com/2016/04/04/the_top_7_design_features_of_the_tesla_model_3_33395.html>

<http://www.realcleartechnology.com/2016/04/05/tesla039s_model_3_can039t_fix_our_energy_problems_33434.html>

<http://www.realcleartechnology.com/2016/04/06/you_might_own_an_electric_car_in_a_decade_33437.html>

<http://www.realcleartechnology.com/2016/04/06/will_end_of_tax_credit_slow_tesla039s_model_3_33446.html>

Knowledge and Uncertainty

The disciplines of the natural sciences and philosophy enjoy a rich, complicated, and, at times, subtle relationship. Philosophic pursuits help to guide and inform the scientific enterprise while the phenomena, which science discovers, categorizes, and explains, expands and grounds the philosophic thought. Nowhere is this interaction more interesting and, perhaps, more important than in the area of knowledge and uncertainty.

Epistemological ideas dealing with what is knowable, unknown, and unknowable have played a large role since the earliest days of philosophy. In the Platonic dialog [*The Meno*](https://en.wikipedia.org/wiki/Meno), Socrates puts forward the idea that much (or perhaps all) human learning is really a kind of remembrance of knowledge attained in past incarnations of the soul ([anamnesis](https://en.wikipedia.org/wiki/Anamnesis_(philosophy))). How exactly the cycle starts and what knowledge the proto-soul possesses or whether Plato/Socrates actually worried about an infinite regress is not clear.

Questions of knowledge continue on for thousands of years without much of a change in the focus or tenor until the rise of quantitative scientific methods in the post-Renaissance world. Almost overnight, there is now a way to discuss three vital components of knowing, at least within the context of physical systems:

* Knowledge characterized by measurement
* Uncertainty characterized by error
* Mathematical description of how the two propagate their influence

These new ingredients are not developed to shed light on ages-old debates but rather to determine just how to deal with these new models of the physical world – differential equations. In differential equations, man had an operational model for cause-and-effect; a laboratory wherein the ideas of what is known and unknown/unknowable could be made the subject of experimentation. Nature’s own fabric helped to shape and mold how mankind saw knowledge.

These ideas matured in many different directions subject to need and taste. The three most interesting ones are:

* Control theory
* Statistical mechanics
* Quantum mechanics

In control theory, the basic notion is one of a state whose evolution is subject to a set of differential equations that describe the influence of the natural environment and the man-made controls used to guide the evolution into a desired behavior. The physical world is divided into pieces known and unknown. The

* Random or stochastic error – some things can’t be predicted
* State error – aleatory & epistemic
* Model error – aleatory & epistemic
* Aleatory – uncertainty that is part of the system; characterized by probability

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