Developing Options Intuition (Draft)

A Curious Person's Guide To Developing Intuitions About Vanilla Options Pricing and Behavior

EZL

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Introduction

Financial derivatives can be confusing and are generally outside the expertise of non-professional investors. Of the many types of financial derivatives, options (calls and puts) are the most widely used by non-professional investors.

Even professional investors who don't specialize in options often lack an instinctual understanding of how options behave, and as a result, they sometimes mischaracterize the risks or use them suboptimally.

This guide is a primer for beginning to develop intuitions about option behavior. It is *not*:

- a manual on how to get rich
- a textbook for options pricing
- a playbook for trading strategies

The intended audience is technically-minded, non-professional traders who already have a basic understanding of what options are and how they work, but may lack a deeply-rooted *intuition* about how options are priced and how they can be expected to behave.

My goal is to jumpstart your path to developing these intuitions through narratives that make it easy for you to understand and explain options as more than just a formula or an expiration P&L diagram.

I will gloss over basic details, and I don't intend to demonstrate how to derive pricing (which is a very complex topic). There are already many fantastic texts on the subject:

- **Taleb**, *Dynamic Hedging* – Taleb's only good book.
- **Natenberg**, *Options Volatility and Pricing* – Widely considered the options bible, but an awful read. (1) However, this book has probably made more millionaires than any other book ever written. I don't recommend it, but any reference to options starter guides is incomplete without it.
- **Hull**, *Options, Futures, and Other Derivatives* – The *real* options bible. Must read for any introductory quants and a fantastic reference for practitioners.

Like learning physics, we will begin with simplified, idealized portrayals of the universe (market), then introduce real world complexity.

There are ways where real world practice diverges from what I've written here, but this is, in my opinion, an appropriate starting point for developing a base for how to think about options that can later be adapted for real world trading.

In this guide, we'll focus on American and European calls and puts. A very basic understanding of options is a prerequisite.

Footnotes

(1) *"If one were to buy (sell) a call (put) bull (bear) spread and the underlying were to go up (down) the value of the call (put) bull (bear) spread would increase (decrease) in value." ~The sound of a thousand trading assistants banging their heads on the desk~ Sorry, Shelly.*

Random Walks

Before we discuss option valuation, we have to touch on the behavior of the underlying stock.

Option value is based on the behavior of the option's underlying stock. More specifically, options have value because there is uncertainty in the future price of a stock and options guarantee the bearer certainty in an otherwise uncertain future.

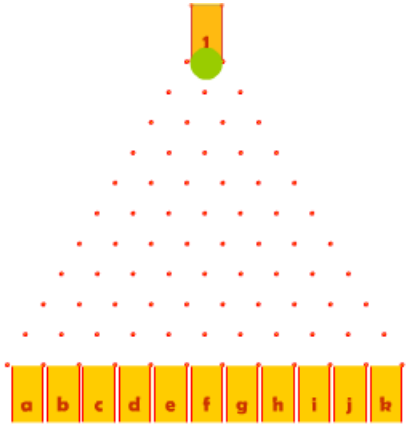
We can't know the exact path that a stock's price will take in the future. Instead, we characterize the stock's behavior and use that to describe all the *possible* future states of the stock.

Example

AAPL stock settled today, Nov 20 2012 at 560.91/share. Throughout the course of the day tomorrow, indepent market participants will buy and sell shares of AAPL, causing the price to move up and down, seemingly at random.

At each moment in the day, the next price that prints on the AAPL ticker may be either higher, lower, or the same as than the current price – this is unpredictable (and not necessarily equally probable).

It's useful to imagine the stock price like a ball running through a series of pins:



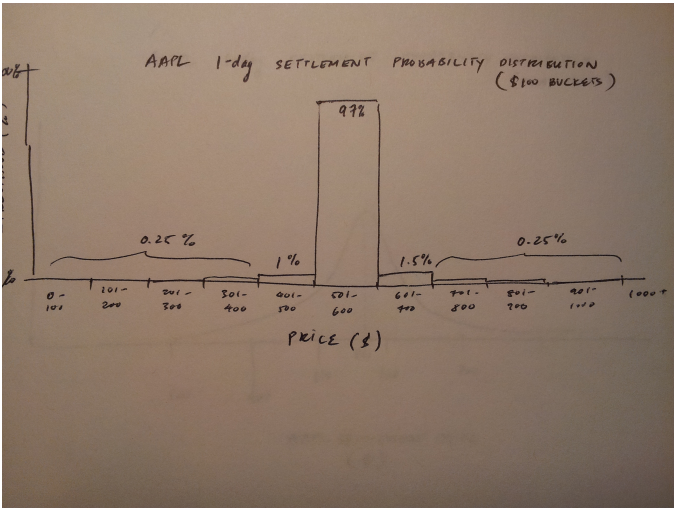
A ball running through pins mimics price behavior

This uncertain, stochastic price movement over time is referred to as a "random walk".

While you don't know what price AAPL will settle tomorrow, you might have a guess that some settlement prices are more likely than others.

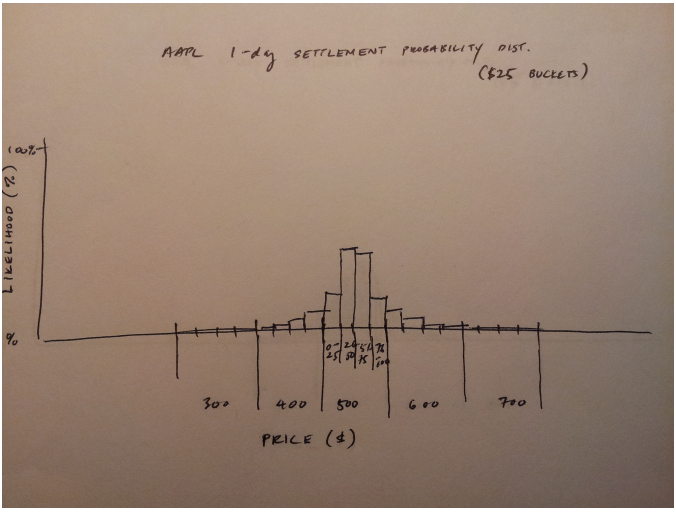
Given, for example, the fact that AAPL has closed between 550 and 575 for the last 10 days, you might say it is highly improbable for AAPL to close between 0 and 100 tomorrow. It is highly probable that AAPL will close between 500 and 650 per share. It's also improbable that AAPL will close between $10,000 and $10,100 per share.

Starting with $100 wide buckets, we can create a histogram of what might be a reasonable guess for where AAPL settles tomorrow.

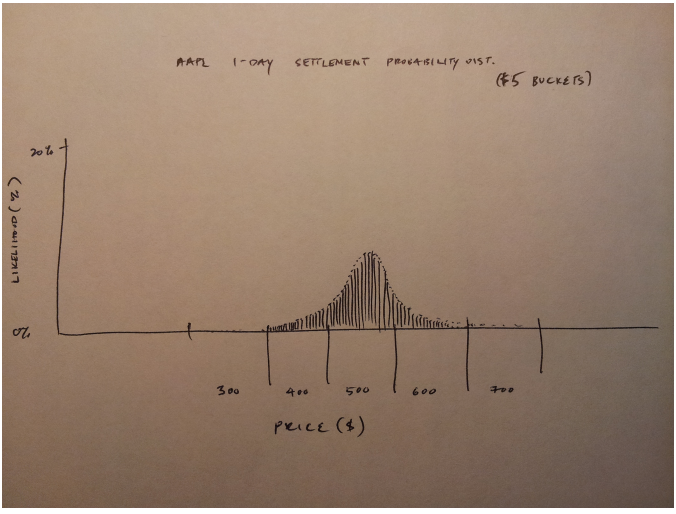


100-wide bucket histogram of AAPL 1-day price distribution

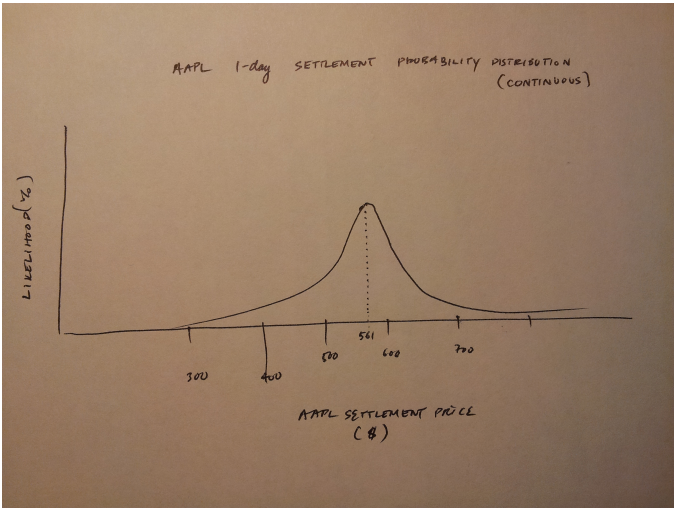
Now repeat this exercise for increasingly small buckets to get a continuous distribution of infinitely small buckets (or at least penny sized).



25-wide bucket histogram of AAPL 1-day price distribution



5-wide bucket histogram of AAPL 1-day price distribution

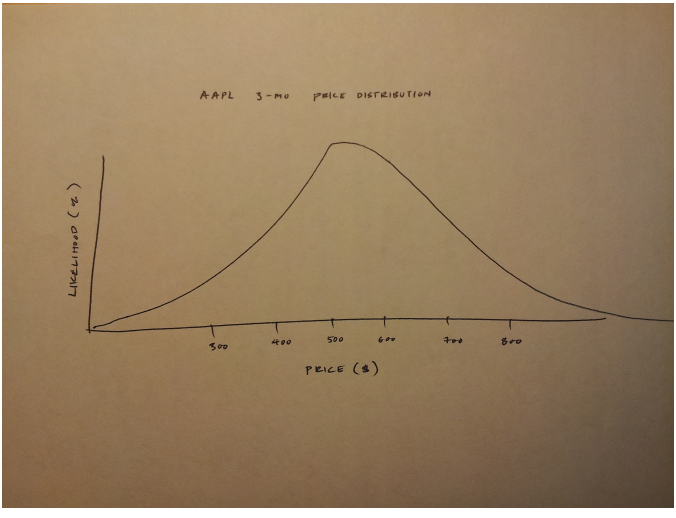


Continuous function of AAPL 1-day price distribution

This is where you think the AAPL stock price will settle tomorrow, described as a **probability density function** of possible prices for a specific instant in time in the future.

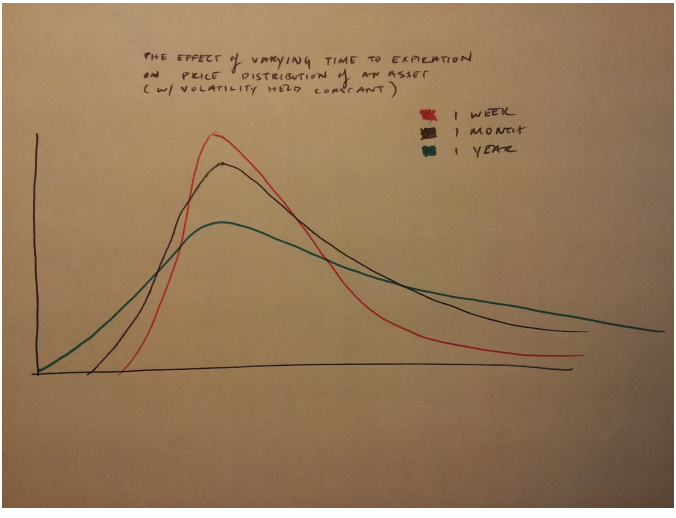
Now imagine repeating this process for every time step between now and the expiration. The further away the end date is, the more pins the ball will run through, increasing the probability of drifting further from the current price.

An expected 3 month price distribution might look like:

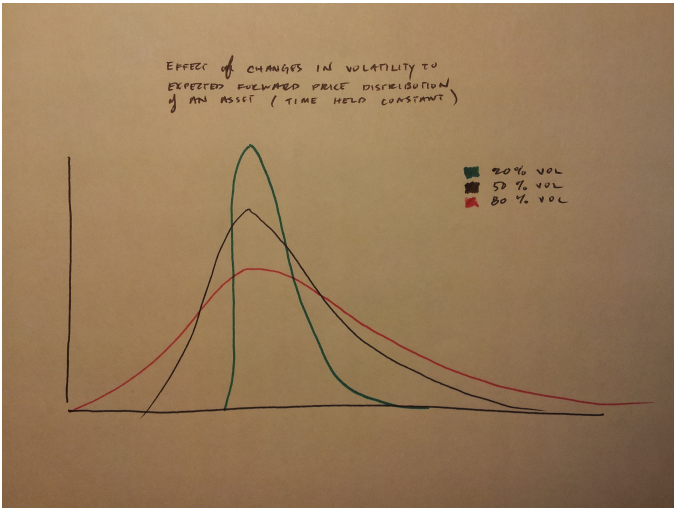


AAPL 3-mo price distribution

Stocks that move more (higher volatility) and have longer times to expiration generate wider probability distributions. Stocks that move less (lower volatility) and shorter times will result in narrower probability distributions.



Terminal distributions for constant vol/varying time



Terminal distributions for varying vol/constant time

There are many different models for how a stock price "walks". For the purposes of developing intuitions about where options get value, they're not particularly important. The important thing to note is that there is uncertainty in the future price, which can be described as a probability distribution of possible stock prices at a specific expiration date.

Different models produce different shapes of probability distributions at expiration (which I'll refer to as a "terminal price distribution"). Option valuation and expected behavior is premised almost entirely on the characteristics of this distribution and the possible paths between today's price and the future price.

What Are Options?

This is a short primer to refresh your memory if it's been a while, but definitely not a substitute for learning options basics.

An option is a financial derivative that confers upon the holder the right, but not the obligation, to make a future transaction with the counterparty. Every options transaction has two parties:

- **A buyer**: The owner of the option. The buyer has the sole decision of whether or not the option will be exercised.
- **A seller**: Often referred to as the "writer" of the option. The seller has no say in whether the option will be exercised, but will have to fulfill the obligation detailed by the contract if the option is exercised

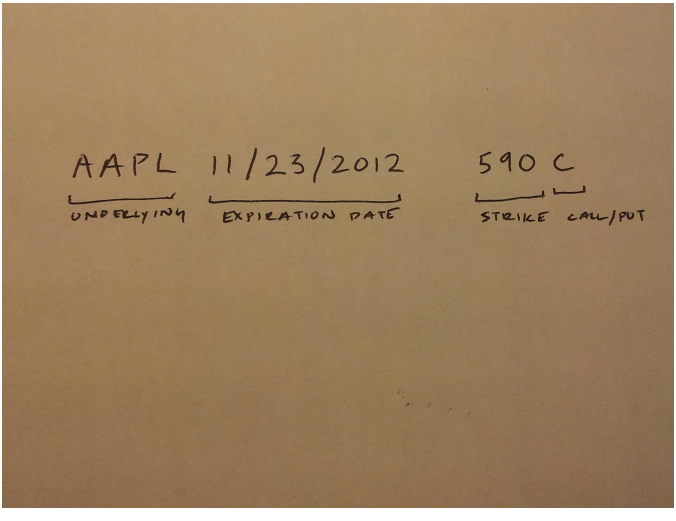
An option is described by:

- **Underlying asset**: asset that can be transacted at a future date, for example AAPL stock or bushels of corn) (1)
- **Expiration date**: last date on which the option can be exercised (2)
- **Strike price**: price at which the underlying will be transacted, if the option is exercised by the buyer
- **Option type**: call or put

Option Trade Example

Anatomy of an Option Symbol

As an example, let's use the "AAPL 11/23/2012 590C" (pronounced the "Apple Nov five-ninety call"):



Option name breakdown

1. Generally there is one expiration per month for every underlying asset (3), so the expiration date will be referred to by just the month, and not the day.
2. Commonly used US exchange-traded equity options are generally American options (AAPL is)

3. Commonly used US exchange-traded equity options are good for 100 shares of the underlying stock
4. The actual cash outlay is 100 times the listed option price (100 multiplier)
5. "C" and "P" are commonly used for "Call" and "Put"

Sample Trade Mechanics

If Bob buys one AAPL 11/23/2012 590C from Sue:

1. Bob will pay Sue a small amount of money today. This is the option price, or premium. If the price listed on his trading screen or Interactive Brokers account is $1.65, he will actually pay $165.00 (plus fees).
2. In return, Sue will have promised Bob that he can buy exactly 100 shares AAPL from her at the price of $590 any time on or before 11/23/2012.
3. Bob isn't incentivized to pay 590 for AAPL at any time on or before 11/23/2012 unless the market stock price is greater than $590 (otherwise he could just pay the market price and get it cheaper).
4. If the publicly traded price of AAPL on 11/23 is 610, Bob would benefit by exercising his option. He would pay 590 on 100 shares of AAPL, 20 points cheaper than the market price.
5. Sue would be obligated to sell at this price, a 20 point loss to what she could have achieved by selling to the broad market.

6. Bob is the only person in this transaction who has the power to decide whether this option is exercised (he probably should, but it is possible to choose not to exercise).
7. If Bob exercises the call , Sue *must* deliver 100 shares of AAPL for the total price of 100 * 590 == 59,000 – regardless of the current market price for AAPL.
8. In principle, it possible for Bob to exercise his 590 call even if the AAPL underlying was trading below 590. If AAPL were trading a lower price, like 550, Bob would be voluntarily paying 590 for the AAPL call via option exercise, despite the fact the fact that he could buy it in the marketplace for 550. He would be losing out on $40/share for 100 shares, effectively throwing away $4000. This would be stupid, and it never happens, but it is *possible*.

For clarity, and at the risk of repetitiveness, I'll repeat this description for an example where Bob buys one AAPL 11/23/2012 550P from Sue:

1. Bob will pay Sue a small amount of money today. This is the option price, or premium. If the price listed on his trading screen or Interactive Brokers account is $2.19, he will actually pay $219.00 (plus fees).
2. In return, Sue will have promised Bob that he can sell exactly 100 shares AAPL to her at the price of $550 any time on or before 11/23/2012.

3. Bob isn't incentivized to sell AAPL at 550 at any time on or before 11/23/2012 unless the market stock price is less than $550 (otherwise he could just sell it to the best bid in the market to get a better price).
4. If the publicly traded price of AAPL on 11/23 is 530, Bob would benefit by exercising his put. He would sell 100 shares of AAPL to Sue at 550, 20 points higher than the market price
5. Sue would be obligated to buy at this price, a 20 point loss to what she could have achieved by buying AAPL from the public markets (530 * 100 vs 550 * 100).
6. Bob is the only person in this transaction who has the power to decide whether this option is exercised (he probably should, but it is possible to choose not to exercise).
7. If Bob exercises the put, Sue *must* pay him 100 * 550 == 55,000 in return for 100 shares of AAPL – regardless of the current market price for AAPL.
8. In principle, it possible for Bob to exercise his 550 put even if the AAPL underlying was trading above 550. If AAPL were trading a higher price, like 580, Bob is voluntarily selling AAPL stock at 550 via option exercise, despite the fact the fact that he could sell it in the marketplace at 580. He would be losing out on $30/share for 100 shares, effectively throwing away $3000. This would be stupid, and it never happens, but it is *possible*.

The rules and specific mechanics of these exercise transactions are governed through networks of brokerage firms, exchanges, and a governing body called the Options Clearing Corporation (optionsclearing.com), so Bob and Sue never actually get directly in contact with one another, and there is virtually no risk to Bob that Sue will be unable or unwilling to fulfil her obligation if the option is exercised.

The privilege of exercising an option belongs solely to the buyer of the option. The seller of the option is subject to the whims of the buyer. However, this behavior is generally very predictable and guided by rules for optimal option exercise (how to maximize expected value via exercise), so professional options traders generally are always aware of when this will happen and can prepare accordingly.

In the early examples, I may only refer to either a put option or a call option. Don't worry about the difference between the two, your goal is first to try to get a deeper, non-technical, intuition of how options work and what makes them tick. Also, for reasons you'll see later, calls and puts are very similar and there are operations to convert one into the other for very low cost (put call parity).

Option Expiration Payouts

It's useful to think of the option payout as the amount of money you would profit by exercising your option then reversing the stock transaction immediately at the market price.

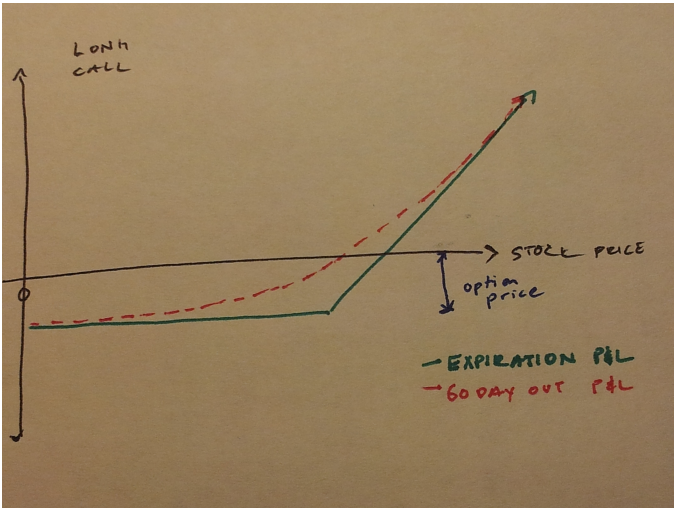
For example, in the above example where Bob purchased 1 AAPL 590C from Sue, if AAPL stock rallied to 605, Bob would want to exercise the option.

It can be daunting to think of paying 590 * 100 == USD$59,000 to exercise your option. Instead, think of it as paying 590 and simultaneously selling at 605 (the market price), you're engaging in a transaction where you earn $15.00 for every share of stock you transact.

There are only 4 possible positions you can hold (or any combination of the following). For these 4 examples, we'll use the ACME 100 call and ACME 100 put.

Long Call

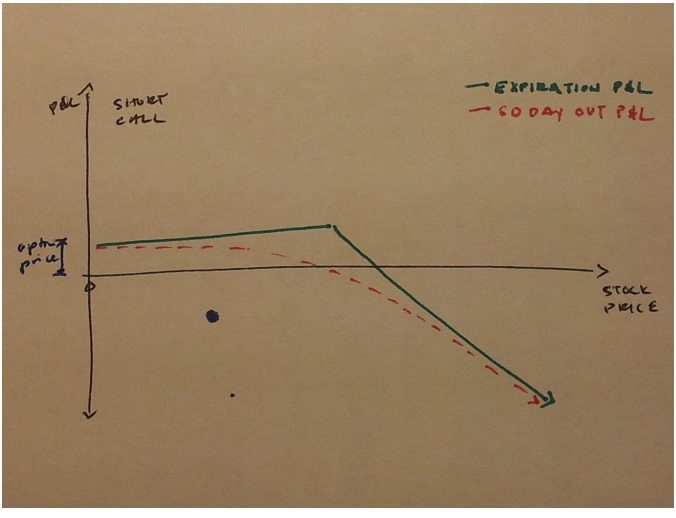
A positive number of calls / "you are long calls"



Long call

Short Call

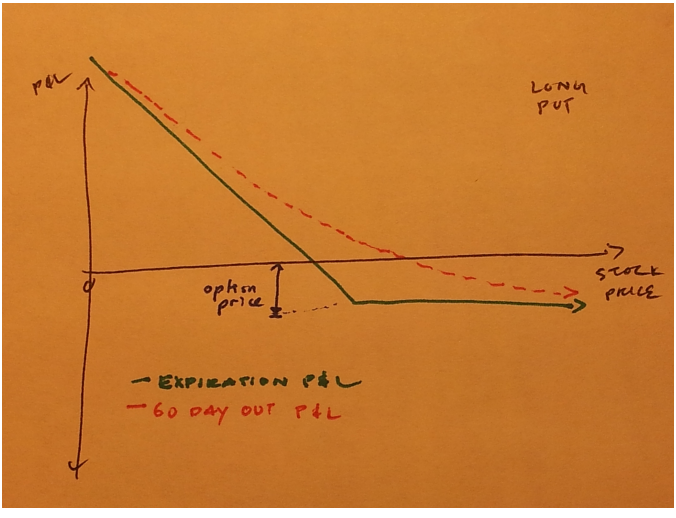
A negative number of calls / “you are short calls”



Short call

Long Put

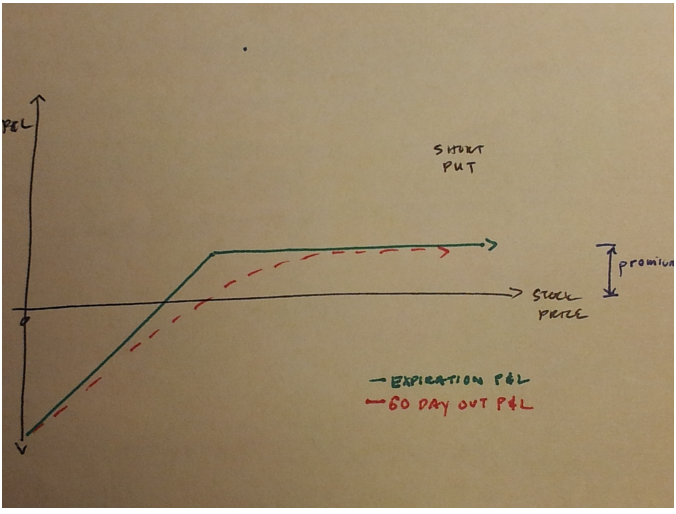
A positive number of puts / “you are long puts”



Long put

Short Put

A negative number of puts / “you are short puts”



Short put

In each of the graphs:

The green line is the value that option has at expiration at all possible stock settlement prices on the expiration date. For example, the "Long Call" plot shows the value of the ACME 100 call at various settlements of the underlying. There is a prominent bend in the green line at x==100. To the left (at underlying prices less than 100), the slope is 0, meaning the payout at expiration of the option is unchanging below underlying prices of 100. Above stock prices of 100, the expiration payout rises with a slope of 1, so the call option increases at the same rate as the underlying stock.

The traded price of the option is the vertical distance ($) between the horizontal part of the green line and the x axis (where P&L==0). For long option positions, this value is a negative number, reflecting the fact that the buyer of the option paid money (incurred an outflow of cash) in order to acquire the position. Conversely, for negative option positions, the horizontal component of the expiration payout is above 0, indicating that the seller receives a cash transfusion to acquire the short option position.

The breakeven stock price for a long option is the underlying price at which the gains from option offset the price paid for the option. The breakeven stock price for a short option is the underlying price at which the losses from the option offset the option premium collected at sale time. This is where the P&L plot crosses the x-axis.

The dotted red line is the option value at a time before the option expires. In this case, I've arbitrarily chosen 60 days, but the salient point here is that there is still uncertainty in the underlying stock's settlement price (volatility value). This value is positive and therefore adds additional value to the option beyond the expiration payout value (the green line).

This plot is always:

- curved (as long as there is uncertainty in underlying price)
- monotonically increasing for calls (monotonically decreasing for puts)

- converges to the expiration plot (the red line) as volatility or time to expiration decreases
- asymptotically approaches the expiration plot as distance from strike price increases

The total option value can be thought of as the sum of:

- **Intrinsic value**: The "zero vol value", i.e. the amount of money that would be made or lost if the stock never moved again between now and expiration, if the future volatility were zero, or there was no time to expiration remaining (the green line)
- **Volatility value**: The amount of option value that can be attributed to optionality conferred to the options buyer due to uncertainty in the underlying price between now and the expiration time of the option (the vertical distance between the green line and dotted red line)

Footnotes

(1) Options typically expire into an underlying asset of some sort, typically shares of stock (stock options, like AAPL), futures (S&P500 futures options), or physical goods (commodities like oil, corn, and gold). For simplicity, I'll often just use stock. While there are differences between different underlying settlements, we won't address them

in this text, and those differences are typically highly specialized and the domain of high volume professionals that don't impact non-professional investors and won't aid in helping you develop INTUITION about option pricing and behavior, which is the explicit goal of this text.

(2) Exercise type (European or American) is defined at the symbol level and implicit in the entire class of options, so rarely explicitly stated on the option.

- European options may be exercised at exactly ONE time: the day of expiration.
- American options may be exercised at any time before the expiration date.
- Most US traded listed stocks, and generally the sorts of options that non-professionals trade, are American options.
- For now, forget about the difference between American and European options. We'll initially begin by discussing European options, then discuss how American options differ at a later time.

(3) not actually true, because of weeklies, dailies, alt settlements, but true enough…