

This lecture can save you 12 million dollars

17-313: Foundations of Software Engineering

<https://cmu-313.github.io>

Michael Hilton and Chris Timperley

Fall 2025

Administrivia

FCEs

Final:

- P5 B) Project Final Report & Presentations
 - Project Presentation (100 points) - Friday, December 12, 2025
08:30am - 11:30am GHC 4401
 - P5 C) Individual Reflections – 20 points – due Saturday, December 13th, 11:59pm

How is the job hunt?

Resume Advice

- Start with what makes you special
 - Next, what makes you “good enough”
 - Finally, keywords for search matching
-
- In my experience, portfolio > resume

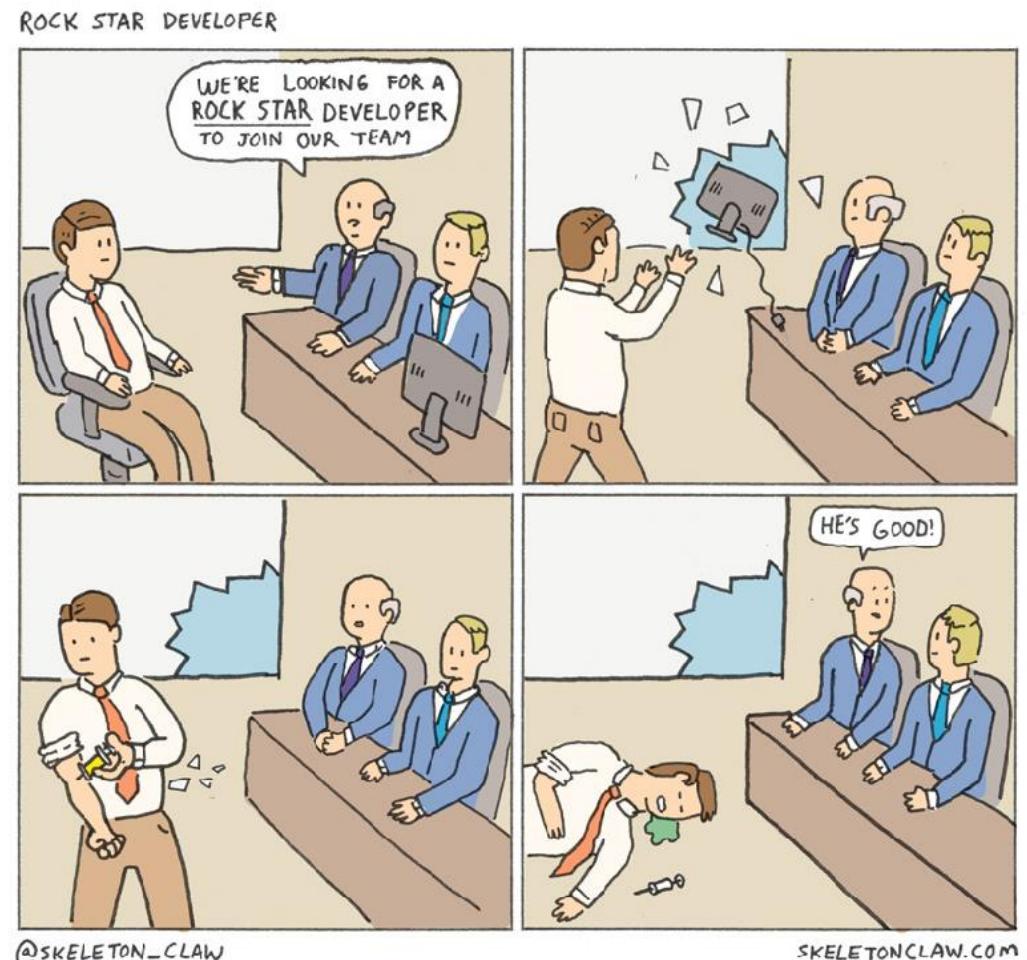
Advice for looking for internships

- Don't fixate on the internship you think you **should** take
- Don't underestimate your intuition
- Consider smaller companies (startups)
- Consider (primarily) non-tech companies
- Don't be afraid to ask for help
- There is a lot of uncertainty, don't feel bad if you hear a no
- Think about the stories you have to tell (open source excursion?)

What should you look for in a company?

10X Engineers

- Aka “rock-star”, “ninja”



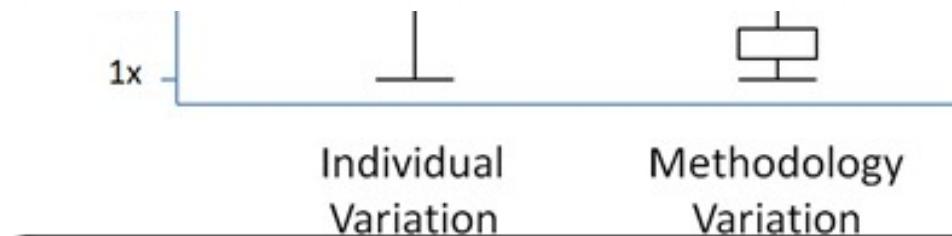
1966 study on online/offline programming performance

Productivity



rmance variables. To paraphrase a nursery rhyme:

When a programer is good,
He is very, very good,
But when he is bad,
He is horrid.



10x

- Reported as early as 1968 (Sackman, Erickson, and Grant)
 - Coding time 20:1
 - Debugging time 25:1
 - Program size 5:1
 - Execution speed 10:1
 - No correlation to amount of experience
- "order-of-magnitude differences among programmers" repeatedly reported
- Differences not explained by
 - programming language
 - years of experience

A Fork in the Road

Going forward, to build a breakthrough Twitter 2.0 and succeed in an increasingly competitive world, we will need to be extremely hardcore. This will mean working long hours at high intensity. Only exceptional performance will constitute a passing grade.

Twitter will also be much more engineering-driven. Design and product management will still be very important and report to me, but those writing great code will constitute the majority of our team and have the greatest sway. At its heart, Twitter is a software and servers company, so I think this makes sense.

If you are sure that you want to be part of the new Twitter, please click yes on the link below:

forms.gle

Anyone who has not done so by 5pm ET tomorrow (Thursday) will receive three months of severance.

Whatever decision you make, thank you for your efforts to make Twitter successful.

Elon

Overwork

GOOGLE

Marissa Mayer: You, Too, Can Work 130 Hours a Week If You Plan When to Take a Shit



Sophie Kleeman

8/04/16 11:15AM • Filed to: GOOGLE

740

12



Overwork: <https://www.nytimes.com/2015/08/16/technology/inside-amazon-wrestling-big-ideas-in-a-bruising-workplace.html>

<https://gizmodo.com/marissa-mayer-you-too-can-work-130-hours-a-week-if-y-1784822446>

Overwork

“Unlimited vacation”

<http://fortune.com/2016/03/10/best-companies-unlimited-vacation/>

<https://www.inc.com/gene-marks/why-unlimited-paid-time-off-is-bad-for-your-employees.html>

Why Unlimited Paid Time Off Is Bad for Your Employees

Netflix and LinkedIn's policies are not helping their employees. Here's why. ↗

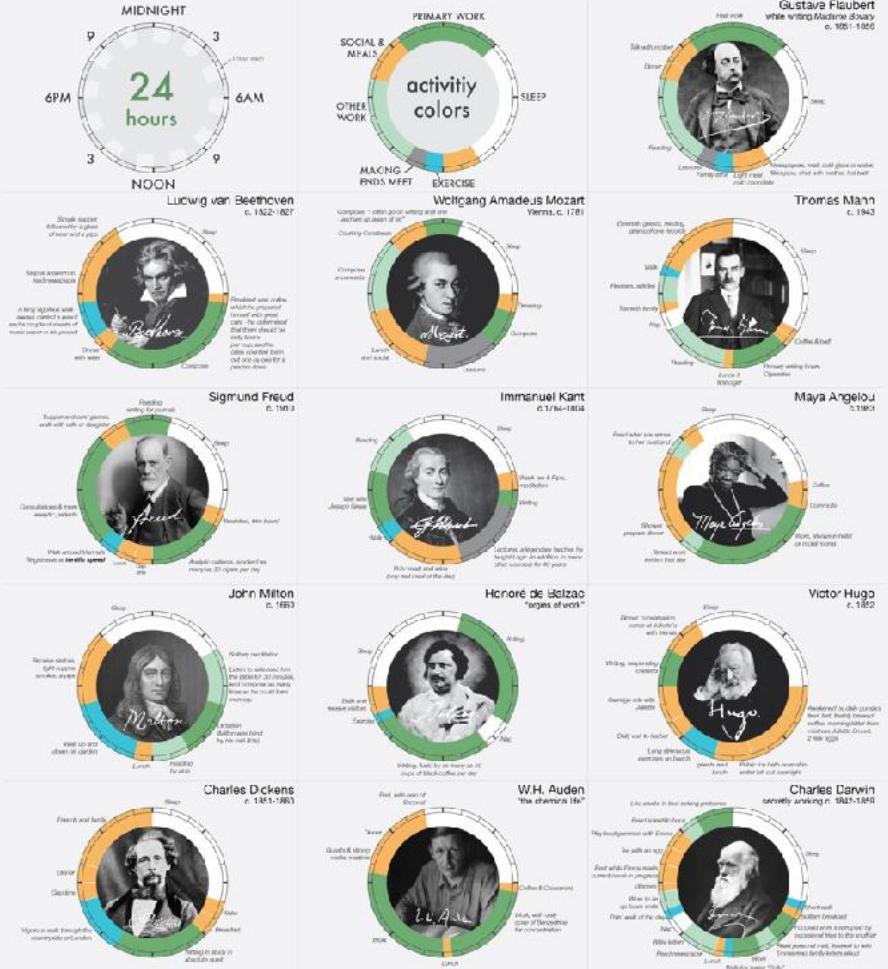
BY GENE MARKS, OWNER, MARKS GROUP @GENEMARKS



Getty Images

CREATIVE ROUTINES

"In the right hands, it can be a finely calibrated mechanism for taking advantage of limited resources... a solid routine fosters a well-worn groove for one's mental energies..." —Mason Corley, author of the inspiring book, DAILY RITUALS



<https://infographwetrust.files.wordpress.com/2014/03/daily-rituals.png>

Inclusive culture - Neurodiversity

Agile in the Wild

Why you want an Autist on your tech team.

salFreudenberg / May 19, 2016 / neurodiversity, psychology of programming, Uncategorized

"By autistic standards the neuro typical brain is easily distractable, obsessively social and suffers from a deficit of attention to detail" – Steve Silberman

Autism is said to effect 1 in 62 people. That's around a million people in the U.K. alone. It appears there is a correlation between autism and the world of science and technology. There is a pretty compelling body of evidence showing this link (Baron-Cohen et al, 1998; Windam, 2009; Roelfsema et al, 2011; Wei, 2003). So why this tendency towards tech for autists? Well there are a number of traits of the autistic mind that lend themselves very well to working in the technology sector. Here are just three examples:

<https://salfreudenberg.wordpress.com/2016/05/19/why-you-want-an-autist-on-your-tech-team/>

<https://salfreudenberg.wordpress.com/2016/05/19/why-you-want-an-autist-on-your-tech-team/>

<https://www.microsoft.com/en-us/research/publication/understanding-the-challenges-faced-by-neurodiverse-software-engineering-employees-towards-a-more-inclusive-and-productive-technical-workforce/>

Implicit Bias

<https://www.ncwit.org/resources>

Conferences: <https://www.ncwit.org/resources/ncwit-tips-13-tips-make-technical-conferences-more-inclusive/ncwit-tips-13-tips-make>

Websites:

<https://www.ncwit.org/resources/ncwit-tips-9-tips-creating-inclusive-corporate-websites>

Job Ads:

https://www.ncwit.org/sites/default/files/resources/ncwitchec_klist_reducingunconsciousbiasjobdescriptions.pdf

Important!

You are interviewing them as much
as they are interviewing you!!

What could you ask when interviewing?

Compensation

Compensation packages

- Salary
- Starting cash bonus
- Starting equity award
- Relocation
- PTO
- Performance cash/stock bonus
- 401k
- Employee stock purchase program

Compensation package example

- Salary \$150,000
- Starting cash bonus \$25,000 (must stay 12 months)
- Starting equity award 350 shares over 4 years
- Relocation Reimbursed up to \$15,000
- PTO Unlimited!
- Performance cash/stock bonus 10% cash, 20% stock
- 401k 50% per dollar match
- Employee stock purchase program 10% discount, \$25,000 max

Congratulations! You were offered equity!: Stock Options

Running Example: Kerri

Kerri's offer tells her the number of shares of option grants she was offered, but not how much they're worth.

This is standard.

MEETLY
2525 CHARLESTON ROAD SUITE 104
MOUNTAIN VIEW, CA 94043

SEPTEMBER 3, 2015

Kerri Stuart
Via email to: kerri@example.com

Dear Kerri:

I am pleased to offer you a position with **Meetly, Inc** (the "Company"), as Senior Engineer. If you decide to join us, you will receive an annual salary of \$100,000, which will be paid semi-monthly in accordance with the Company's normal payroll procedures. In addition, subject to the approval of the Company's Board of Directors, you will be granted 100 shares of option grants of the Company, which shares will vest in accordance with the following vesting schedule: 25% on your first year anniversary date, and the remainder for 1/36th for each month of continuous service thereafter. You should note that the Company may modify job titles, salaries and benefits from time to time as it deems necessary.

The Company is excited about your joining and looks forward to a beneficial and productive relationship. Nevertheless, you should be aware that your employment with the Company is for no specified period and constitutes at will employment. As a result, you are free to resign at any time, for any reason or for no reason. Similarly, the

Congratulations! You were offered equity! Stock Options

Running Example: Kerri

Kerri has 100 shares of option grants.

But what does this even mean?

To make sense of this, there are 4 things Kerri should consider:

1. Types of Stock Options
2. Option Agreement
3. Vesting
4. Termination

What's a Stock Option anyway?

Stock Options:

A stock option is the right to buy a set number of shares at a fixed price.

Think of it as a coupon to get a discount on a future purchase.

**In Kerri's case, that fixed price
is \$1**

The goal is for the **value** of that stock to increase. But since the fixed price stays fixed for Kerri, that means Kerri can make money on the difference.

What's an RSU?

Restricted Stock Units:

RSU is a the company giving you stock, no more transactions needed.

RSUs have some major benefits:

- Less dilution
- No cost to exercise
- Less risk if stock price goes down

Generally, RSUs have more upside for you as an employee

Know what kind of Stock Option you have

There are generally two types:

ISO vs NSO

ISO = incentive stock option, NSO = non-qualified stock option

Employees usually get ISOs.

Consultants usually get NSOs.

The main difference is tax benefits, which we'll cover later.

Make sure you get an option agreement

An offer letter talking about stock options you've been offered is ***not legally binding***.

Until you've received and signed an option agreement, you technically don't own stock options.

MEETLY, INC. 2005 STOCK PLAN NOTICE OF STOCK OPTION GRANT

The Optionee has been granted the following option to purchase shares of the Common Stock of XYZ, Inc.:

Name of Optionee:	«Name»
Total Number of Shares:	«TotalShares»
Type of Option:	«ISO» Incentive Stock Option (ISO) «NSO» Nonstatutory Stock Option (NSO)
Exercise Price per Share:	\$«PricePerShare»
Date of Grant:	«DateGrant»
Date Exercisable:	This option may be exercised with respect to the first 25% of the Shares subject to this option when the Optionee completes 12 months of continuous Service beginning with the Vesting Commencement Date set forth below. This option may be exercised with respect to an additional 1/36 th of the remaining Shares subject to this option when the Optionee completes each month of continuous Service thereafter.
Vesting Commencement Date:	«VestComDate»
Expiration Date:	«ExpDate». This option expires earlier if the Optionee's Service terminates earlier, as provided in Section 6 of the Stock Option Agreement.

You don't get your stock options right away

You don't get it until it **VESTS**

Vesting means that you have to earn your stock options over time.

Companies do this because they want employees to stay with them and contribute to the company's success over several years.

If stock options didn't vest, an employee could join a company, work there for a month, buy a bunch of the company's stock, and leave. Vesting prevents this.

Traditional Vesting

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MOUNTAIN VIEW, CA 94043

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The Company is excited about your joining and looks forward to a beneficial and productive relationship. Nevertheless, you should be aware that your employment by the Company is for no specified period and constitutes at-will employment. As a result, you are free to resign at any time, for any reason or for no reason. Similarly, the Company is free to conclude its employment relationship with you at any time, without cause, and with or without notice. We request that, in the event of resignation, you give the Company at least two weeks notice.

The Company reserves the right to conduct background investigations and/or reference checks on all of its potential employees. Your job offer, therefore, is contingent upon the clearance of such a background investigation and/or reference check, if any.

For purposes of federal immigration law, you will be required to provide to the Company documentary evidence of your identity and eligibility for employment in the United States. Such documentation must be provided to us within three (3) business days of the date of hire, or our employment relationship with you may be terminated.

MEETLY, INC. 2005 STOCK PLAN
NOTICE OF STOCK OPTION GRANT

The Optionee has been granted the following option to purchase shares of the Common Stock of MEETLY, Inc.:

Name of Optionee:	«Name»
Total Number of Shares:	«TotalShares»
Type of Option:	«ISO» Incentive Stock Option (ISO) «NSO» Nonstatutory Stock Option (NSO)
Exercise Price per Share:	«PricePerShare»
Date of Grant:	«DateGrant»
Date Exercisable:	<p>«This option may be exercised with respect to the first 25% of the Shares subject to this option when the Optionee completes 12 months of continuous Service beginning with the Vesting Commencement Date set forth below. This option may be exercised with respect to an additional 1/36th of the remaining Shares subject to this option when the Optionee completes each month of continuous Service thereafter.»</p> <p>«VestComDate»</p>
Vesting Commencement Date:	<p>«ExpDate». This option expires earlier if the Optionee's Service terminates earlier, as provided in Section 6 of the Stock Option Agreement.</p>
Expiration Date:	

By signing below, the Optionee and the Company agree that this option is granted under, and governed by the terms and conditions of, the 2010 Stock Plan and the Stock Option Agreement. Both of these documents are attached to, and made a part of, this Notice of Stock Option Grant. Section 13 of the Stock Option Agreement includes important acknowledgements of the Optionee.

There are all kinds of vesting schedules (so pay attention to this if you get an offer with a non-traditional vesting schedule!) but what's called *traditional vesting* is most common.

Traditional Vesting

Two parts of a traditional vesting schedule:

1. the “cliff”
2. the total length of the schedule

Kerri's example:

1 year cliff. This is standard. After 1 year of working at Meetly, she can buy 25% of her shares, which is 25 shares out of 100.

Traditional Vesting

Date	Options vested	Cumulative
Nov 1, 2015	25	25
Dec 1, 2015	2	$100 \div 4 = 25$
Jan 1, 2016	2	29
Feb 1, 2016	2	31
Mar 1, 2016	2	33
Apr 1, 2016	2	35
May 1, 2016	2	37
Jun 1, 2016	2	39
Jul 1, 2016	2	41

Traditional Vesting

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1. the “cliff”
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Kerri’s example:

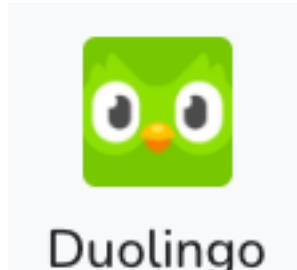
1 year cliff. This is standard. After 1 year of working at Meetly, she can buy 25% of her shares, which is 25 shares out of 100.

36 month schedule. This outlines how often, and for how long, Kerri will continue to vest her shares. After Kerri reaches her cliff, she will continue to vest the remaining shares for 36 months, or 2 shares each month.

Traditional Vesting

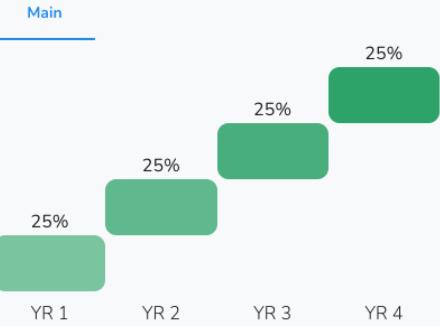
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Jun 1, 2016	2	39
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levels.fyi



Duolingo

Vesting Schedule

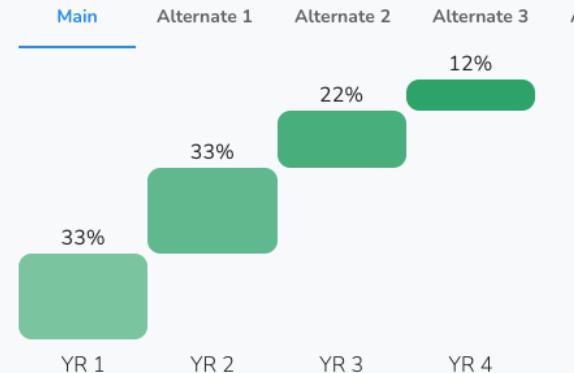


Stock Type Options

At Duolingo, Main Options are subject to a 4-year vesting schedule:

- 25% vests in the 1st-year (25.00% annually)
- 25% vests in the 2nd-year (2.08% monthly)
- 25% vests in the 3rd-year (2.08% monthly)
- 25% vests in the 4th-year (2.08% monthly)

Vesting Schedule



Stock Type RSU

At Google, Main RSUs are subject to a 4-year vesting schedule:

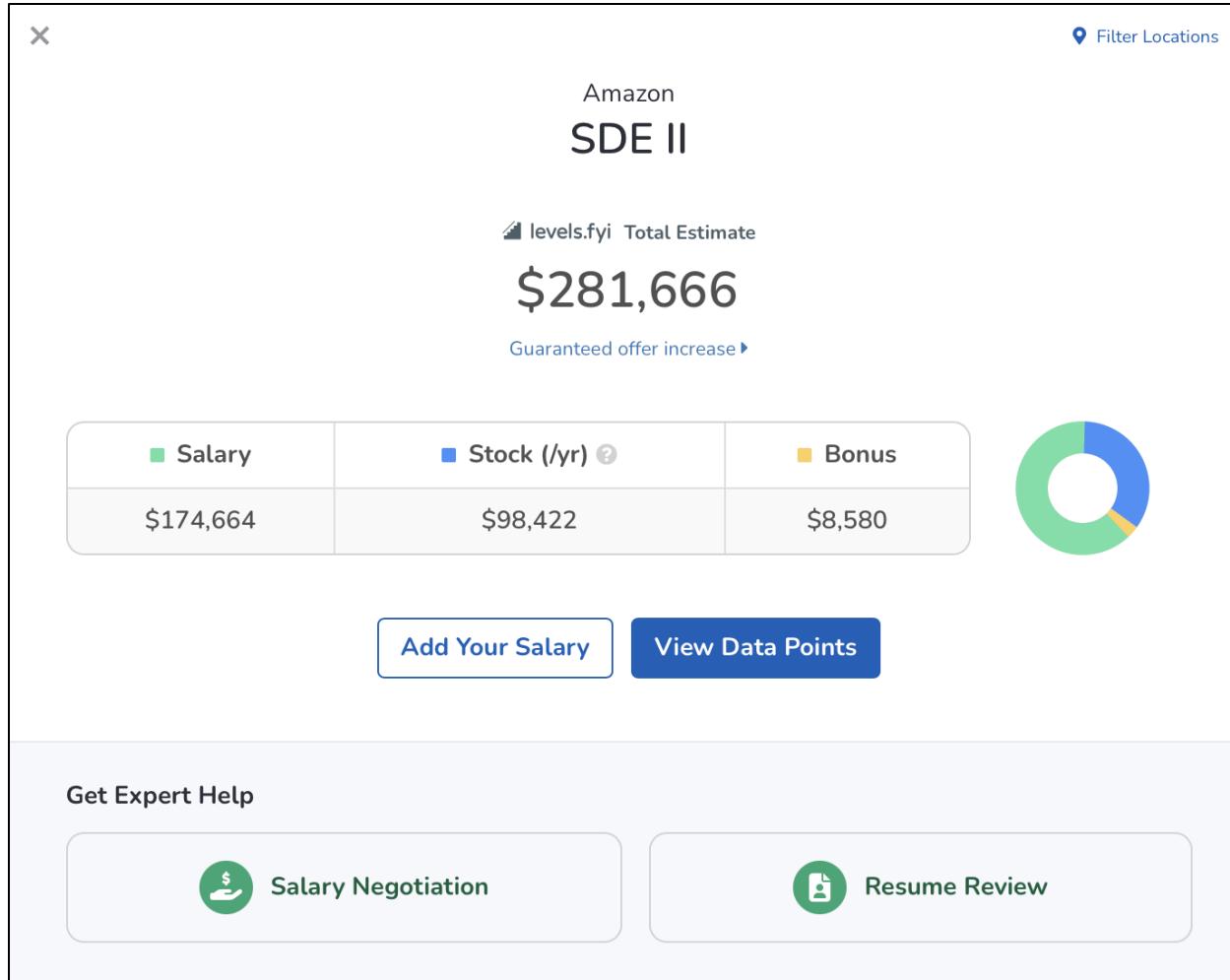
- 33% vests in the 1st-year (2.75% monthly)
- 33% vests in the 2nd-year (2.75% monthly)
- 22% vests in the 3rd-year (1.83% monthly)
- 12% vests in the 4th-year (1.00% monthly)



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What happens when I leave the company?

Startups have higher

Jargon: you must remember on your own to exercise on your options in that 90-day window!

And most importantly,

**YOU ONLY HAVE THAT RIGHT FOR A FIXED WINDOW OF TIME,
TYPICALLY 30-90 DAYS** 

Your company won't remind you of this window when you leave. Typically they only tell you about it in your option agreement when you join!

But how much is it worth anyway?

The short answer:

First, **some terms**:

But wait, what if our company
isn't publicly-traded... It's a private
company.

strike price: the cost for you to buy 1 share of stock.
This is also called an exercise price.

FMV (fair market value): to figure out the strike price, the company has to determine the fair market value of the stock if it were publicly traded on the open market. The strike price is almost always equal to the Fair Market Value of the stock on the day the option is granted.

Where does the FMV come from?

For startups, which are private companies and not publicly-traded on the stock market, we have to estimate the FMV somehow.

This is done via a **409a valuation**

Where does the FMV come from?

DEFINITION

A 409A valuation is an assessment private companies are required by the IRS to conduct regarding the value of any equity the company issues or offers to employees. A company wants the 409A to be low, so that employees make more off options, but not so low the IRS won't consider it reasonable. In order to minimize the risk that a 409A valuation is manipulated to the benefit of the company, companies hire independent firms to perform 409A valuations, typically annually or after events like fundraising.

The 409A valuation of employee equity is usually much less than what investors pay for preferred stock; often, it might be only a third or less of the preferred stock price.

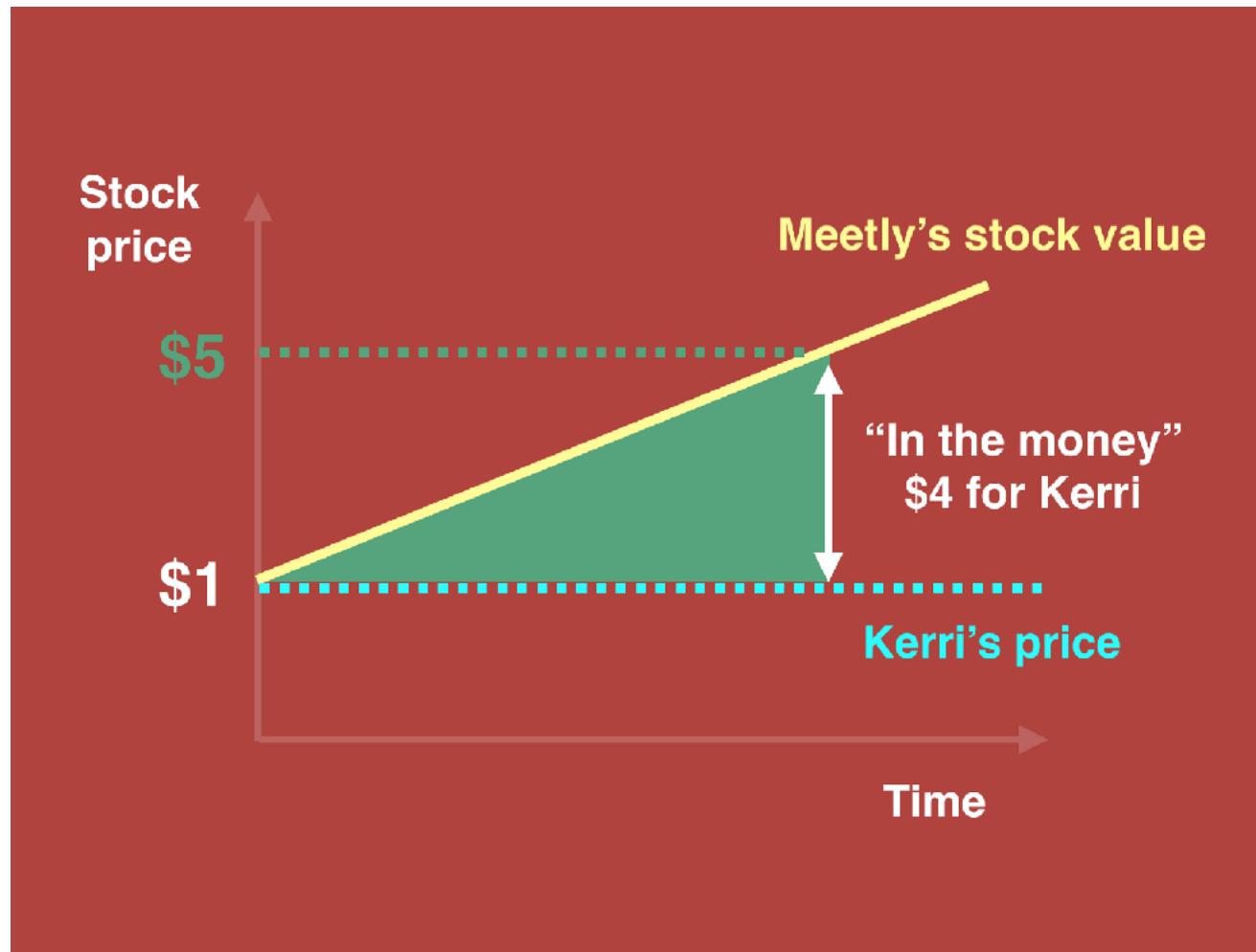
 controversy Although the 409A process is required and completely standard for startups, the practice is a strange mix of formality and complete guesswork. It has been called “quite precise—remarkably inaccurate,” by venture capitalist Bill Gurley. You can read more about its nuances and controversies.

From the Holloway Guide on Equity Compensation:
<https://www.holloway.com/g/equity-compensation>

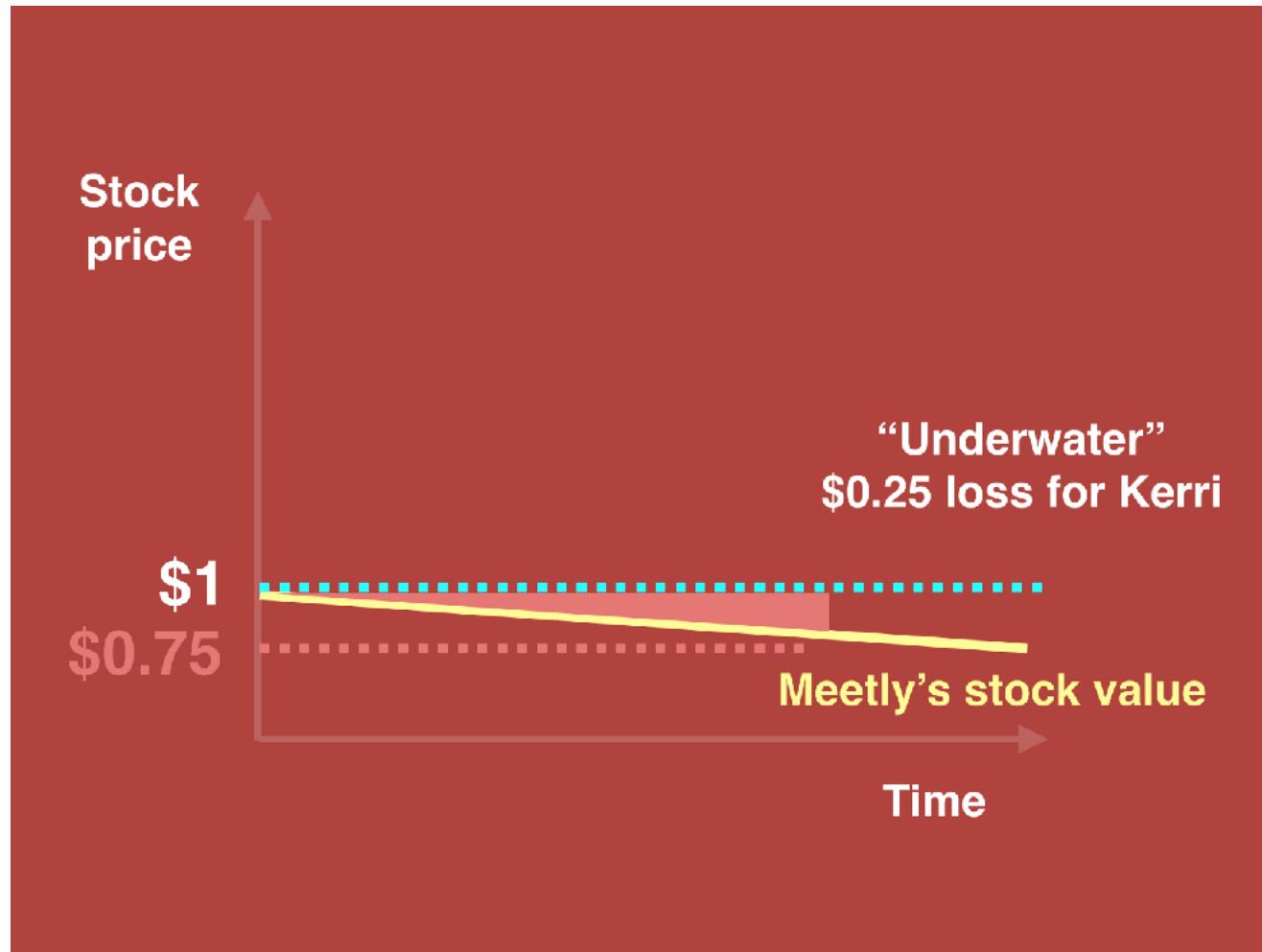
How stock options gain value



How stock options gain value



How stock options gain value



But things won't stay this way forever...

Dilution happens.



See for explanation: <https://youtu.be/njx09wXb9o0?t=47>

Dilution in Kerri's example

Shareholder	Percentage	Shares
Kerri	2%	100
Everyone else	98%	4,900
Total	100%	5,000

Kerri's 100 shares were worth 2% of the company.

Dilution in Kerri's example

Shareholder	Percentage	Shares
Kerri	1.4%	100
Everyone else	70%	4,900
New investors	28.6%	2,000
Total	100%	7,000

A year later, Meetly decides it needs more money, so it brings in new investors.

Dilution in Kerri's example

BEFORE

Shareholder	Percentage	Value
Kerri	2%	\$2M
Others	98%	\$98M
Total	100%	\$100M

AFTER

Shareholder	Percentage	Value	
Kerri	1.4%	?	↙
Others	70%	?	↙
Investors	28.6%	\$20M	
Total	100%	\$120M	

Dilution in Kerri's example

BEFORE

Shareholder	Percentage	Value
Kerri	2%	\$2M
Others	98%	\$98M
Total	100%	\$100M

AFTER

Shareholder	Percentage	Value
Kerri	1.4%	\$2M
Others	70%	\$98M
Investors	28.6%	\$20M
Total	100%	\$120M

Liquidation preferences...

- Investors get paid first, sometimes a minimum or multiple
- Owning 10% and selling for \$20M doesn't mean you get \$2M

Even after acquisition, you may not see cash for years!

- Many deals aren't cash
- Stock swaps are common
- Earn out
- Lock-up period
- Golden handcuffs

Taxes really matter when you
exercise your options...

Taxes really matter when you exercise your options...

[what-i-wish-id-known-about-equity-before-joining-a-unicorn.md](#) Raw

What I Wish I'd Known About Equity Before Joining A Unicorn

Disclaimer: This piece is written anonymously. The names of a few particular companies are mentioned, but as common examples only.

This is a short write-up on things that I wish I'd known and considered before joining a private company (aka startup, aka unicorn in some cases). I'm not trying to make the case that you should *never* join a private company, but the power imbalance between founder and employee is extreme, and that potential candidates would do well to consider alternatives.

None of this information is new or novel, but this document aims to put the basics in one place.

The Rub

Lock In

- After leaving a company, you generally have 90 days to exercise your options or they're gone. This seems to have originally developed around a historical rule from the IRS around the treatment of ISOs, but the exact reason doesn't really matter anymore. The only thing that does matter is that if you ever want to leave your company, all that equity that you spent years building could evaporate if you don't have the immediate cash reserves to buy into it.
- Worse yet, by exercising options you owe tax immediately on money that you never made. Your options have a *strike price* and private companies generally have a *409A valuation* to determine their fair market value. You owe tax on the difference between those two numbers multiplied by the number of options exercised, even if the illiquidity of the shares means that you never made a cent, and have no conceivable way of doing so for the foreseeable future.

Taxes really matter when you exercise your options...

The Rub

Lock In

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 - Even if you have the money to buy your options and pay the taxman, that cash is now locked in and could see little return on investment for a long and uncertain amount of time. Consider the opportunity cost of what you could otherwise have done with that liquid capital.
 - Due to tax law, there is a ten year limit on the exercise term of ISO options from the day they're granted. Even if the shares aren't liquid by then, you either lose them or exercise them, with exercising them coming with all the caveats around cost and taxation listed above.
- Does ten years sound like a long time? Consider the ages of these unicorns:
- Palantir is now thirteen years old.
 - Dropbox will be ten years old this year (2017).
 - AirBnB, GitHub, and Uber are all within a year or two of their ten year birthdays.
- Some companies now offer 10-year exercise window (after you quit) whereby your ISOs are automatically converted

Taxes really matter when you exercise your options...

There are two types of taxes you should keep in mind when exercising your options:

Ordinary Income Tax

vs

Capital Gains

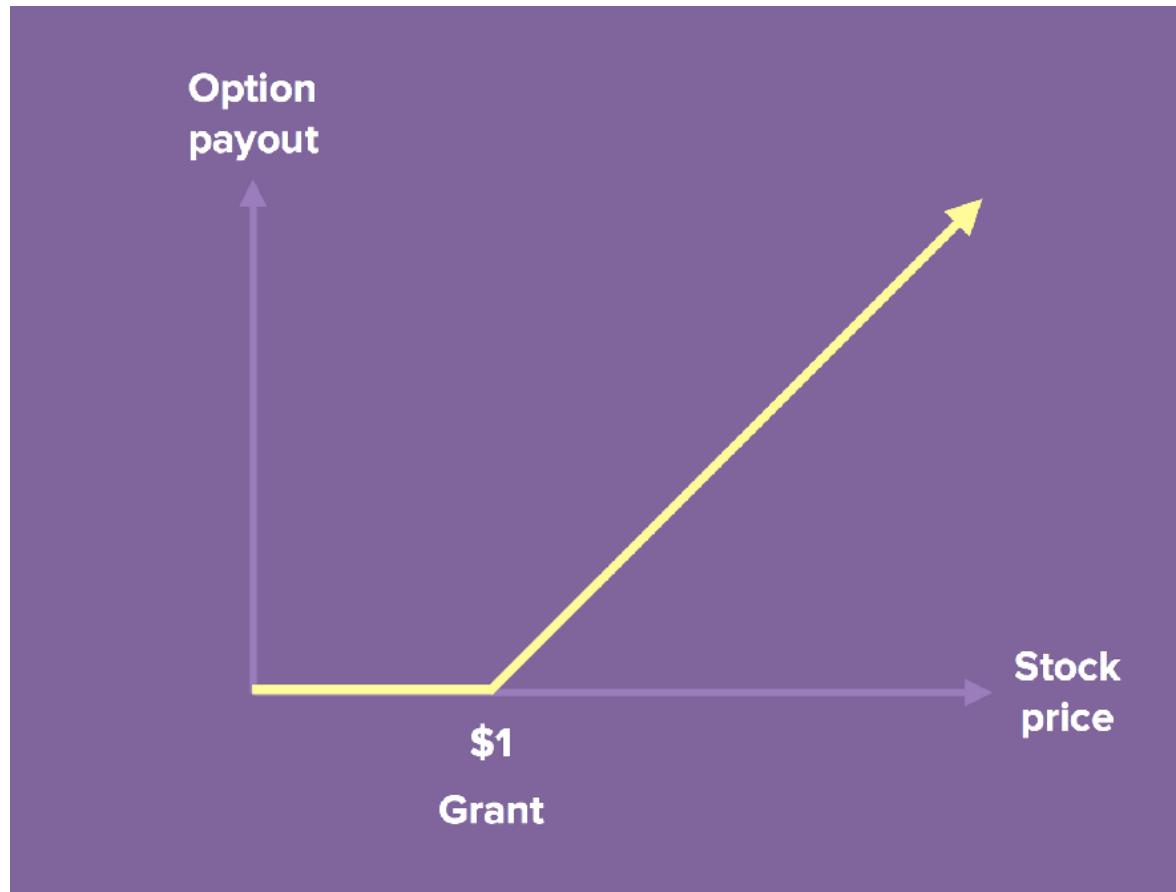
Taxes really matter when you exercise your options...

There are two types of taxes you should keep in mind when exercising your options:

Ordinary Income Tax applies to things like wages and salaries.

Capital Gains tax applies to any profits you make from selling an asset.

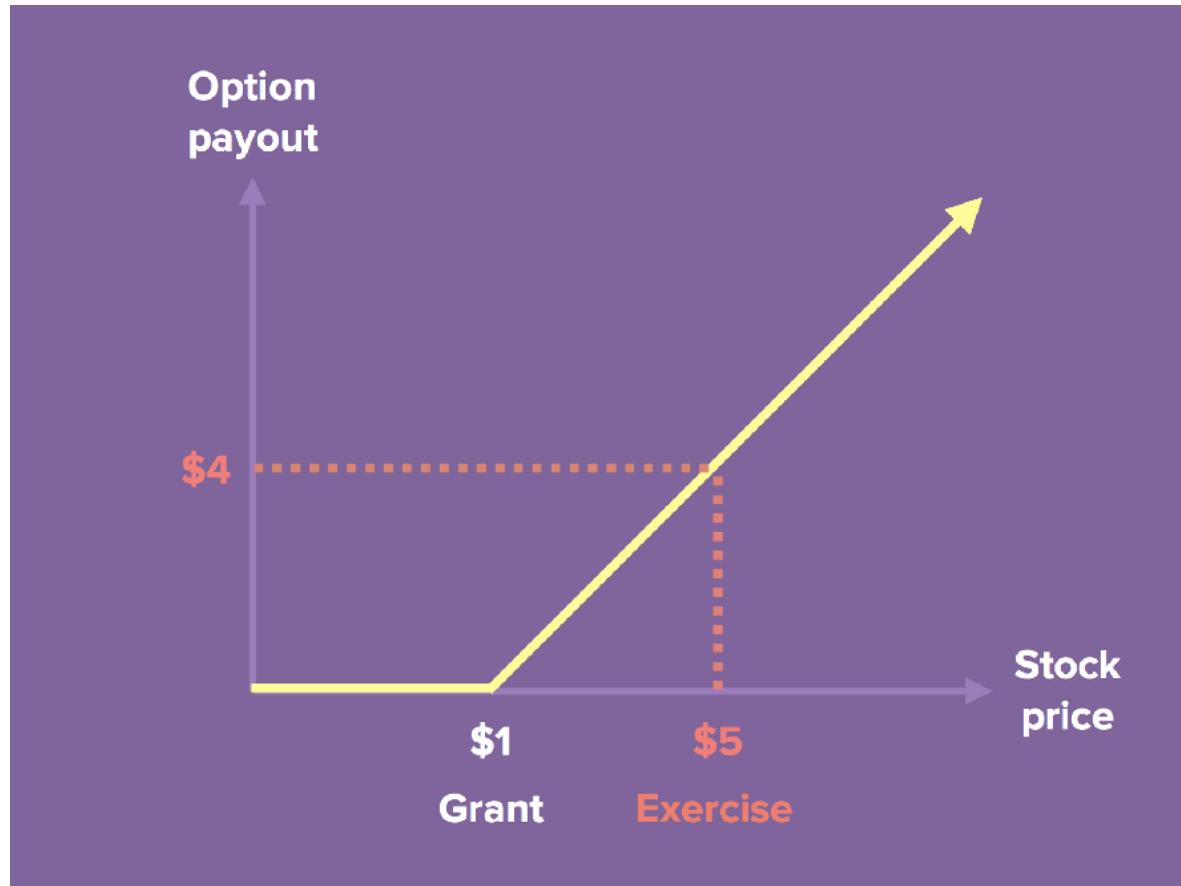
Taxes on payouts in Kerri's example



This graph shows Kerri's option payout as a function of Meetly's stock price.

The option payout is represented by the yellow line.

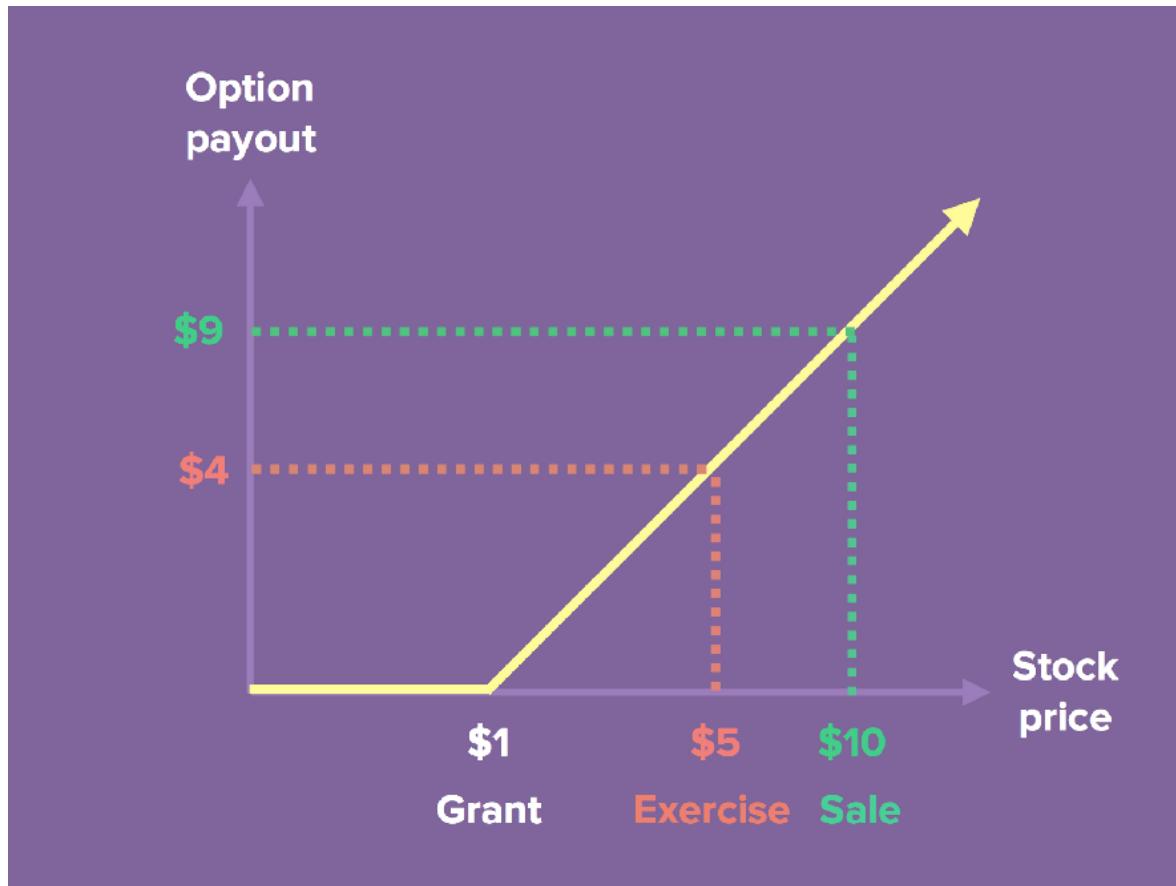
Taxes on payouts in Kerri's example



If Kerri decides to exercise when the stock price is \$5, her option payout is \$4.

That's the \$5 stock price minus her \$1 strike price.

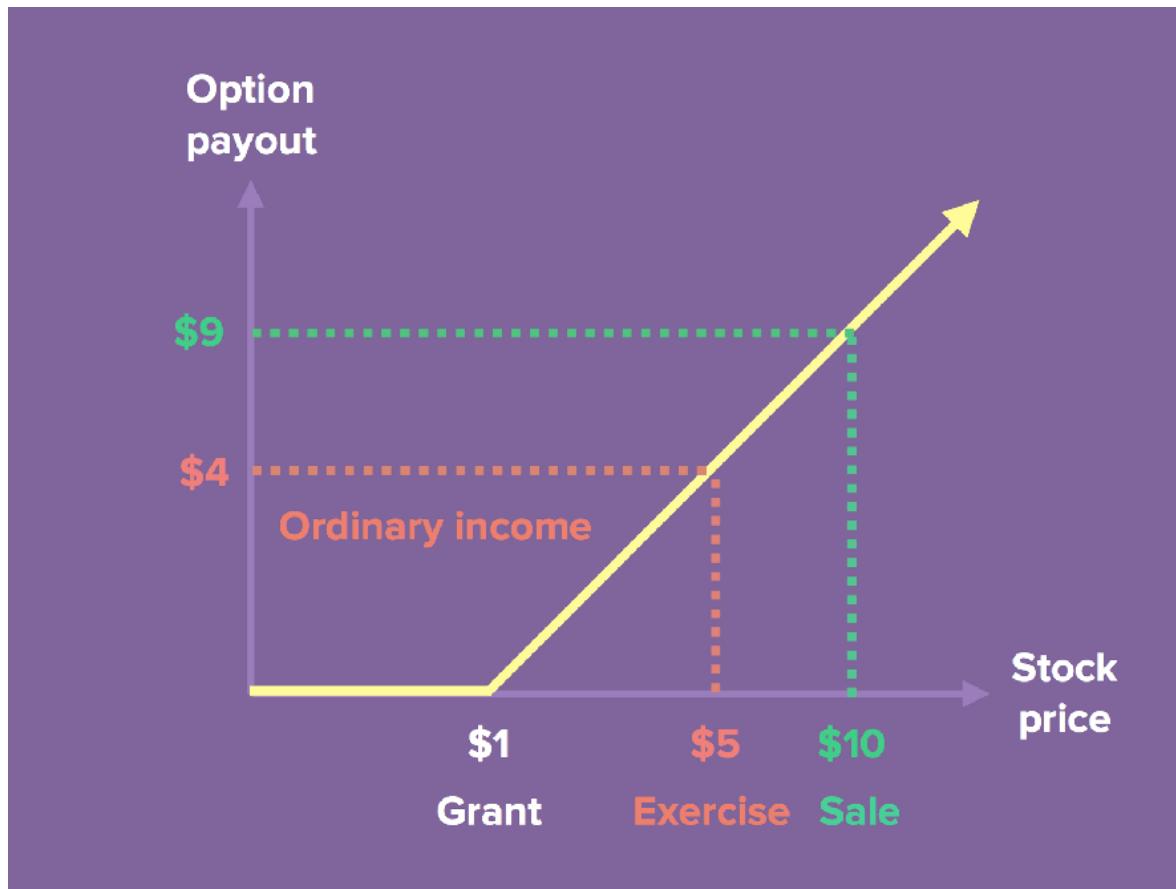
Taxes on payouts in Kerri's example



Now let's assume Kerri sells the stock when the stock price is \$10. Her option payout here is \$9.

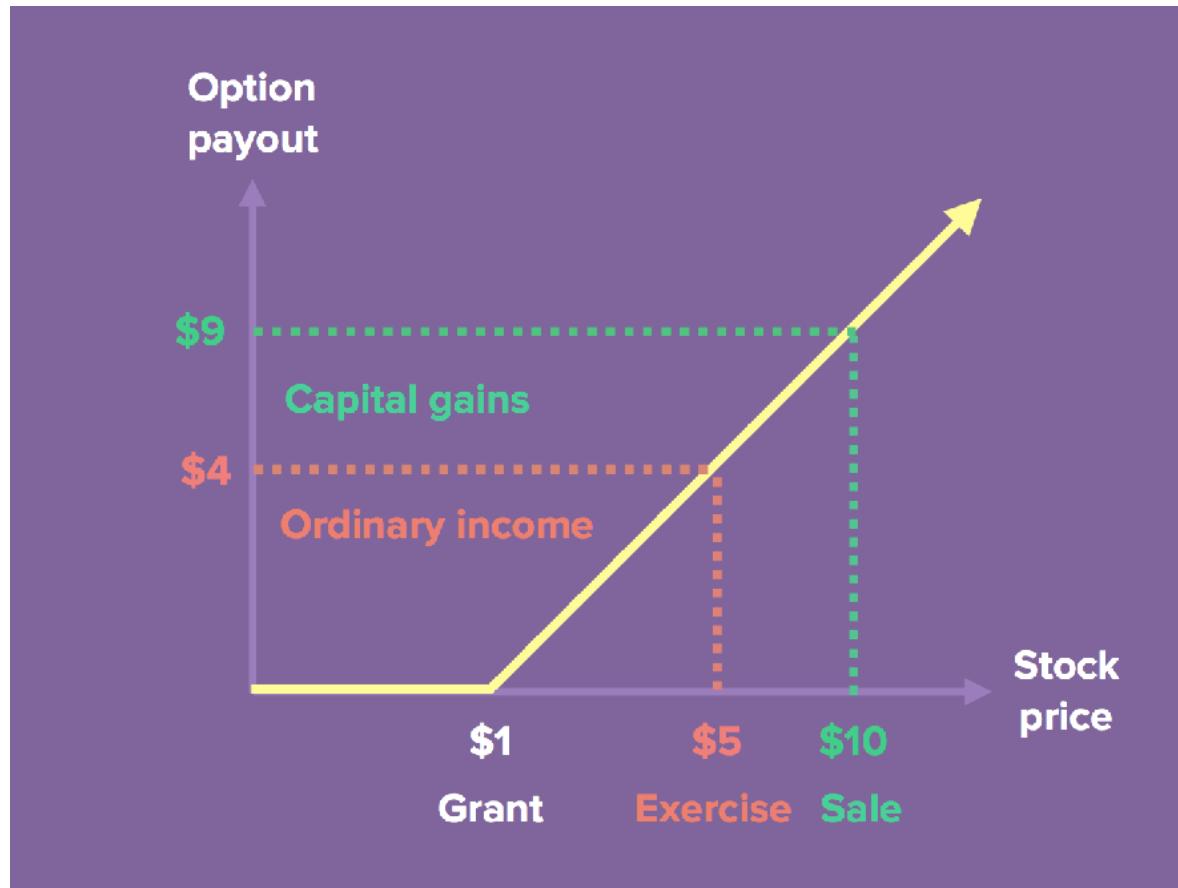
Again, the \$10 stock price minus her \$1 strike price.

Taxes on payouts in Kerri's example



Any gain before the exercise is treated as Ordinary Income tax

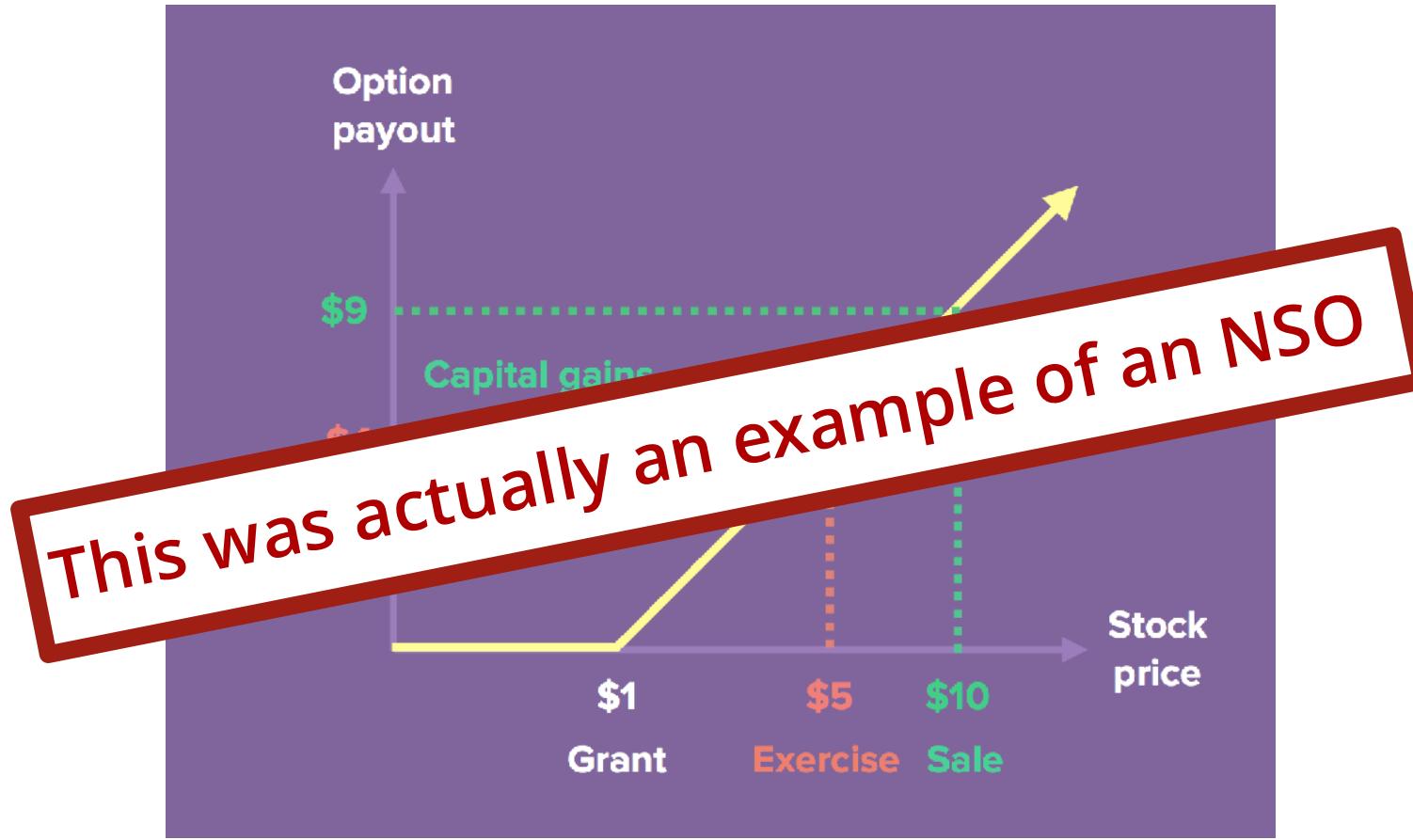
Taxes on payouts in Kerri's example



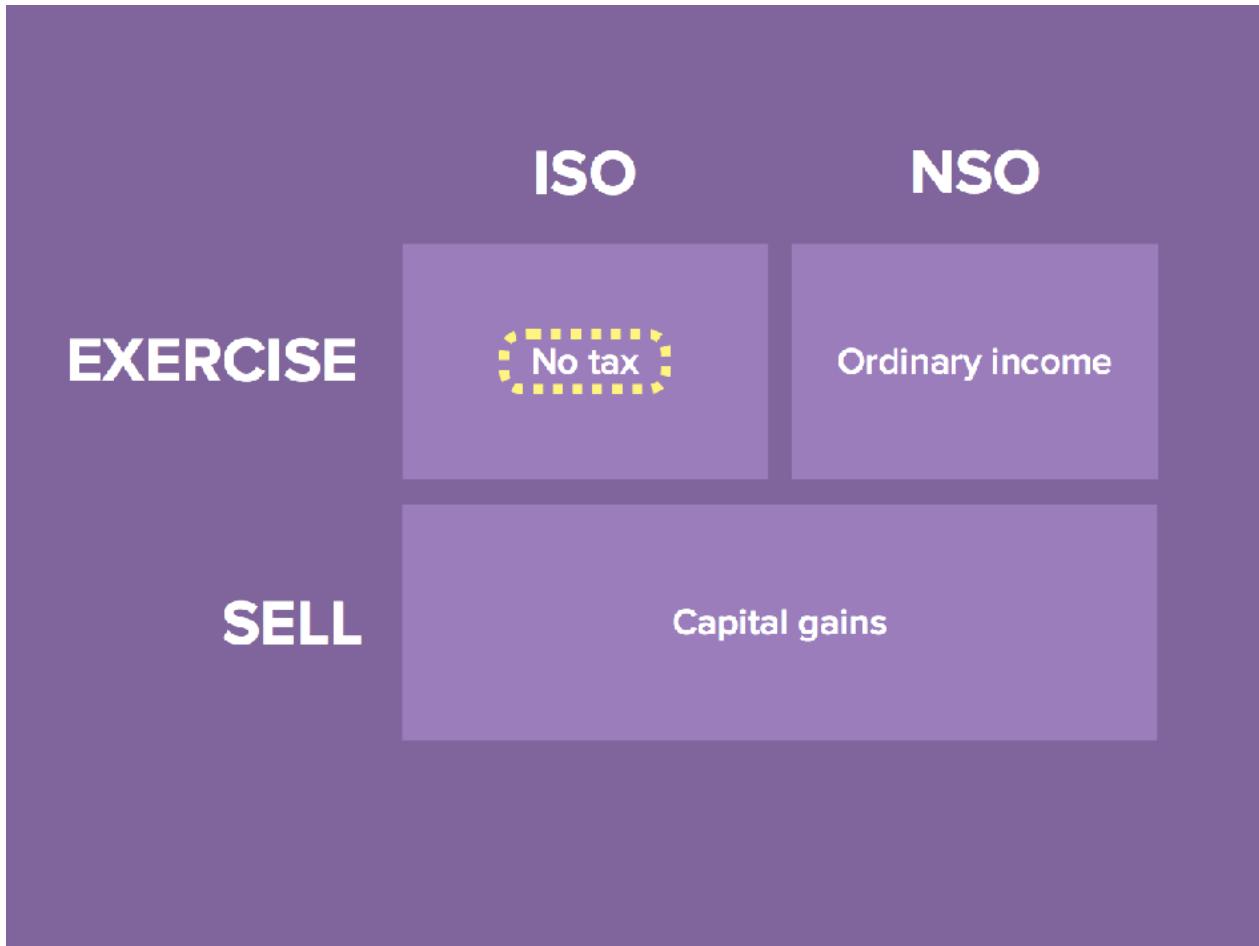
On top of that, any gain in the stock price after the exercise is treated as Capital Gains tax.

Because Kerri owns the stock at this point, any gain she makes at sale is a profit from selling as asset.

Taxes on payouts in Kerri's example

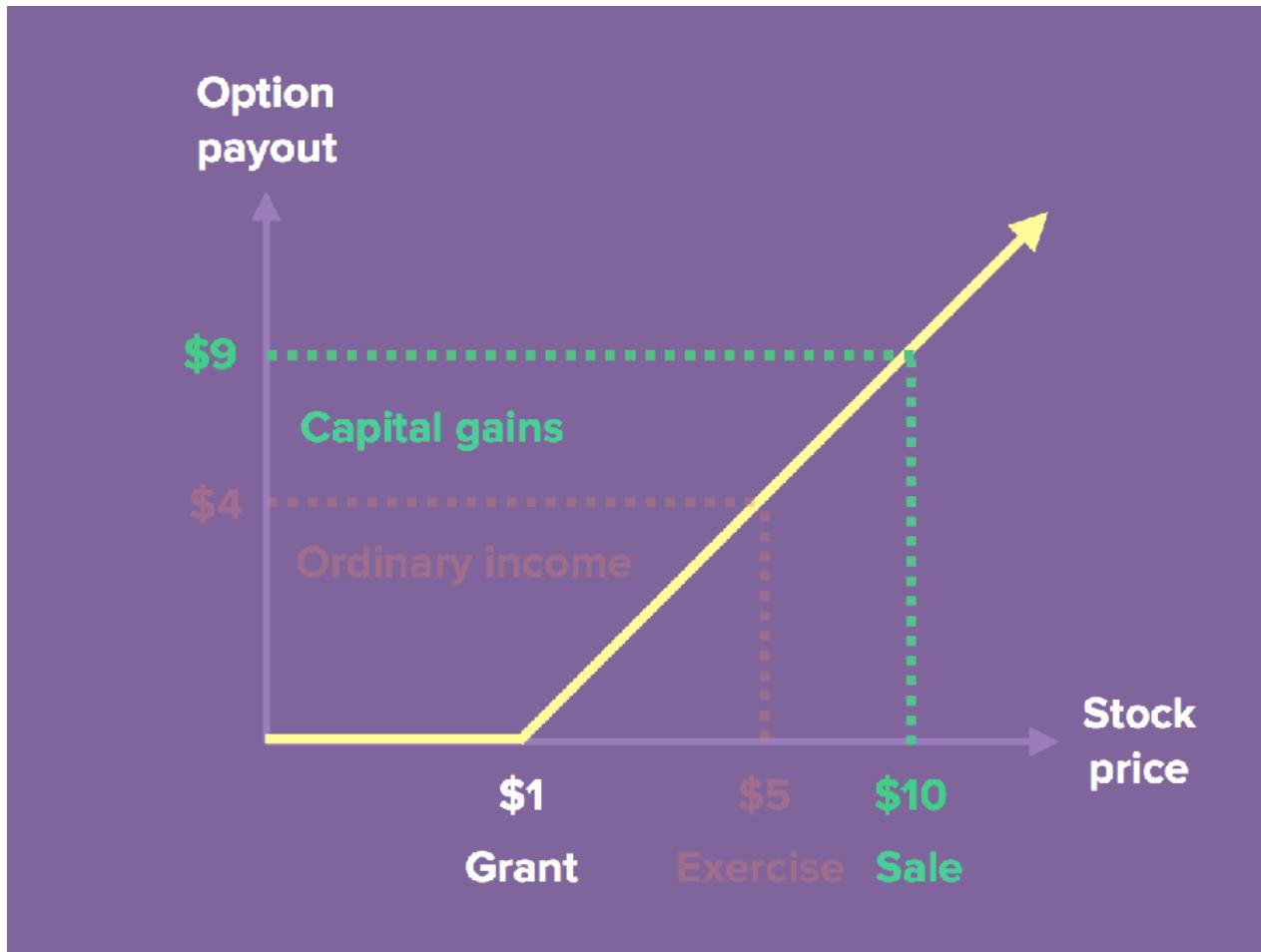


ISOs vs NSOs on Kerri's example



The benefit of having ISOs is that you do not pay tax on the day you exercise.

ISOs vs NSOs on Kerri's example



In Kerri's case, the entire \$9 payout is taxed as Capital Gains and she does not have to pay that tax until she sells the stock.

One other tax you should be aware of...

Alternative Minimum Tax (AMT)

AMT is a separate set of tax rules that include external factors like ISO exercises in your tax calculation.

If the AMT calculation exceeds the normal amount, you will need to pay the greater of the two calculation.

AMT can potentially be thousands of dollars, depending on your income and the gain you realize from the exercise.

In order to receive tax benefits, you must adhere to a holding period

The main reason ISOs are nice is that you don't have to pay tax on the day that you exercise (unless you owe AMT)

To receive this benefit, however, you have to meet certain holding periods:

the day you sell the stock needs to be at least **2 years after the day your options were granted**, and **1 year after the day your options were exercised**.

Holding periods in Kerri's example



If either of these holding periods aren't met, your options are treated as NSOs (=more tax)

Other tax concept: QSBS

- Qualified small business stock
- Hold for 5 years after exercising
- Exclude \$10M in capital gains

Calculator

Salary component

Gross yearly salary in USD

\$ 0

Equity component

Stock options granted, vested over 4 years

100,000

Strike price

Price at which you can purchase your options

\$ 1

Final value of one share

Expected valuation / final # of shares

\$2.00

Package value

After 4 years

from salary

\$0

from equity

\$100,000

total

\$100,000

Expected company valuation

The value at which the company will exit

 \$20m

Expected additional dilution

Share owned by future investors

 0%

Number of fully diluted shares

Existing shares at the time of the offer

10,000,000

Spread of your options

Final share value minus your strike price

\$1.00

Calculator

Salary component

Gross yearly salary in USD

\$ 0

Expected company valuation

The value at which the company will exit

 \$20m

Equity component

Stock options granted, vested over 4 years

100,000

Strike price

Price at which you can purchase your options

\$ 1

Number of fully diluted shares

Existing shares at the time of the offer

10,000,000

Final value of one share

Expected valuation / final # of shares

\$1.60

Final share value minus your strike price

\$0.60

Package value

After 4 years

from salary

\$0

from equity

\$60,000

total

\$60,000

Yearly

from salary

\$0

from equity

\$15,000

total

\$15,000



But when do people exercise
then?

But when do people exercise then?

Scenario 1: (Usually) **upon termination.**

And remember, you always have a window—typically 30-90 days—to exercise your vested options.

When this happens, you are exercising at some point in the middle of the grant's life. That means you will most likely pay some mix of Ordinary Income tax and Capital Gains tax upon the sale of the stock.

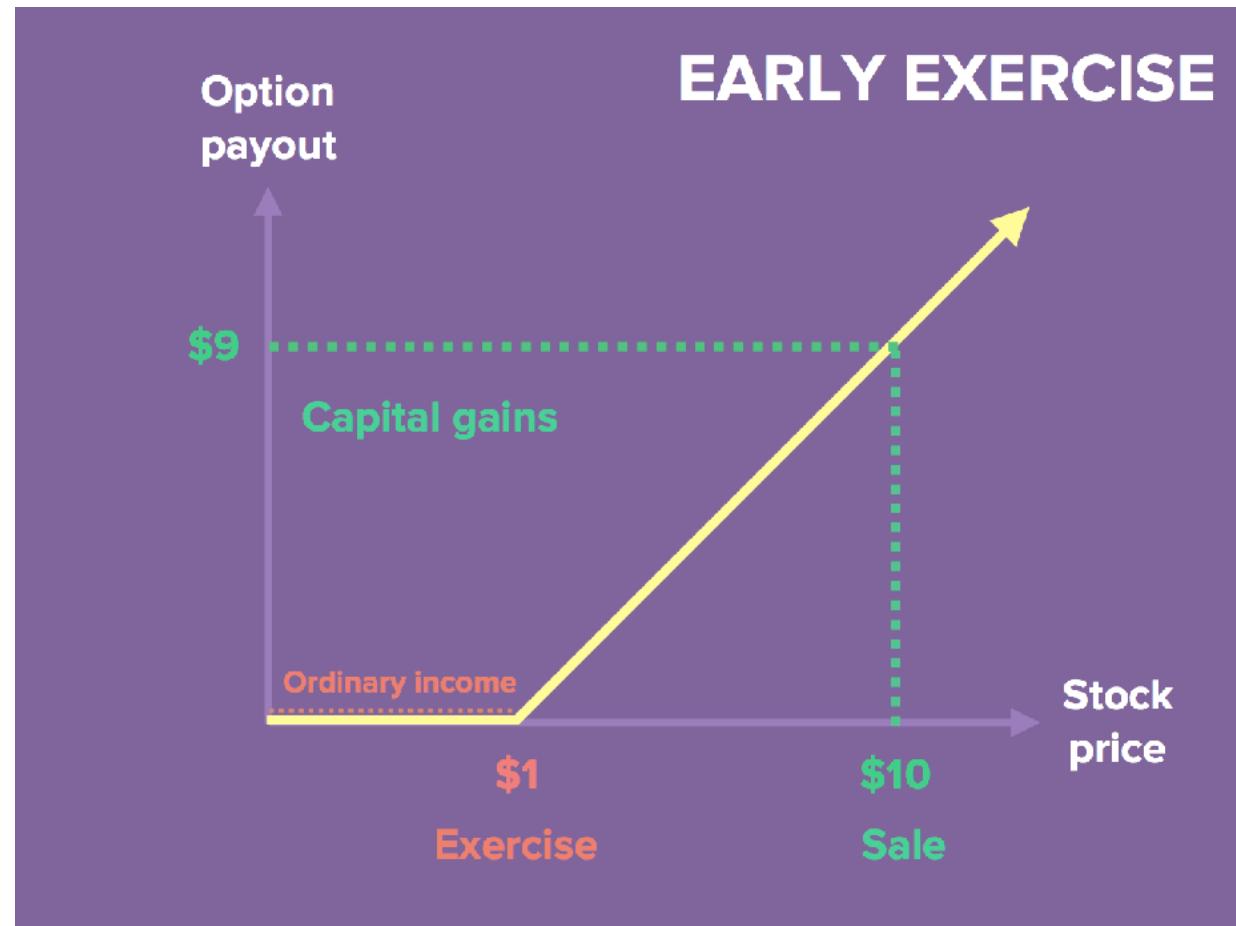
But when do people exercise then?

Scenario 2: Early exercise.

Some companies allow this, and it just means you can exercise your options before they have vested.

This is risky but low tax!

Holding periods in Kerri's example



Risky because:

There is no guarantee that your stock will ever be liquid, so you are paying to buy stock that could one day be worthless.

But when do people exercise then?

Scenario 3: Upon Exit

This is the least risky time to exercise, because you know the stock is liquid immediately.

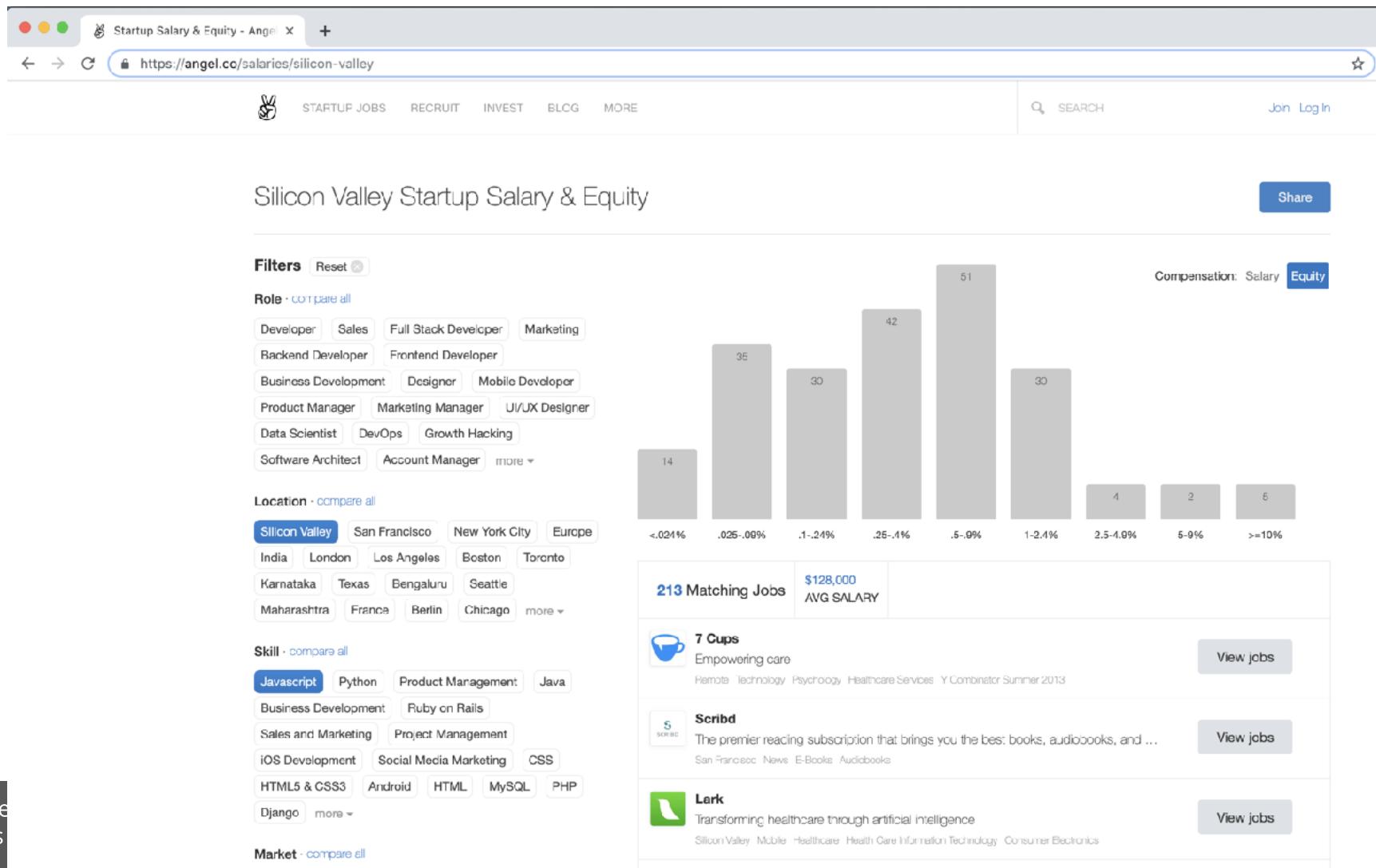
You can turn around and sell the stock for a gain (hopefully) the same day you pay to buy it.

The downside in this situation is that you usually end up paying more tax.

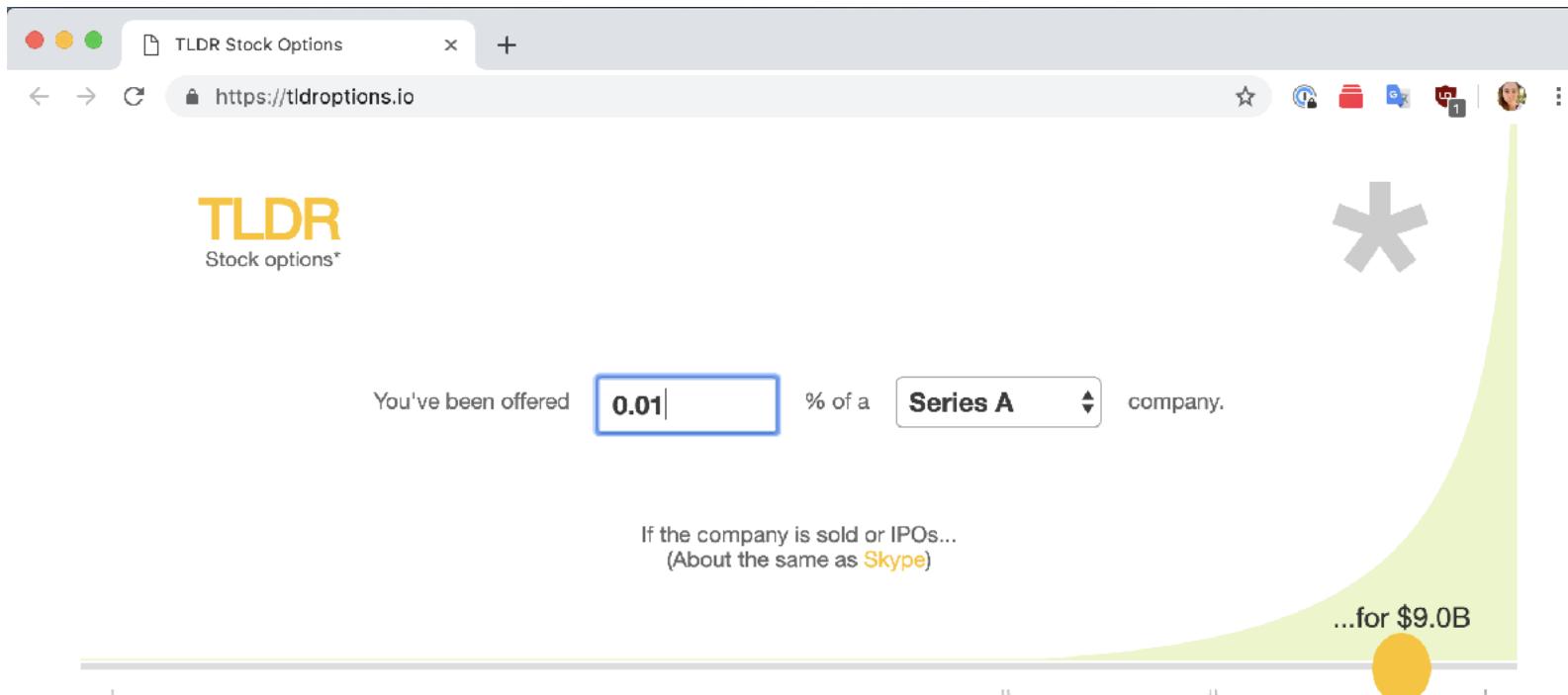
Remember those holding periods we talked about (the day you sell the stock needs to be at least one year after the day you exercised your options)? That holding period won't be met if you sell the stock on the same day you buy it. If this happens, your options will be treated like NSOs, and any pre-exercise gain is taxed as Ordinary Income.

Risks to exercising?

Equity. How much should I ask for?



I need more intuition about stock options.



~65% of companies will never exit

~15% of companies will have low exits*
~20% of companies will make you money

...in 6-ish years you could be looking at something like:

\$356,987
(or not)*